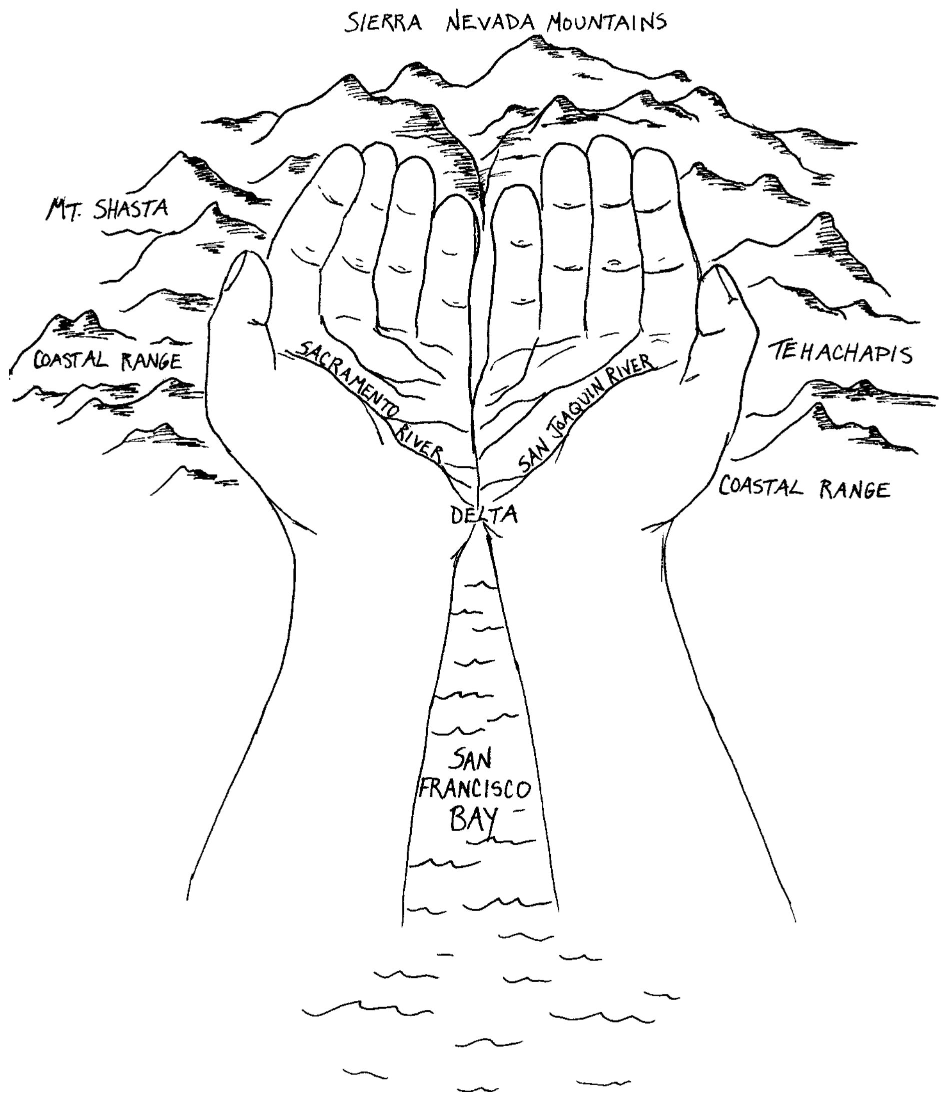
San Francisco Bay Watershed Curriculum



A Collection of Activities and Action Projects About the San Francisco Bay Watershed for Middle and High School Students

Save The Bay's
San Francisco Bay Watershed Curriculum

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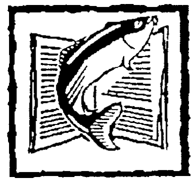


1. How does this curriculum fit into your classroom?

This curriculum is designed as a tool to help you bring the San Francisco Bay into your classroom. There are, of course, many different ways to use this guide. Here are some of our suggestions:

- Use individual activities to cover content standards within the subject you are teaching: Every activity in this guide is designed to stand on its own so that you can pick and choose the activities that best suit the needs of your students. Whether you teach Science, History, or Language Arts, you can use this curriculum to help you cover the content standards while teaching about the Bay. For example, if you are teaching your students how to do a research project, you could use "Life In the Bay, Getting to Know the Bay's Plants and Animals" from this curriculum. Use the **Content Standards Matrix**, and the **Excerpts from the California Content Standards,** located in the appendix, to help you choose activities that will fulfill content standards for your class. Note that the content standards are excerpts from a larger text, and may appear out of sequence.

- Use the San Francisco Bay as a theme across the disciplines: Create a month-long, semester-long, or even year-long unit around wetlands and watersheds, featuring the San Francisco Bay. This curriculum features activities for many different subject areas including Science, History, Geography, Language Arts, Math, and Art. Use the action projects at the end of the curriculum to enhance the unit and to connect classroom learning with the "real world."

- Use the San Francisco Bay as a vehicle for project-based learning: All the activities in this curriculum can be used to supplement a series of field trips and action projects around the Bay. The final section features six possible action projects. For more information about field trips and action projects, please contact the education department of Save The Bay at **510-452-9261**.

2. How is the curriculum organized?

This curriculum is organized into five sections. Each section covers a different theme that relates to San Francisco Bay. You will find a table of contents for each section on the back of each section divider. The sections are the following:

- Welcome to Your Watershed: Introduces students to the concepts of wetlands and watersheds and gives them a sense of their own place within the San Francisco Bay watershed.
- Geology of the San Francisco Bay and its Wealth of Resources: Covers some of the basic geologic forces that have helped shape the Bay Area as well as how geology relates to the area's resources.
- The Evolution and Ecology of Life in the San Francisco Bay: Introduces students to the Bay's plants and animals and covers several important factors of the Bay's ecology today.
- The History of Human Impacts on the Bay: Involves students in decisions that have impacted the Bay from the Gold Rush to the present.
- How Can We Save The Bay? Gives ideas for how students can get involved in projects that monitor, restore, and educate others about the Bay.

3. How are the Activities Organized?

Each activity is divided into two sections: teacher's pages and student pages. Look for the following symbols at the top of each section:

The **teacher's pages** describe each activity and tell you everything you need to know about how to present the activity to your class, including an overview, background information, timing, materials and a detailed procedure. The teacher pages also outline the content standards covered by the activity.

The **student pages** that accompany most activities are designed to be photocopied and handed out to students. They include an introduction, background information, materials and procedure when applicable, and any articles or resources that accompany the activity.

The Bay and You

A Watershed Journal

Overview

This activity is meant to be integrated throughout your unit on the San Francisco Bay's Watershed. Students make a journal at the beginning of the unit and write journal entries throughout the unit.

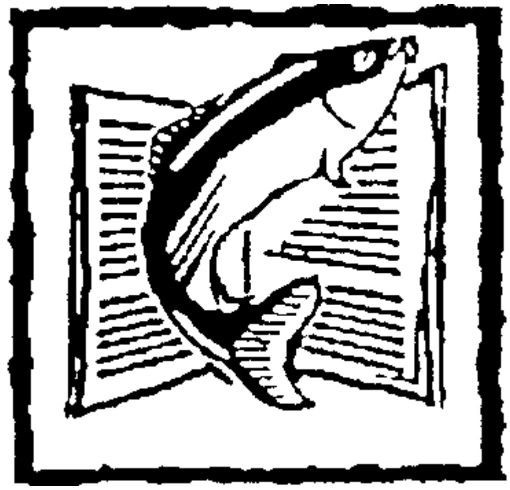
Materials

For each student:

- Copies of Student Pages
- 30 - 50 pieces of reused 8 ½" X 11" paper (one-sided paper) – for insides of journal
- Approximately 9" X 12" mat board, foam core, or cardboard (not corrugated) – for back cover
- Approximately 9" X 12" front covers (cut from reused posters or heavy duty paper)
- Hole punches
- Thick, big rubber bands
- Sticks or pencils – approximately 8" long
- Large ziploc bags for journal storage

Language Arts Standards

Keeping a journal can address many of the writing standards for 4th through 12th grades, specifically in writing strategies and writing applications. Fourth and fifth graders write clear, coherent sentences and paragraphs that develop a central idea and describe and explain familiar objects, events, and experiences. Sixth, seventh, and eighth graders write clear, coherent, and focused essays, with formal introductions, supporting evidence, and conclusions, and narrative, expository, and persuasive texts of at least 500 to 700 words in each genre. Ninth through twelfth graders write coherent and focused essays that convey a well-defined



perspective and tightly reasoned argument, demonstrating students' awareness of the audience and purpose. They also combine the rhetorical strategies of narration, persuasion, and description to produce texts of at least 1,500 words each. Modify journal assignments to meet these standards for different grade levels.

Journal writing can also address other standards, which are used for the content of the journal assignments. The journal assignment ideas tie into other sections of this curriculum, including evolution, ecology, history, and service learning.

Additional Resources:

Save The Bay's Watershed Journal
http://www.savesfbay.org

River of Words
http://www.riverofwords.org/

Journal Entry Ideas:

These suggested ideas for journal entries can be used after specific activities or sections of the curriculum as indicated, or used whenever it fits into your unit. You may want to store journals in ziploc bags and create a box to store all of the journals when they are not being used, so they don't get left in lockers, etc., and so you can easily carry them outside or on a field trip.

Beginning of Watershed Curriculum

1. **What Do We Know?**
   The first entries in the journal can be used before you begin your San Francisco Bay unit, as an assessment of what your students already know and what they want to learn:
   - What experiences have you had around water, such as a river, lake, ocean, or bay? Describe your experience.
   - What do you already know about San Francisco Bay? What things do you want to find out about the San Francisco Bay?
   - Write down a definition for the word "watershed."

Introduction to the Bay's Watershed

1. **Watershed Definition**
   The students should revisit their definition of "watershed." Was it correct? What would their definition of "watershed" be now?

2. **Personal Watershed**
   Students can draw their personal watershed to evaluate their background, beliefs, and goals using the metaphor of a watershed. Lead a discussion with the students about the importance of understanding their own identity and defining goals. This journal entry encourages them to look to their past, think about their present, and make goals for the future. It's nice to provide color pencils or watercolors for this journal entry. Write down the following instructions:

   - The rivers represent the first influences in our lives. What experiences did you have as a child that shaped who you are today? Where did you play? What friends, family, teachers, community members influenced you in the distant or recent past?
   - The bay represents who you are now. What are the most important things in your life now, such as your friends, family, school, job, or hobbies? What do you do in your free-time?
   - The ocean represents your goals for the future. What do you want to be doing in the future? What are your most important goals?

   Upon completion, you can ask students who want to share their Personal Watersheds to describe their past, present, and future and show their drawing.

3. **Letter to a Friend**
   Write a letter to a friend telling him/her how they would get to your house if they were to travel only along the waterways. Be creative!

4. **Watershed Metaphors**
   Many objects make good representations of, or metaphors for, a watershed: a tree, the nervous system, or a bathtub, for example. Ask your students to come up with a good watershed metaphor and explain it in a descriptive paragraph or in a poem.

Mapping the Bay's Watershed

1. **A Paved State**
   Imagine that the whole state of California, except for the streams, creeks, and rivers had been paved with concrete. Write a paragraph or two describing what would happen to these waterways when it rained.

2. **Mapping the Storm Drains**
   Have students draw a map of the outside of their school, including parking lots, play areas, and surrounding streets. Then do a walking tour of the school grounds and draw in all the storm drains. Label the storm drains A, B, C, etc. on their maps. Have students record what they see on and around each storm drain (trash, soap, oil, dirt, etc). They then, of course, pick up any trash they see! You can extend this activity by doing ongoing storm drain monitoring. Assign a group of students to each storm drain. Have them periodically check the storm drain, record their findings in their journal, and then pick up any litter they find. You can analyze the results over time – which storm drains seem to get the most litter? Which are the cleanest? Are there different types of litter found at different sites? Why?

Geology of the Bay and Its Wealth of Resources

1. **The Future Bay**
   Using what you know about the way the earth is moving and the rate of development and restoration around the bay, draw a picture and write a description of what you predict the bay might look like in the future.

Evolution and Ecology of Life in the Bay

1. **Extinction Debate**
   Are the plant and animal extinctions currently happening natural or unnatural? Should we be concerned about the loss of species on Earth or is this a natural phenomenon? Write an essay supporting your point of view.

2. **Salmon Research**
   Write a research paper about salmon. Describe their natural history, life cycles, habitat needs, threats to their survival, and what can be done to protect salmon. What are the different points of view on salmon protection by fishermen, environmentalists, and farmers?

3. **The Human Connection**
   We have been talking about how a healthy ecosystem has high biodiversity, meaning there are many different types of plants and animals. When we talk about having many different types of *people* in an area, we say that there is diversity. How does having diversity add to human society? What are the benefits of living and working with people of many different cultures, races, religions, ages, sizes, and abilities?

4. **Design a Store**
   One reason our increasing population is harmful to the environment is that we use so much packaging for the food and other products we use on a daily basis. Imagine what it would be like to go to a grocery store where none of the products are packaged. What would it look like? How could the store owners keep everything in order? How could shoppers take items home? Design a store that uses no packaging, and draw a picture to illustrate it.

History of Human Impacts on the Bay

1. **Save The Bay Commercial**
   Create a commercial for Saving the Bay. Imagine that you have been given the opportunity to do a TV commercial for Save The Bay. You only have sixty seconds to get your message across! Write a script for your commercial and describe the visual images you would like to show.

2. **Past and Present**
   Research the history of water rights in California, from the Gold Rush to present day. How have water rights been assigned over the past 150 years? Who are the stakeholders in California's water wars? What are the issues? What are some of the

proposed solutions? Can California continue to support a growing population and agriculture? How do you think the water wars can be solved?

3. **Airport Debate**
   Should the San Francisco Airport build new runways in the Bay? Write a persuasive essay arguing your case. Use supporting evidence and a well-defined thesis to convince your audience that you are correct.

Taking Action to Protect the Bay

1. **Solo Sit**
   Prepare a page in the journal with four columns labeled "what I see," "what I hear," "what I smell," and "what I feel". Lead a brief discussion about observation, and how we can use all of our senses to discover more about the world around us. Have each student find a place, apart from other people, to sit in silence for five minutes. Encourage students to keep their bodies as quiet and still as possible, and to use all their senses to observe their spot. After they have been sitting for five minutes, they should spend another five minutes recording observations on the page they have prepared.

2. **The Three Levels of Reflection**

- *The Mirror*
  (A clear reflection of the Self)
  Who am I? What are my values? What have I learned about myself through this experience? Do I have more/less understanding or empathy than I did before volunteering? In what ways, if any, has your sense of self, your values, your sense of "community," your willingness to serve others, and your self-confidence/self-esteem been impacted or altered through this experience? Have your motivations for volunteering changed? In what ways? How has this experience challenged stereotypes or prejudices you have/had? Any realizations, insights, or especially strong lessons learned or half-glimpsed? Will these experiences change the way you act or think in the future? Have you given enough, opened up enough, cared enough? How have you challenged yourself, your ideals, your philosophies, your concept of life or of the way you live?

- *The Microscope*
  (Makes the small experience large)
  What happened? Describe your experience. What would you change about this situation if you were in charge? What have you learned about this agency, these people, or the community? Was there a moment of failure, success, indecision, doubt, humor, frustration, happiness, sadness? Do you feel your actions had any impact? What more needs to be done? Does this experience compliment or contrast with what you're learning in class? How? Has learning through experience taught you more, less, or the same as the class? In what ways?

- *The Binoculars*
  (Makes what appears distant, appear closer)
  From your service experience, are you able to identify any underlying or overarching issues which influence the problem? What could be done to change the situation? How will this alter your future behaviors/attitudes/and career? How is the issue/agency you're serving impacted by what is going on in the larger political/social sphere? What does the future hold? What can be done?

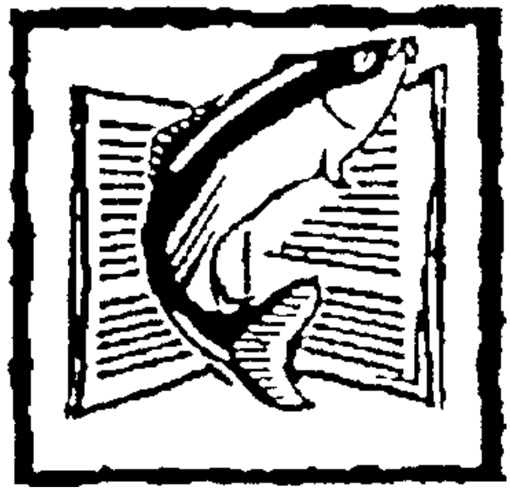
The Bay and You

A Watershed Journal

Student Pages

INTRODUCTION

People keep journals for many reasons. Scientists keep track of data and information in journals, people write down their daily activities and emotions in diaries, naturalists note sightings and observations in field journals, travelers record their adventures in travel logs, gardeners account for plantings in a notebook. You can record what you have experienced and learned about the environment in a Watershed Journal. After hand-making your own journal, you will use it over the course of this unit to describe your thoughts, feelings, and ideas.



MATERIALS

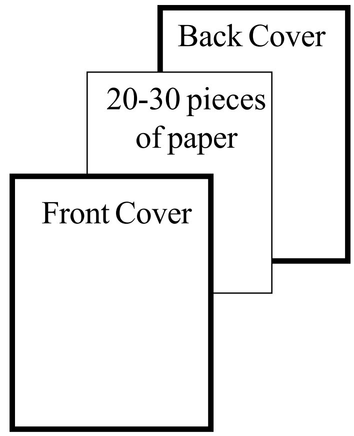
To make a journal, you will need:

- 20 – 30 pieces of reused 8 ½" X 11" paper (one-sided paper) – for insides of journal
- Approximately 9" X 12" mat board, foam core, or cardboard (not corrugated) – for back cover
- Approximately 9" X 12" front covers (cut from reused posters or heavy duty paper)
- Hole punches
- Thick, big rubber bands
- Sticks or pencils – approximately 8" long

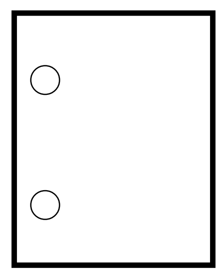
Making A Watershed Journal

Student Pages

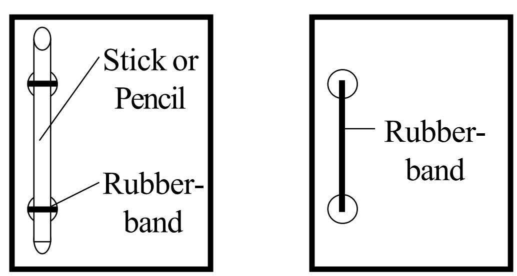
1. Stack back cover, 20 – 30 pieces of paper, and front cover in a neat pile.



2. Using a hole punch, punch two holes through front cover, 20-30 pieces of paper, and back cover, along spine of journal. These holes must line up.



3. Poke rubber band through holes from back (you may need to use a pencil to poke rubber band through) and place stick or pencil inside rubber band on front. If you use a pencil, you will have a writing implement in an emergency, but your journal may fall apart when you need to use the pencil!

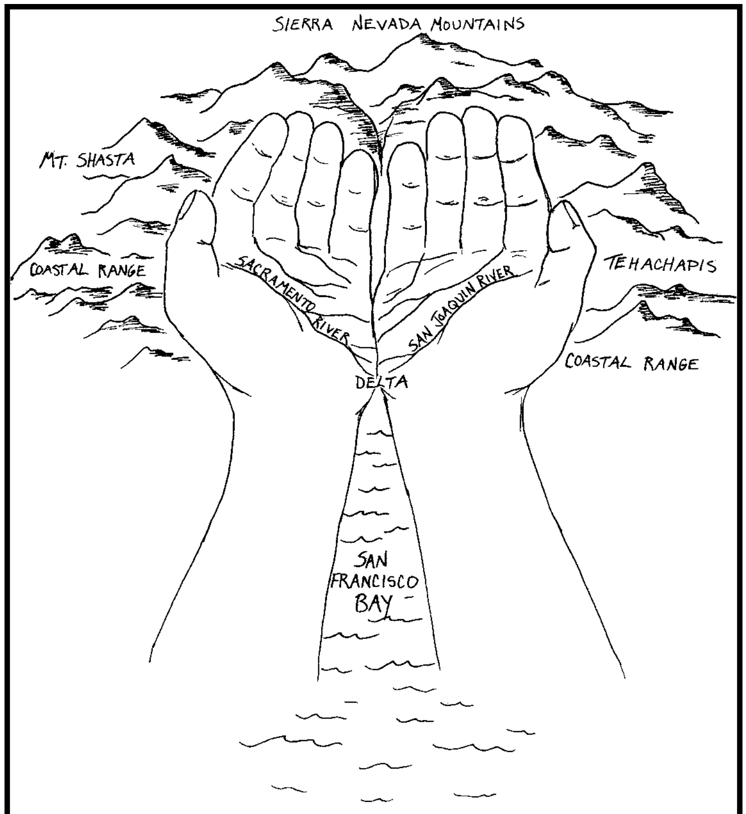


Front of Journal   Back of Journal

4. Write your name inside the front page of the journal. Voila! You have a Watershed Journal.

The San Francisco Bay's Watershed in Your Hands

TEACHER'S PAGES



Sharón Friedner

Overview
Students first use crumpled paper to create a model demonstrating the basic features of a watershed. They then create the San Francisco Bay's Watershed using their hands to represent major geographical features.

Estimated Time
30 minutes

Objectives
Students will be able to:
- Describe the major geographical features of San Francisco Bay'sWatershed.
- Define the term "watershed."

Materials
- One sheet of 8 ½" X 11" paper for each student (reuse one-sided paper for this activity)
- Water soluble markers or watercolors, paintbrushes, and cups of water
- Spray bottles of water
- A pair of hands!
- Overhead of "Watershed in Your Hands" and/or a map of California

Vocabulary
watershed, ridge lines, urban runoff, drainage, erosion

California Science Content Standards
Grade 4
Standard Set 5.c: moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).
Grade 5
Standard Set 3.e: the origin of the water used by their local communities.
Grade 6
Standard Set 2.a: water running downhill is the dominant process in shaping the landscape, including California's landscape.

Adapted from Kids in Creeks, by Aquatic Outreach Institute

Additional Resources
The Watershed Project
http://www.aoinstitute.org/
Watershed Finder
http://www.museumca.org/creeks/resc.html

Background

A watershed is defined as *an area of land that water flows over or through on its way to a larger body of water*; a watershed is the drainage basin for a body of water, such as the San Francisco Bay. Everyone lives in a watershed. Homes, farms, ranches, forests, small towns, big cities and more exist in watersheds. Watersheds can be large or small. Some cross county, state, and even international borders. Larger watersheds are comprised of many small ones. For example, if water from your schoolyard drains into a creek, and that creek drains into San Francisco Bay, you are part of that creek's watershed, which is in turn part of the San Francisco Bay's watershed.

"A watershed starts at mountain peaks and hilltops. Snowmelt and rainfall wash over and through the high ground into rivulets which drain into fast-flowing mountain streams. As the streams descend, tributaries and groundwater add to their volume and they become rivers. As they leave the mountains, rivers slow and start to meander and braid, seeking the path of least resistance across widening valleys, whose alluvial floor was laid down by millennia of sediment-laden floods. Eventually the river will flow into a lake or ocean. Where the river is muddy and the land is flat, the sediments laid down by the river may form a delta, splitting the river into a bird-foot of distributaries which discharge into the sea. The river's estuary, the place where its sweet waters mix with the ocean's salt, is one of the most biologically productive parts of the river – and of the ocean." (Patrick McCully, Silenced Rivers: The Ecology and Politics of Large Dams)

The California watershed covers approximately 40% of the state of California. It begins in the Sierra Nevada mountain range, continues through the Central Valley, and eventually drains into the San Francisco Bay and out into the ocean. By tracing the path of water as it flows through the watershed and into the Bay, one can begin to understand how everyone who lives in the watershed can affect the Bay's health.

Teacher Procedure

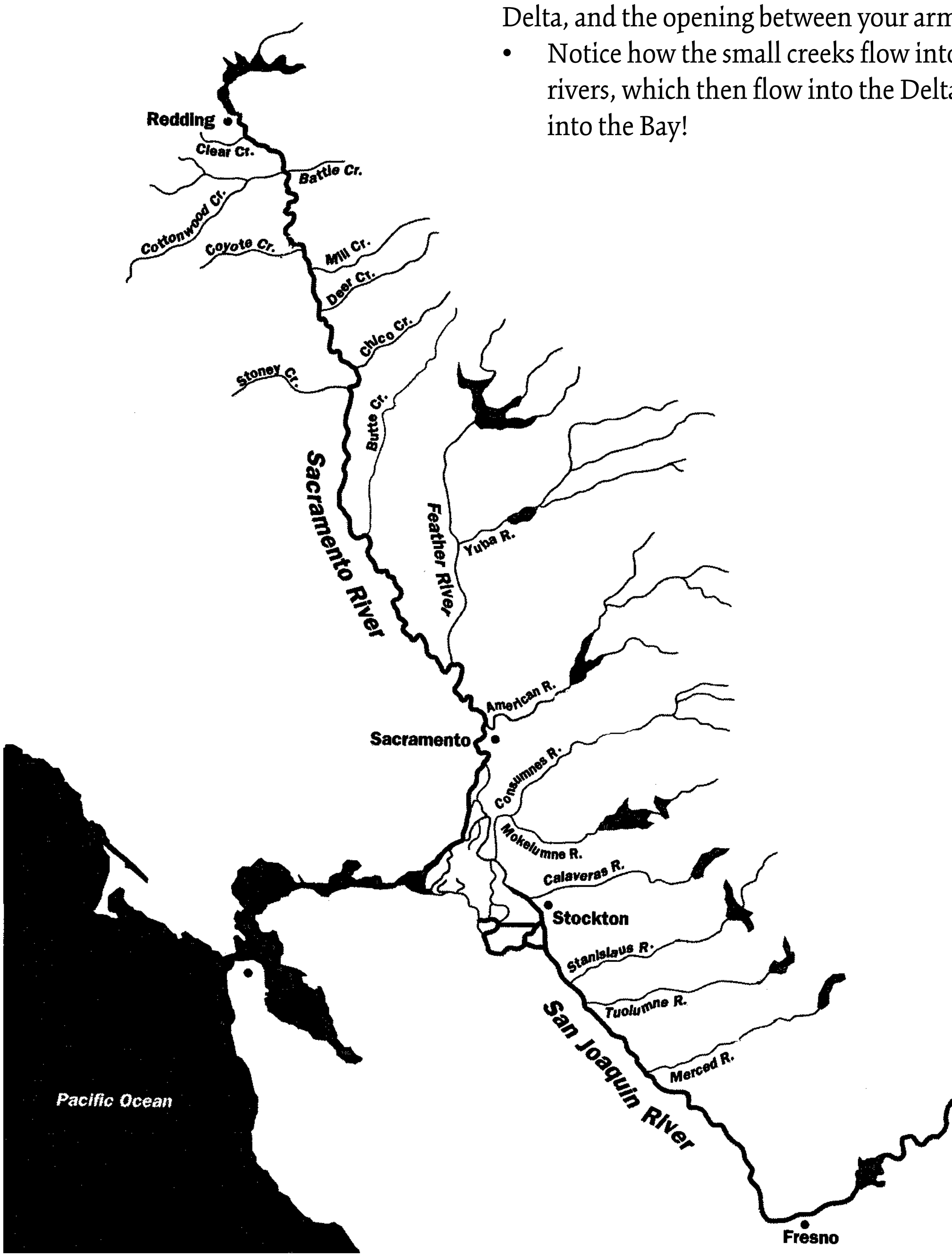
Making a Watershed Model

1. Conduct this activity outside or in an area that can get slightly wet (lab area, tables with paper towels nearby, etc.)
2. Pass out a piece of paper and water soluble markers or water color supplies.
3. Instruct the students to crumple their piece of paper into a ball and to gently open up the paper without flattening it out completely. It should look like a landscape with mountains and valleys.
4. They should use one color to represent ridge lines, the highest points on the paper, which separate one valley from another.
5. Another color should be used to represent bodies of water. They may need to guess where rivers or lakes will form on their landscape.
6. A third color should be used to represent human settlements, such as houses, factories, offices, roads, etc.
7. Either hand out the spray bottles to a few students or walk around the classroom with one spray bottle, lightly spraying the finished maps. The spray represents rainfall. The students should notice where rain travels on their landscape.
8. Lead a discussion using some of the following questions:
    - What path does the rain take on your landscape?
    - How does this landscape represent the idea of a watershed?
    - What happened to human settlements? Was there erosion or urban runoff?
    - How should the flow of water affect our choice of building sites within a watershed?

Watershed in Your Hands

1. Tell the students that they can use their hands to make a model of San Francisco Bay's watershed.

2. You can use a map of California and the overhead of "Watershed in Your Hands" while you are doing this activity to help your students identify major geographical features of the San Francisco Bay's Watershed.
   - Put your hands together, palms upward, and curve them to make a bowl.
   - Imagine that the tips of your fingers are the peaks of the Sierra Nevada Mountain Range.
   - Your left thumb is Mount Shasta, your right thumb is the Tehachapi Mountain Range, and the fleshy parts at the bases of your thumbs are the Coastal Range.
   - The cracks between your fingers are all the small creeks and rivers trickling down from the Sierras, such as the American, Kern, and Mokelumne.
   - The large crease in your left palm (sometimes called your "lifeline") represents the Sacramento River, and the crease in your right palm represents the San Joaquin River.
   - The crack between your two hands represents the Delta, and the opening between your arms is the Bay.
   - Notice how the small creeks flow into the large rivers, which then flow into the Delta and out into the Bay!



Wetlands In A Pan

A watershed model demonstrating the functions of wetlands

TEACHER'S PAGES

Overview

In this activity students will create a model of a wetland habitat that demonstrates the functions of a wetland. Students will observe, form hypothesis, perform experiments and record their conclusions with their model and evaluate the functions of a wetland.

Central Question

What are the functions of a wetland?

Estimated Time

2 hours

Objectives

Students will be able to:

- *conduct* experiments and record their observations.
- *explain* how wetlands filter the sediments and pollutants from water that flows through the watershed into the Bay.

Materials

For each group of 2-3 students

- Modeling Clay
- Long shallow pan: a sturdy metal or glass pan with a smooth, flat bottom works well or a rolling metal or plastic paint pan
- Sponges (enough to span the width of pan)
- Cup of soil
- Spray bottle with water
- Q-tips
- Colored drink mix
- Optional: items to represent wetland plants or animals, such as pine needles, clay for animals, toothpicks and marsh-mallows for cattails

Tara Reinertson

Vocabulary

watershed, sediment, pollutants, wetland buffer

California Science Content Standards

Grade 6

Standard Set 2.a: water running downhill is the dominant process in shaping the land-scape, including California's landscape.
Standard Set 2.b: rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.
Standard Set 2.d: earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

Additional Resources

US EPA Watershed Academy Slideshow
http://www.water-ed.org/store/default.asp?parentid=2
http://www.water-ed.org/store/default.asp?parentid=2.gov/watertrain/wetlands/index.htm
US EPA Wetlands Overview
http://www.epa.gov/owow/wetlands/

Background

Wetlands are lands transitional between terrestrial and aquatic systems where water is usually at or near the surface. For land to be designated as a wetland it must have one or more of the following three attributes: 1) evidence of surface water or water in the root zone; 2) hydric soils or undrained soils; 3) vegetation that has adapted to thrive in wet conditions (hydrophytes).

In the past, wetlands were viewed as wastelands full of mosquitos and mud with no obvious functions. Because of this cultural view, humans have destroyed much of the wetlands. Approximately 90% of the salt marshes around San Francisco Bay have been dredged, diked, drained, and filled. Buildings, roads, salt ponds, and landfills have been built on top of them.

The loss of wetlands around San Francisco Bay has resulted in a loss of habitat for wildlife. While some plants and animals are capable of adapting to other habitats, two endangered species, the Salt Marsh Harvest Mouse and the California Clapper Rail, live only in the salt marshes of San Francisco Bay and depend on the wetlands for their survival.

While wetlands are important because they serve as habitats, they also serve us in other ways. One of the most important functions of wetlands is how they serve as filters to trap pollution and sediment from urban runoff. Because wetlands often lie on the borders between uplands and open waterways, they act as a buffer between the two. Wetland plants slow the flow of water enough to allow the heavier particles to settle out. Smaller particles are trapped in the mesh of leaves, stems and roots of a densely vegetated wetland. The result of urban runoff traveling through a wetland is cleaner water entering the Bay.

By slowing the flow of water, wetlands are also helpful in flood control. For example, when a heavy rainstorm increases runoff, the added water may cause waterways to overflow and flood adjacent land (towns, lawns, farms). Wetlands offer runoff a place to "rest" and soak into the soil, thereby reducing the potential for flooding.

Teacher Procedure

1. Before you begin this experiment, review with the students what they have learned about wetlands and watersheds. Put up a map of San Francisco Bay as a teaching visual. Ask the students the following review questions:

- What is a watershed?
- Where are the wetlands that we visited on our field trip?
- How do you think wetlands act like sponges?
- Wetlands also act as a filter; what does that mean?

2. Divide students into groups of two. Give each group the materials for their experiments. You may want to show them a demonstration model that you have created previously.

3. Instruct the students to read the student pages and to follow the directions on how to build their watershed wetland model.

4. Instruct the students not to proceed with the experiments until you have had a chance to see their model. Once you have approved their model, allow them to proceed with their experiments.

5. Remind the students to write down their predictions of what will happen before actually conducting that part of the experiment.

Wrap up and Brainstorm Questions:

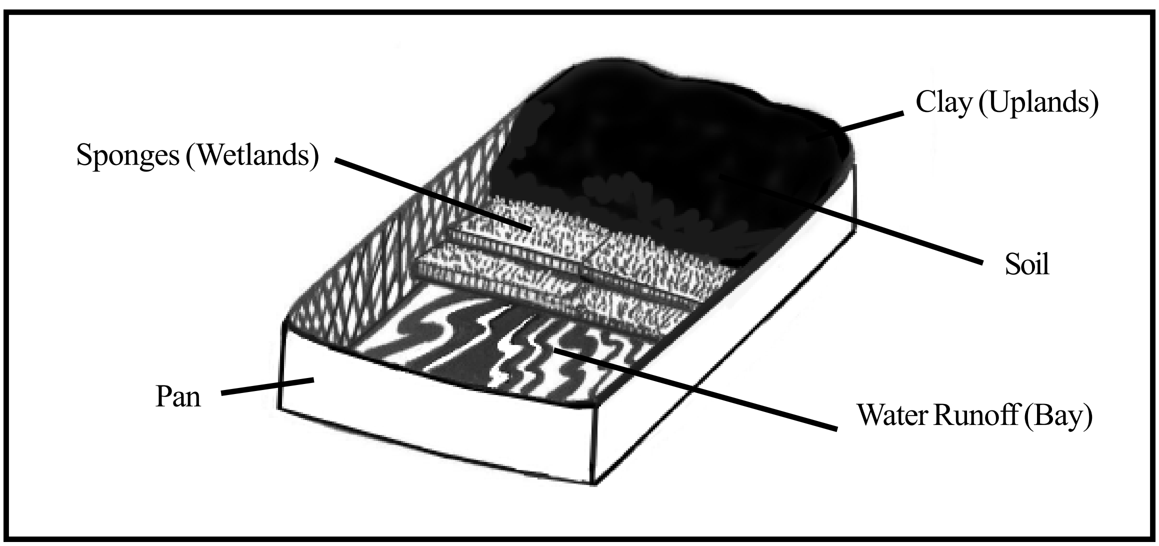
1. When sediment runs directly into the Bay, what negative things can happen?

2. How does a wetland protect the Bay from pollution?

3. **90%** of the wetlands around San Francisco Bay have been destroyed; how have they been destroyed?

4. Knowing that wetlands are effective filters, do you think wetlands often become polluted?

5. What can you do to help preserve wetlands?



Wetlands In A Pan

INTRODUCTION

Think about what happens when rain hits the land. What happens to the water after it falls to the ground? Imagine a rainstorm in a wetland. Grass, reeds, soil, and vegetation act like a sponge, soaking up the water into the floor of the wetland. Now imagine the same rainstorm on a road or in a parking lot. These surfaces are solid and water has nowhere to go. As it flows along, it gains speed and is able to pick up and carry nutrients or chemicals that might be on the land. Soil not protected be vegetation is easily eroded or washed away by fast moving water. In this activity you will work in small groups to build a model of a wetland and test how wetlands act as a buffer and filter as they trap pollutants from city runoff flowing towards the Estuary.

MATERIALS

Your group will need:

- Modeling Clay
- Long shallow pan: a sturdy metal or glass pan with a smooth, flat bottom works well or a rolling metal or plastic paint pan
- Sponges (enough to span the width of pan)
- Cup of soil
- Spray bottle with water
- Q-tips
- Colored drink mix
- Optional: items to represent wetland plants or animals, such as pine needles, clay for animals, toothpicks and marshmallows for cattails

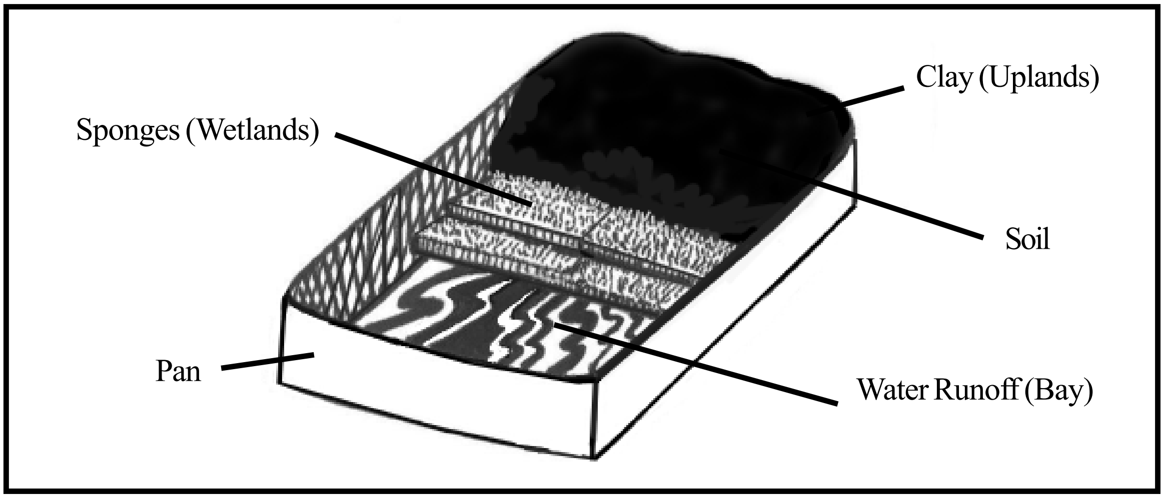
Tara Reinertson

PROCEDURE

1. In the first part of this activity you and your partner will build a watershed with the supplies provided. Spread the modeling clay over half of the pan. Leave half of the pan empty to represent San Francisco Bay. Shape the clay so that it slopes down to the Bay. Smooth the clay along the sides of the pan to seal the edges. You can also form meandering rivers or creeks in the clay that lead into the Bay. Be creative!

2. Next, you will create a wetland along the low edges of land. To do this use the pieces of cut sponges to completely fill the space across the pan along the edge of the clay (Make sure the wetland fits well - the model won't work if there are spaces under the wetland or at the sides).

3. Make sure the sponges aren't completely dry - wet them with the spray bottle to moisten them.



Experiment I - Rain on land with wetland

1. Predict what will happen to the water when it rains.

____

____

2. Create rain on the land by spraying water on the upland area.

3. Record your observations: What happened to the water as it hit the wetland?

____

____

Experiment II - Rain on land with wetland removed.

1. Predict what will happen to the water when it rains on the upland.

____

____

2. Remove the sponges from your model and spray water in the upland area. Record your observa tions.

____

____

Experiment III - Rain on land with sediment / pollution (with wetland).

1. Put sponges back in place and then sprinkle the soil on top of upland areas (clay).

2. Place about 1 tsp. of colored flavored drink mix somewhere on the upland above the wetland. This simulates pollution.

3. Predict what will happen to the sediment and pollution when rain hits the land.

____

____

4. Predict what will happen to the sediment and pollution when it reaches the wetland.

____

____

5. Spray water on the land of your model. Record your observations. What happened to the sediment and pollution?

____

____

____

Experiment IV: Rain on land with sediment (wetland removed).

1. Pour the water out from the last experiment into a sink and rinse out sponges. Replace a new layer of soil on top of the land surface. Do <u>not</u> replace the wetland (sponges).

2. Predict what you think will happen to the sediment and pollution as the rain hits the land.

____

____

Conclusions:

A "wetland buffer" is an area of wetland habitat that acts as a transition between the urban development around the San Francisco Bay and the water in the Bay. Thinking about your experiments, what functions does a "wetland buffer" serve?

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____

____

When Rain Hits the Land

Experimenting with Runoff

Overview

In this activity students will do an experiment to determine how land surfaces affect the flow of rain water as it flows through the watershed. They then apply their knowledge to their own schoolyard.

Central Question

How do different land surfaces affect the flow of rain water?

Estimated Time

3 - 3.5 hours

Objectives

Students will be able to:

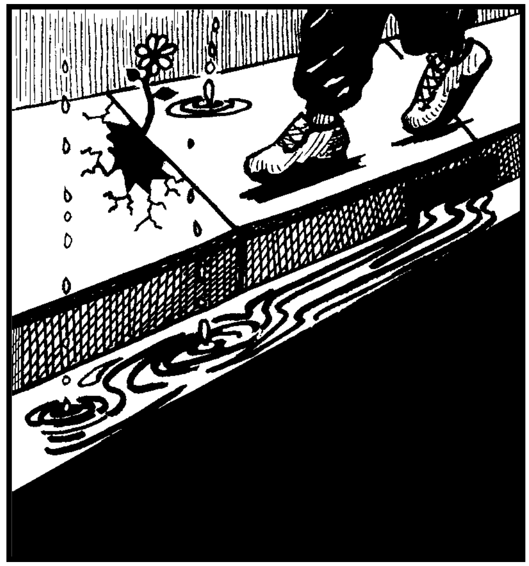
- *build* a model to demonstrate the difference between runoff and groundwater
- *create* graphs to express the result of their experiment
- *identify* which land surfaces cause runoff and which cause water to soak into the ground
- *apply* what they demonstrate in the classroom to the schoolyard environment
- *map* land surfaces around the schoolyard

Materials

For each group of 4-5

Part I:

- Cardboard milk or orange juice carton with back panel cut out
- Plastic cup with small holes in the bottom
- 3 cups of dirt
- 3 cups of sod
- 3 cups of gravel
- 3 cups of sand
- 3” x 6” strip of rooted grass or sod
- 3 handfuls of straw
- Small plastic tub for catching runoff water
- 1 large bucket (or sink) for disposing of wastewater
- 250 ml. or larger beaker or measuring cup
- Pitcher or empty jug for pouring
- Stop watch
- Ruler
- Protractor



Tara Reinertson

- Containers of fresh water (or sink)
- Clean up rags

Part II:

- Metal can (or other cylinder) with two open ends
- Beaker or measuring cup
- Pitcher or empty jug for pouring water
- Stop watch

Part III:

- Sheet of large paper or posterboard
- Markers, pens, colored pencils
- Other art supplies, as needed

Vocabulary

erosion, experimental control, groundwater, impervious, percolation, pollutant, run-off

California Science Content Standards

Grade 6

Standard Set 2.a: water running downhill is the dominant process in shaping the landscape, including California’s landscape.

Grade 7

Standard Set 7.a: select and use appropriate tools and technology (including calculators,

Additional Resource: Runoff in the Bay http://www.savesfbay.org/campaigns/fillpollution/prunoff.cfm computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Standard Set 7.c: communicate the logical connection among hypothesis, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.

Standard Set 7.d: construct scale models, maps and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

Grade 8

Standard Set 9.a: plan and conduct a scientific investigation to test a hypothesis.

Standard Set 9.c:distinguish between variable and controlled parameters in a test.

Standard Set 9.e:construct appropriate graphs from data and develop quantitative statements about the relationships between variables.

Standard Set 9.g:distinguish between linear and non-linear relationships on a graph of data.

Background

When rain hits the land, it either flows over the surface or it is absorbed. Whether rain becomes groundwater or runoff depends on the type of land it encounters. Rainwater runs off impervious surfaces such as concrete, asphalt, rooftops, and even packed soil, because it cannot soak in. As runoff glides over these smooth hard surfaces, it encounter no resistance and picks up speed. Depending on the slope of the land, the volume and power of this runoff can erode land and pick up pollutants such as oil and fertilizers. In contrast, water falling on loose soil and vegetated areas is able to seep into the ground to become groundwater. In this case, water is absorbed and slowed, minimizing erosion, filtering out pollutants, and preventing flooding. The faster the runoff and the greater its volume, the more pollutants it can carry to the Bay, and the more flooding and erosion can occur. The type of land surface and the slope of the land determine the volume and the rate of runoff.

Teacher Procedure

Part I:

1. Collecting materials: This experiment requires a fairly large quantity of materials. Most of these are inexpensive and may be collected at home. You may wish to distribute a list of materials to students a week in advance and instruct them to gather their own materials. It is probably easiest if you purchase the gravel and sod.

2. Review the concept of experimental controls with your students. Explain that for the purposes of this experiment, the only thing that should change from trial to trial is the type of material being tested. Note: Students should be especially careful to hold the milk carton at the same angle for each trial. Having a student hold the milk carton so that one end leans against a stand and the other end leans against the runoff container (see illustration) will help keep the angle consistant.

3. Question 5 asks students to predict their results, and step 7 asks for a write-up of the experimental procedure. Consider assigning these steps as homework or class work before the day of the actual experiment, depending on the amount of time you have.

4. Divide the class into groups of 4-5 students. If your students are less experienced with lab procedures, you may wish to show them a demonstration of the activity. Allow plenty of time for students to conduct the experiment and clean up. If your class periods are short, plan to conduct this activity over 2-3 days.

5. Step 14 instructs students to graph the results of their experiment. If graphing is not something with which they are familiar, you may want to determine the axis and the type of graph students use. This is a good opportunity to involve the math teacher.

Part II:

1. This part of the activity provides a very simple way to solidify concepts illustrated by the experiment in Part I by trying them out in the real world. You will need to take your students outside to explore their schoolyard.

2. Allow a specified amount of time for groups to conduct a "percolation" test on each of the land surfaces they have chosen. This involves pouring a specified amount of water onto various surfaces and recording the amount of time it takes for all of the water to soak into the ground each time.

3. Students can add the results of their percolation tests to the schoolyard maps that they will make in Part III.

Part III:

1. In this part, students will map land use around the school. They might like to share their maps with another class or display them on a bulletin board so that others can see what they have learned.

When Rain Hits the Land

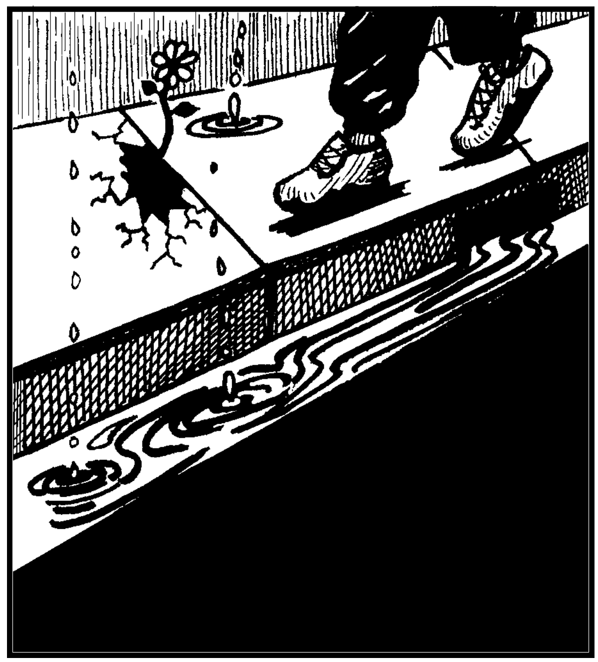
Experimenting with Runoff

Student Pages

Part I

INTRODUCTION

Think about what happens when rain hits the land. What happens to the water as it falls to the ground? Imagine a rainstorm in a wooded area. Grass, leaves, soil, and vegetation act like a sponge, soaking the water into the floor of the forest. Now imagine the same rainstorm on a road, or in a parking lot. These surfaces are solid, and water has nowhere to go. As it flows along, it gains speed and is able to pick up and carry nutrients or chemicals that might be on the land. Soil not protected by vegetation is easily eroded or washed away by fast moving water. In this activity you will work in small groups to test materials that represent various land surfaces and record your observations.



TaraReinertson

MATERIALS

Your group will need:

Part I:

- Cardboard milk or orange juice carton with back panel cut out
- Plastic cup with small holes in the bottom
- 3 cups of dirt
- 3 cups of gravel
- 3 cups of sand
- 3" x 6" strip of rooted grass or sod
- 3 handfuls of straw
- Small plastic tub for catching runoff water
- 1 large bucket (or sink) for disposing of wastewater
- 250 ml. or larger beaker or measuring cup
- Pitcher or empty jug for pouring
- Stop watch
- Ruler
- Protractor
- Containers of fresh water (or sink)
- Clean up rags

PROCEDURE

Part I:

In this part, you will conduct an experiment to find out how different land surfaces affect the rate and amount of water that will run off when it hits that surface.

1. Read the introduction to this activity. Explain how a stream might be affected by a rainstorm in a paved area. How is this different from what you expect would happen in a forest?

____

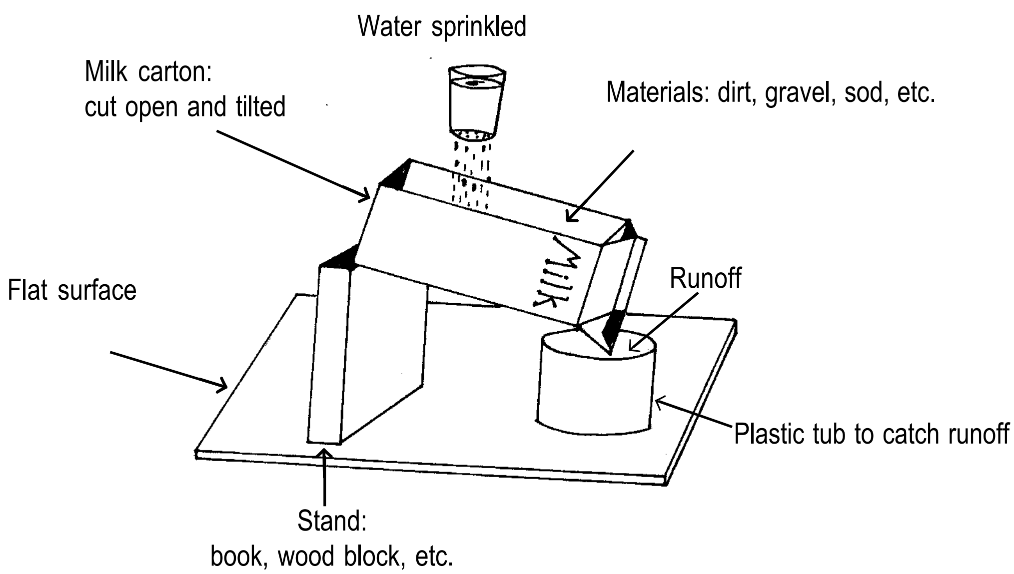
____

____

____

____

2. Your group is going to set up an experiment testing what happens when rain hits different land surfaces. Take a look at the diagram of the experiment below. You will be filling the milk carton with a material, creating a rainstorm using your plastic cup, and timing and measuring the resulting runoff. Make a list of all the things that must be done exactly the same way during each trial in order to get good results. These represent the experimental controls. Share your list with another group.



____

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____

____

3. All groups will run their first trial using only the plain surface of the milk carton. What land surface do you think the bare carton represents?

____

____

____

4. Choose three materials from the following list that you and your group members would like to test. List the materials that you choose in the Runoff Data Table.

- ☐ dirt
- ☐ sod
- ☐ straw
- ☐ gravel
- ☐ sand

5. Before running your experiment, predict which of your testing materials will produce the fastest and the most runoff, including your 3 choices and the bare carton. Rank the materials from 1 (fastest/most runoff) to 4 (slowest/least runoff), and give a brief explanation for your answer.

Bare Carton: ____

#1 ____

#2 ____

#3 ____

6. Each person in your group will be responsible for a certain job in the experiment. Use the descriptions below to decide who will be in charge of each job.

JOB DESCRIPTIONS

Title	Duties
Water Manager	Measures water quantities Sprinkles water for each trial Disposes of wastewater as instructed
Timekeeper/Recorder	Times each trial Records all data in the chart Keeps group on time
Materials Manager	Organizes all materials Places materials in milk carton each time Cleans the carton after each trial Returns all materials after use
Quality Control	Makes sure the procedures are followed correctly Makes sure everyone has a chance to speak Makes sure everyone understands
Cleanup Crew	Washes materials, desktops, and floor area.

7. Use information from the previous steps and questions to write a plan for conducting your experiment. Write your plan on a separate piece of paper and check it with your teacher when you are finished.

8. Conduct your experiment following your group's plan. Record all data in the table on the following page.

Runoff Data Table

Material	Predictions		Amount of Water Added	Amount of Runoff Collected	Time for Runoff to slow to one drop every 3 Seconds	Observations
	Time for runoff to slow to one drop every 3 seconds	Amount of Runoff				
Plain carton						
Final combination						

9. Once you have finished running your experiment, use the results from each trial to mix materials in an attempt to make the slowest and least possible runoff. You must follow one new rule:

- You may only fill your carton a total of 3 cm full with materials. List the materials you use in the Runoff Data Table under "Final Combination." Record your results.

10. When your group has finished, compare your results with those of another group. Which combination produced the best results for slowing and reducing runoff?

____

____

11. Now look back at the predictions that you made for each material. How correct were your predictions? In what way did your predictions differ from actual results?

____

____

____

12. How would you explain these differences?

13. Below, give examples of land surfaces in your schoolyard that correspond to materials you tested.

14. Individually, use graph paper to create a graph that shows how different materials affect the speed and amount of runoff. Be sure to label all parts of your graph.

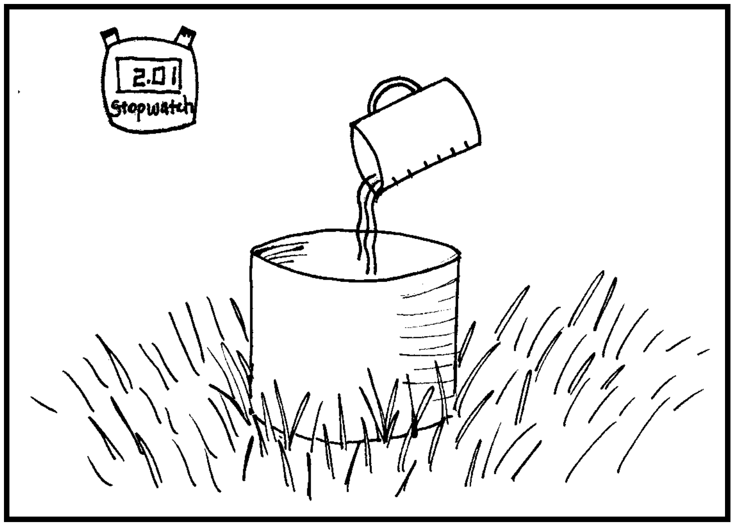
When Rain Hits the Land

Experimenting with Runoff

Student Pages

Part II

INTRODUCTION



Sharón Friedner

When rain hits the land, water either soaks into the ground to become groundwater, or runs off the land to become runoff. In this activity, your group will do a percolation test on various land surfaces around your school. A percolation test measures how long it takes for water to soak into the ground. This test will help you determine whether water that falls on your schoolyard becomes groundwater, runoff, or both.

MATERIALS

- Metal can (or other cylinder) with two open ends
- Pitcher or empty jug for pouring water
- Beaker or measuring cup
- Stop watch
- Data chart (included)

PROCEDURE

1. Read through this procedure and answer questions 1, 2 and 3 before beginning your experiment.

2. Find various land surfaces around your schoolyard: grass, gravel, packed dirt, loose dirt, pavement etc. Record these in your data chart .

3. Place the cylinder on a land surface. If possible, twist the percolation cylinder into the ground slightly so that water will not flow out the edges.

4. Measure an amount of water and pour it into the cylinder. Record amount of water in your data chart.

5. With a stopwatch, time how long it takes for all the water to soak into the ground. Record this in your data chart.

6. Repeat steps 3-5 for each land surface.

1. In this experiment you will be pouring water into a can that is placed on a land surface and recording the amount of time that it takes for the water to soak into the ground. List the things that you think should be kept constant in this experiment.

___

___

___

___

2. Before you go outside, decide who will be responsible for each task. You will need a timer, a recorder, someone to twist the percolation can into the ground, someone to pour the water, and at least one person to observe the water as it seeps into the ground or runs along the surface. After the first test, switch jobs so everyone gets a chance to do everything.

Timer: ___

Recorder: ___

Can twister: ___

Water pourer: ___

Observer: ___

3. Decide the following things before you go outside:

How much water will you pour at each location? ___

At what point will you begin timing? ___

___

4. Summarize and explain the results of your "perc" test. Which surfaces soaked up water quickly? Which did not absorb water? Based on what you learned about land surfaces during this activity, describe the runoff that you think would occur around your school after a big rainstorm.

Percolation Data Chart

Land Surface/ Location	Amount of Water Poured	Time for water to soak in	Observations

When Rain Hits the Land

Experimenting with Runoff

Student Pages

Part III:

INTRODUCTION

In this section, you will illustrate the land uses around you by making a map that shows where different types of land surfaces are located around your school.

MATERIALS

- Sheet of large paper or posterboard
- Markers, pens, colored pencils
- Other art supplies, as needed

PROCEDURE

1. Decide within your group how you will show different land surfaces on your map. In the space below, draw a key for your map that indicates the different land surfaces that you will be marking. The key will make your map easy to understand!

2. Use a large sheet of paper to draw your schoolyard.

3. Add your key to the schoolyard map when you are finished.

4. List the different land surfaces that you found in your schoolyard in the table below. Beside each one, decide whether water would more likely "run off" or "soak in" when it hits the surface.

Land Use	Runoff or Soak In?

5. In general, how do you think your schoolyard rates as far as land uses? For example are there more parking lots than fields? What things might you change to reduce runoff? Write these on the back of this piece of paper.

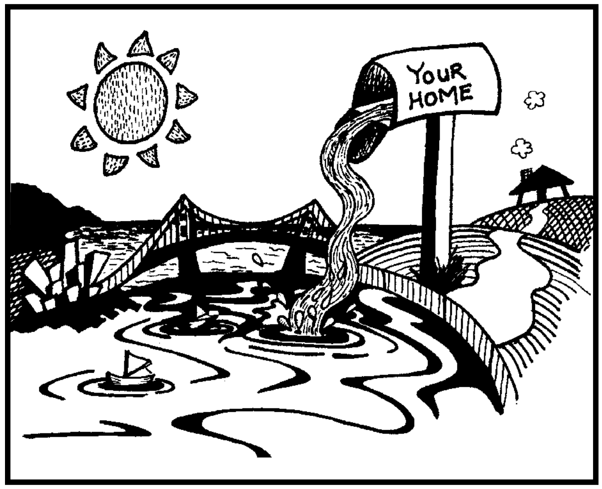
The Bay Starts Here!

Understanding Your Watershed

TEACHER'S PAGES

Overview

The first step in caring for San Francisco Bay's waterways is understanding how you are connected to them. In this activity, students will study maps and read an article to gain information about the watershed of San Francisco Bay. In addition, they will investigate the connection between their local creeks and San Francisco Bay by creating a comic strip about the journey of a raindrop as it travels from their school to the Bay.



Tara Reinertson

Central Question

How is your neighborhood connected to San Francisco Bay?

Estimated Time

1 1/2 hours

Objectives

Students will be able to:

- *define* and *describe* a watershed
- *examine* maps to trace the path that water travels from their local waterway to San Francisco Bay
- *determine* what kinds of pollution water may pick up as it travels over different land surfaces

Materials

For each group of 3-4 students

- Student pages: *The Bay Starts Here!*
- San Francisco Bay Regional Map (From AAA or store)
- San Francisco Estuary Project Fact Sheet

Vocabulary

non-point source pollution, watershed, bioaccumulation, erosion

Background

The San Francisco Bay and Delta combine to form the West Coast's largest estuary, totaling 1,600 square miles, and draining more than 40% of the state's water. The San Francisco Bay - Delta Estuary collects the waters of two great California rivers - the Sacramento and San Joaquin. The fresh water from this watershed provides 20 million Californians with drinking water and irrigates 4.5 million acres of farmland. The health and productivity of the San Francisco Estuary are, in many ways, dependent on the condition of the watershed and land that drains into it.

Even though the relationship between land and water may seem obvious, most people never recognize that what they do on land can have a direct affect on the quality of the water. One way to make this relationship more tangible to students is to have them examine local maps from the perspective of a rain drop and trace the path of water as it flows through its watershed.

Additional Resource: Watershed Finder http://www.museumca.org/creeks/resc.html

As your students gain understanding of their watershed, they will become increasingly aware that their local waterways are a part of a larger and interconnected system.

California State Science Standards
Grade 6

Standard Set 2.a: water running downhill is the dominant process in shaping the landscape, including California's landscape.

Standard Set 2.b: rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.

Grades 9-12

Biology/Life Sciences Standard Set 6.b: analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

Earth Sciences Standard Set 9.c: the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

History/Social Science Standards
Grades 6-8 Analysis Skills

Chronological and Spatial Thinking

3. Students use a variety of maps and documents to identify physical and cultural features of neighborhoods, cities, states, and countries and to explain the historical migration of people, expansion and disintegration of empires, and the growth of economic systems.

Grades 9-12 Analysis Skills

Chronological and Spatial Thinking

3. See above.

Historical Interpretation

5. Students analyze human modifications of landscapes and examine the resulting environmental policy issues.

English/Language Arts Standards
Grades 6-12

. . . [I]n giving writing assignments . . . teachers should take advantage of every opportunity to link reading and writing to other core curricula, including . . . science.

Teacher Procedure

1. To begin this activity introduce the concept of a watershed or drainage basin. Your students should understand that due to gravity, water moves over land and underground into waterways which then feed into bays and oceans. The San Francisco Bay watershed is made up of many smaller stream and river watersheds, which include the water that runs through your neighborhood and school yard.

2. Allow students time to read the introduction on the student pages. For the introduction activity your students should be divided up into working groups of 3-4 students. Each group will get the student pages of this activity and a AAA road map of the Bay Area. (You can get the road maps for free if you or a friend is a member of AAA.)

3. Instruct the working groups that they have about 10 to 15 minutes to examine the maps and answer the questions in Part I of their student pages.

4. After the students have finished answering the questions about the map in Part I, pass out copies of the article on the San Francisco Bay - Delta and give them time to read and answer the questions in Part II pertaining to information in the article.

5. As homework or as a final conclusion to this activity, instruct the students to create a comic strip (Part III) that illustrates the story of a raindrop as it travels through your local watershed. Tell the students that the first caption should begin with a drawing of a raindrop falling on the roof of your school and end with it flowing into thebay.

Class Discussion and Wrap up Questions

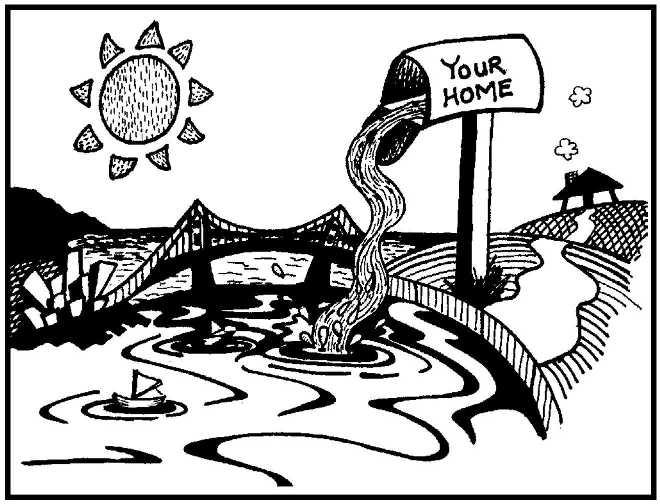
- Share raindrop stories.
- Share what kinds of substances a raindrop might have come into contact with.
- Are these substances human made or natural?
- Are they harmful or beneficial to the water and the estuary or stream?
- Are any of these human made items things that we personally use (lawn fertilizers, oil in our car, garbage, etc.)?
- Ask the class " Why should we care about whether the water is polluted anyway?"
- Do we get anything from the Bay? What does it provide for us?

The Bay Starts Here!

Understanding Your Watershed

Student Pages

INTRODUCTION



Tara Reinertson

You live within walking distance of the largest estuary on the west coast! All around this neighborhood water flows from small creeks and streams, over asphalt and down rain gutters to the San Francisco Bay. Think about the area around your home or school - chances are there is a little stream or creek flowing nearby. Most people never stop and wonder where this flowing water has come from or where it might be going. In this activity, you will explore the concept of a *Watershed-* the network of land and water that carries water into a stream, river, or Bay. You will investigate the watershed of San Francisco Bay by examining maps and gathering information from reading. Lastly you will create your own comic strip about the journey of a raindrop from the time it lands on your school roof to the time it flows into the Bay.

MATERIALS

Your group will need

- San Francisco Bay Regional Map
- San Francisco Bay-Delta Estuary Fact Sheet.

PROCEDURE

Part I:
Interpreting a Map - Where are you anyway?

With your group, study the road map of the Bay area. Try and find the following things:

1. Where is your school located? ______________________________

2. Find the name of the nearest creek. __________________________

3. Locate where that creek originates. __________________________

4. Into what part of the Bay does the creek empty? ______________________________

Locate the scale of the map.

1. How many miles are in one inch of this scale?______________________________

2. Approximately how many miles as the crow flies are you away from the San Francisco Bay?

____

3. Locate where the salt water enters into the Bay. ______________________________

4. Locate and name three large rivers that flow into the Bay.

a. ________________________ b. ________________________ c. ________________________

Part II:
Gathering Information about the San Francisco Bay - Delta Estuary

In the fact sheet titled, " San Francisco Estuary Project, San Francisco Bay - Delta Estuary" find the following information.

1. What year was San Francisco Bay discovered by the Spanish? ______________________

2. What did new California settlers do to cause 1 billion cubic yards of sediment to go downstream into the Estuary? ____

3. What is the average depth of the Central Bay?______________________

4. What is the average depth of the South Bay and North Bay?____________________

5. What and where is the deepest part of the Bay? __________________________

6. What is the largest contributor to estuary pollution? ________________________

7. What percent of tidal marsh remain of the original 543,375 acres in the 1850's Hint: do the math. ________________________

8. List four animals that are on the government's rare, endangered, or threatened list that live in the Estuary.

a.___________________________ c.___________________________

b.___________________________ d.___________________________

The Bay Starts Here!

Part III:

1. Create a comic strip of a raindrop using the space below. Imagine that you are a drop of rain falling on the roof of your school. Where would the water go? In each box draw what happens along the journey to the estuary. What might it encounter on its voyage from your school to the estuary? What might it say along the way? Is there anything that may be dangerous to this drop of water? Be creative and have fun!

2. There are many different surfaces that rain water has to travel over or through before it reaches the estuary. Water might travel through dirt, over a side walk and down a rain gutter before it eventually gets to the Bay. On this journey this water might pick up things from the land that may affect the water. List as many things as you can think of that could run off the land and into the water. Use this list to help you develop your comic strip.

__________________________ __________________________

__________________________ __________________________

__________________________ __________________________

Comic Strip Title:

SAN FRANCISCO ESTUARY PROJECT

San Francisco Bay-Delta Estuary

San Francisco Bay and the Delta encompass one of the nation's most biologically productive estuaries. Development, farming, commerce and recreation on its shores and waters, however, stress the Estuary's wildlife and ecosystem. To maintain and restore these natural resources, the San Francisco Estuary Project is charged with promoting environmentally sound management of the Bay and Delta.

The Estuary

The San Francisco Bay-Delta Estuary conveys the waters of two great California Rivers—the Sacramento and San Joaquin—into the Pacific Ocean. The Estuary sustains rich communities of crabs, clams, fish, birds and other aquatic life, serving as both an important wintering site for migrating waterfowl and as a spawning area for anadromous fish. Its waterways, wetlands and bays also form the centerpiece of America's fourth largest metropolitan region, enabling residents to pursue fishing, sailing, shipping, farming, oil refining and a host of other important economic and recreational activities.

The Estuary

History & Development

About 20,000 years ago, when the Pacific shore lay out beyond the Farallon Islands, the Bay consisted of a dry landscape traversed by gentle rivers. About 10,000 years later, melting glaciers raised the sea level — sending ocean waters inland through the Golden Gate, drowning the river valleys and creating the West Coast's largest estuary.

Indians thrived on the Estuary's shores for thousands of years until the Spanish discovered the Bay in 1769. Since then, a variety of human activities have changed the Estuary's size and ecology. First, upstream gold mining between 1849 and 1914 sent about 1 billion cubic yards of sediment downstream into the Estuary. Second, reclamation of land at the edge of the Bay and Delta filled in or altered 85-95% of the Estuary's wetlands. Third, 20th century water projects diverted millions of acre feet of freshwater away from the Estuary to farms, towns and industry.

Other activities which have modified the Estuary's ecology include: the overharvesting of fish in the early 1900s, the introduction (accidental) of many non-native species, the discharge of sewage and agricultural drainage into the water, and a century of ongoing dredging and levee construction to control flooding and maintain waterway navigability and Delta agriculture. Today, 7.6 million people live and work in the 12-county Bay-Delta region — placing ever increasing pressures on the Estuary's natural resources.

Vital Statistics

- ***The Estuary encompasses an area of roughly 1600 square miles, including 700 miles of rivers and sloughs and 1100 miles of levees. At mean sea level, the Bayshore extends for 275 miles.***

- ***Central Bay depths average 43 feet, southern and northern areas 15-17 feet. The Estuary's deepest point — 360 feet below sea level — lies under the Golden Gate Bridge.***

- ***The Estuary receives 90% of its freshwater from the Sacramento and San Joaquin Rivers and 10% from local drainage basins. Of the river flow, 80% comes from the Sacramento.***

- ***The Estuary drains about 40% of California's landscape (over 60,000 square miles) and 47% of the state's total runoff.***

- ***The Bay's total water volume at mean tide is over 5 million acre feet (see glossary). Each tidal cycle brings an enormous quantity of salt water in and out of the estuary — about 1 1/4 million acre feet per cycle (the tidal prism). Daily freshwater inflows average 50 thousand acre feet.***

- ***The salinity of freshwater flowing into the Delta ranges from 0.1-0.8 parts per thousand of salt to water; at the Golden Gate, the salinity can be up to 30 times greater.***

Management Concerns

Glossary

***acre foot:* An acre of water 1 foot deep (approximately 326,000 gallons). The typical California family of five uses an acre-foot of water in and around the home each year.**

***anadromous fish:* Fish that live some or all of their adult lives in saltwater but migrate to freshwater to spawn.**

***brackish:* Somewhat salty water that is less salty than seawater.**

***dredging:* The removal of sediments from the Estuary floor.**

***estuary:* A body of water at the lower end of a river which is connected to the ocean and semi-enclosed by land. In an estuary, seawater is measurably diluted by freshwater from the land.**

***invertebrates:* Small animals such as clams and worms that lack a spinal column.**

***levee:* Raised bank of earth built to control or confine water (also known as dike).**

***mean:* Mid-point between high and low points.**

***phytoplankton:* Tiny floating plants that are eaten by minute animals, fish larvae and other larger organisms.**

***slough:* A river inlet or a creek through a marsh or mudflat.**

***trace element:* A naturally occurring compound such as selenium and silver that can be found in water and soil.**

***wetland:* Transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Two major types of concern are seasonal wetlands inundated by winter and spring rainfall and flooding, and tidal wetlands flooded daily by ocean tides.**

Pollution

The Estuary receives pollutants from a wide range of sources, including municipal sewage treatment plants, industry, urban and agricultural runoff, spills, marine vessel discharges and atmospheric fallout. Though significant progress has been made in reducing pollutant flows and eliminating raw sewage since the 1950s, trace metals, synthetic compounds, oil, grease, pesticides and other pollutants continue to accumulate in the Estuary. As of 1991, 5,000 to 40,000 tons of pollutants were entering the Estuary each year, and the amount has likely increased since then with recent population growth and urban development. Urban runoff from streets, storm drains and developed shorelines is one of the largest contributors to the Estuary's pollution. The greatest uncontrolled sources are untreated urban and agricultural runoff, although stormwater control and watershed management increased dramatically with new regulations under Clean Water Act Amendments.

Wetlands

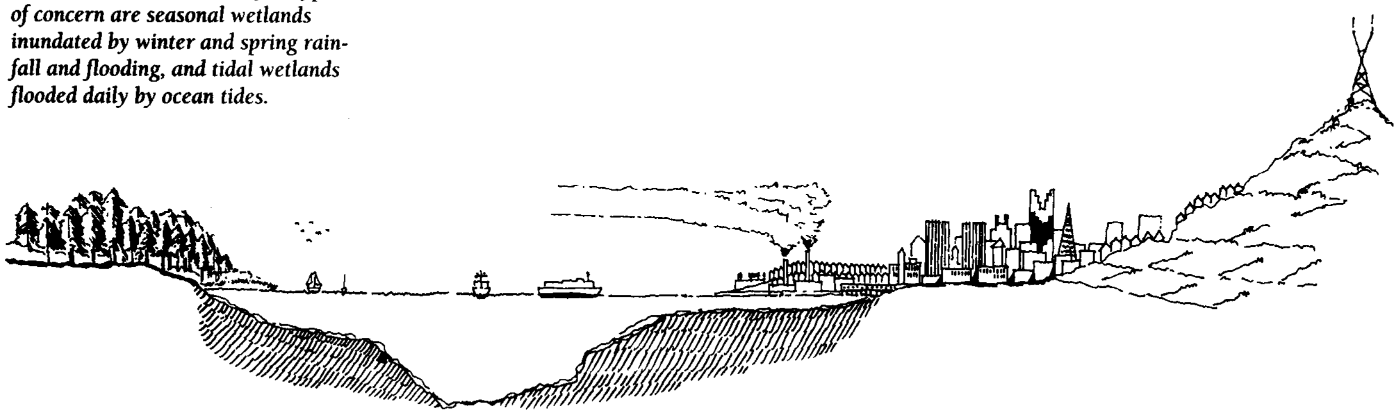
Wetlands provide vital nursery grounds for fish and crabs, and feeding and sheltering grounds for waterfowl and other wildlife. They also act as powerful natural filters and traps for sediments, making them vital not only to the estuarine ecosystem but also to water quality. Many of the Estuary's historic wetlands have been filled in or altered over the years as a result of urban development, agriculture, flood control and other activities. Experts estimate that in 1850, the Estuary (San Pablo, San Francisco and Suisun bays, and the Delta) included over 543,375 acres of tidal marsh. By 1985, these tidal wetlands had been reduced to 66,125 acres. Currently, the Estuary contains approximately 628,549 acres of tidal, seasonal and freshwater marshes, as well as farmed wetlands, mudflats, salt ponds and riparian woodlands, with Suisun Marsh the largest remaining wetland area in California.

Freshwater Flows

The dams, canals and reservoirs of California's water diversion projects represent the world's largest manmade water system and provide vital water to industries, farms, homes and businesses throughout the state. This diversion of fresh water flowing from rivers, streams and other sources into the Estuary has, however, fueled statewide controversy over possible adverse effects on water quality, fisheries and the ecosystem. The total volume and timing of fresh water reaching the Estuary can vary widely, mainly due to changing rainfall levels. During the past 60 years, annual freshwater flows have ranged from more than 60 million acre feet to less than 6 million acre feet, and averaged about 23 million acre feet. More than 14 million acre feet are currently diverted from the Estuary's supply. While most of this water is now used for agriculture, demand from California's growing cities and suburbs is on the rise.

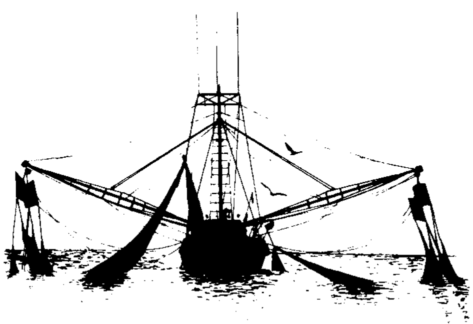
Dredging

To accommodate today's big tankers and container ships, the Estuary's harbors and channels have to be deepened by dredging. About 7 million cubic yards of sediment are dredged from the Estuary every year. Dredged sediments are then dumped at various aquatic or upland disposal sites around the Estuary. Some dredging activities can pose significant hazards to the estuarine ecosystem by stirring up toxics long buried in the mud, smothering bottom-dwelling organisms and clouding the water (turbidity).



Land Use

Primary land uses on Estuary shores include residential, commercial, agricultural and open space. In the northern and southern extremes of the Estuary, open space and agriculture predominate while residential and commercial land use concentrate in the Central Bay Area. About 1.6 million more people are expected to move into the Bay-Delta region by the year 2010—increasing water usage, placing added pressures on wetlands and fueling expansion throughout the region. With continued population growth over the past few decades, housing, industry, and other urban land uses are slowly replacing wetlands, farms and open space regionwide. Industries occupy over 8,000 acres of land on the bayshore and many send run-off and wastewater effluent into the Estuary. Meanwhile, chemically-intensive farming of almonds, sugarbeets, rice, cotton and other crops upstream promotes erosion and contributes pesticides and fertilizers to the Estuary via irrigation drainage. The Bay Area is also a leader in environmental preservation, however, with thousands of acres reserved for fish and wildlife habitat.



Who Uses the Estuary?

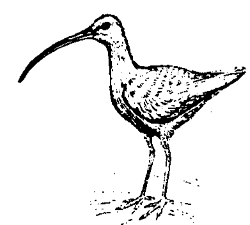
- ***Visitors to 290 shoreline recreational areas***
- ***489,000 recreational boaters***
- ***4000 commercial vessels per year***
- ***Six major ports***
- ***Over 300 marinas***
- ***21 Naval facilities***
- ***Thousands of fishermen***
- ***Over 200 industries and municipal sewage treatment plants***
- ***The farmers of over 4.5 million acres of irrigated land***
- ***Over 200 duck hunting clubs***
- ***Hundreds of swimmers and windsurfers***
- ***20 million Californians (who receive drinking water diverted from the Estuary).***

In Indian times, herds of elk and antelope roamed the hillsides around the Estuary, and hordes of salmon and thousands of seals and sea otters frequented its waters. According to eyewitness historical reports, the flocks of birds were sometimes so thick they blacked out the sky. Today the Estuary supports a more limited but substantial community of aquatic flora and fauna. Many of these plants and animals can be adversely affected by pollution, loss of habitat and other human impacts on the Estuary's ecosystem.

Plankton and Invertebrates *The Estuary's food chain begins with minute drifting plants and animals known as plankton—which provide food for invertebrates such as shrimp, clams and worms. These small organisms sustain herring, bottom-feeding sturgeon and other larger aquatic creatures and form the basis of the entire estuarine food web.*

Fish *Estuarine waters provide habitat for over 120 fish species which can be divided into four basic groups: marine species from the ocean such as herring, anchovy and English sole; estuarine species requiring brackish waters, such as the longfin smelt and yellowfin goby; freshwater species such as sunfish and catfish; and anadromous (see glossary) species such as salmon, American shad and striped bass. Species popular with local sport fishermen include starry flounder, striped bass, sturgeon and salmon.*

Birds *The Estuary's wetlands feed and shelter millions of waterfowl, shorebirds and seabirds every year. As many as half the birds migrating the Pacific Flyway between the Arctic and Baja winter around the Estuary. On average, the region hosts 600,000–800,000 waterbirds at a time. Wintertime populations for the Delta include over a million pintail, mallard and other ducks, a quarter of a million geese, and thousands of tundra swans, greater sandhill cranes and other migrating birds, not to mention hundreds of stilts, avocets, hawks and other avian fauna. These significant bird populations led to the Estuary's designation as a "Western Hemispheric Shorebird Reserve of Critical Importance" and make it a favorite with birdwatchers and duck hunters.*



Marine Mammals *Though marine mammal populations were greatly reduced by overhunting and development, a few hundred harbor seals still frequent the shores of Mowry Slough below the Dumbarton Bridge and other spots within the Estuary. River otters can also be seen in Delta waterways and sea lions at San Francisco's Pier 39.*

Endangered Species *The Estuary area hosts 18 species of fish and wildlife on the government's rare, endangered, or threatened list, including the brown pelican, the salt marsh harvest mouse, the California freshwater shrimp, and the Delta smelt. About 3/4 of these species are associated with wetlands, among them the California clapper rail, whose local population dropped from 4,200–6,000 birds in 1979 to 1,200 in recent years. Wetlands also host many rare and endangered plants, such as soft-haired birds beak and Delta button celery.*

Current Issues

Resources

San Francisco Estuary Project 1990–1998

- ***Comprehensive Conservation and Management Plan***
- ***Status and Trends Reports:*** *Dredging, Pollutants, Wetlands, Aquatic Resources, Wildlife, and Land Use.*
- ***Information Sheets:*** *Dredging, Pollutants, The Delta, Fish and Wildlife, Water Use, Wetlands, Land Use, Agricultural Drainage, Monitoring.*
- ***An Introduction to the Ecology of the San Francisco Estuary***
- ***State of the Estuary, 1992–1997: Vital Statistics, New Science, Environmental Management***

Lay Person's Guide to the Bay and Delta, *Water Education Foundation, 1997*

Health Tips

- *According to state health standards, Estuary waters are generally safe for swimming except after a storm.*
- *Fresh water from rivers and streams is not drinkable without treatment.*
- *California Department of Fish & Game (CDFG) regulations warn of potential health hazards from eating the Estuary's striped bass, shellfish and several species of diving ducks due to elevated levels of mercury, selenium and/or other trace contaminants. Copies of the regulations are available from CDFG.*

Contacts

California Department of Fish & Game, *1416 9th St., 12th floor, Sacramento, CA 95814 (916)653-7664*

California State Department of Water Resources, *1416 9th St., Sacramento, CA 95814-5515 (916)653-5791*

Central Valley Regional Water Quality Control Board, *3443 Routier Road, Suite A, Sacramento, CA 95827-3098 (916)255-3000*

Communities for a Better Environment, *500 Howard St., Suite 506, San Francisco, CA 94105 (415)243-8373*

S.F. Bay Conservation and Development Commission, *30 Van Ness Avenue #2011, San Francisco, CA 94102 (415)557-3686*

San Francisco Estuary Institute *180 Richmond Field Station, 1301 South 46th St., Richmond, CA 94804 (510)231-9539*

S.F. Bay Joint Venture, *Coastal Conservancy, 1330 Broadway, Suite 1100, Oakland, CA 94612 (510)286-6767*

S.F. Bay Regional Water Quality Control Board, *1515 Clay St., Suite 1400. Oakland, CA 94612-1413 (510)622-2300*

San Francisco Estuary Project, *c/o RWQCB, 1515 Clay St., Suite 1400, Oakland, CA 94612-1413 (510)622-2465*

Save S.F. Bay Association, *1736 Franklin St., 4th floor, Oakland, CA 94612 (510)452-9261*

U.S. Environmental Protection Agency, Region 9, *75 Hawthorne St., San Francisco, CA 94105 (415)744-2125*

Water Education Foundation, *717 K St., Suite 517, Sacramento, CA 95814 (916)444-6240*

Wetland Loss

Human activities in the Estuary nave caused the loss or conversion of more than 500,000 acres of tidal wetlands and thousands of acres of shoreline and stream habitat. Many remaining wetlands are still threatened by filling or diking. Other wetlands may suffer from illegal filling in the future.

Fish Population Decline

Over the years, pollution, dam construction, overfishing and other stresses have diminished the Estuary's recreational and commercial fisheries. Only a few species—herring, anchovies, crayfish, staghorn sculpins, gobys and bay shrimp—remain stable enough for commercial catch inland and most are sold as bait. Of the Estuary's current fish species, striped bass, Delta smelt and winter-run salmon have been hard hit. The adult striped bass population numbered about 0.6 million (less than 1/3 its historic level). Winter-run salmon have been listed as a threatened (state) and endangered (federal) species, while the abundance of other salmon runs is kept stable through large-scale hatcheries. Meanwhile, the Delta Smelt was listed as a federal and state threatened species in 1993. This native smelt has proved much more susceptible to habitat alterations in the Delta than some non-native "exotic" species such as the chamaeleon goby.

PCB and DDT Contamination

Organochlorines, such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT), are among the most toxic pollutants. Although banned for more than 20 years and declining over the long run, these chemicals persist in the Estuary and are still found in fish, seals, and waterfowl. In 1993—1996, PCB concentrations in water were considerably higher than EPA criteria at all 24 water quality monitoring stations in the Bay. DDT concentrations in sediment samples were also high at many stations during this period.

Diversion Debate

California continues to debate how to protect the various beneficial uses of the Estuary's water and what the quality of Estuary waters should be. Agriculture now receives 80% of California's water, and cities and industries 20%. Some scientists consider current flow levels too low to sustain the Estuary's fish, wildlife and water quality; others contest that current flow levels are no lower than historic natural ones. The U.S. Environmental Protection Agency has set a standard allowing up to two parts per thousand of salt water in the Delta; if salt water levels exceed that standard, more fresh water must be released.

Dredging Planning

Concern over the impacts of dredging activities on water quality and wildlife have led to disagreements about whether to limit dredging and where to locate disposal sites. Some fishermen believe that ongoing disposal off Alcatraz is a major cause of a declining Central Bay fish catch. Meanwhile, the navigability of the Estuary is at stake, with ports and marinas in need of dredging and disposal sites such as Alcatraz reaching capacity. To address the issue, the Army Corps of Engineers and other agencies initiated a cooperative effort to establish a Long Term Management Strategy (LTMS) for Estuary dredging activities. The LTMS seeks to develop an environmentally suitable and economically sensible approach to dredging over the next 50 years.

Exotic Species Invasion

Native species of estuarine organisms are fast giving way to exotics, many of whom currently arrive via ship hulls and ballast water. One such intruder, a small clam from Asia called *Potamocurbula amuerensis*, has multiplied from a few specimens found in 1986 to densities of over 30,000 per square meter in one year. By itself, this clam species may have ingested enough plankton to prevent some Suisun Bay plankton blooms. Exotic species growth among fish and other organisms promises to continue altering the Estuary's food web and ecosystem.

Sea Level Rise

Recent studies indicate that global warming could lead to an accelerated sea level rise of 2–3 feet in the next 100 years. Concerned over impacts on the Estuary's shoreline, the Bay Conservation and Development Commission conducted further research and found that during the last two decades the relative annual sea level rise has been nearly double the historic rate of .0039 feet per year observed since 1854. Homes and shoreline property throughout the region may be threatened by this sea level rise, not to mention the Estuary's low-lying farm and marshlands.

Estuary Project

The San Francisco Estuary Project's primary goal is to restore and maintain water quality and natural resources while promoting effective management of Bay and Delta Waters. This publication includes an introduction to the five major issues the Estuary Project addressed in the **Comprehensive Conservation and Management Plan** *completed in March 1993: decline of the Estuary's biological resources, increased pollutants, freshwater diversion and altered flow regime, increased waterway modification, and intensified land use. If you'd like to volunteer for the Estuary Project, or have a project representative come speak to your group, please call (510)622-2465.*

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Mapping Your Watershed

Interpreting maps of the San Francisco Bay

Overview

In this activity, students will become familiar with the geography of California as it relates to San Francisco 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.

Estimated Time

1 hour

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 San Francisco Bay

Materials

- Copies of map questions and worksheet
- A 12-15 inch length of string
- Masking tape
- Some or all of the following maps:

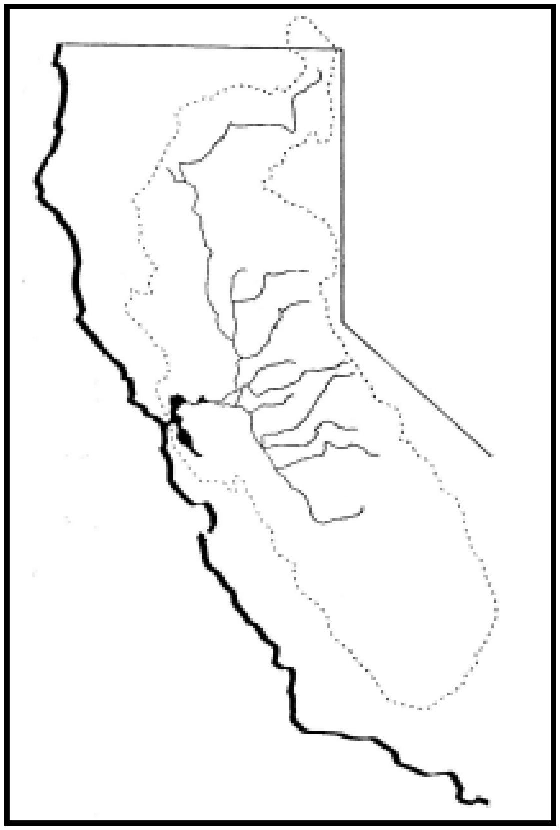
Bay Area Road Map
AAA or Grocery Store

Satellite and/or Physical maps
Bay Model (415) 332-3871
http://www.spn.usace.army.mil/bmvc/

Past and Present Habitat Maps
San Francisco Estuary Institute (510) 231-9539 or
http://www.sfei.org/ecoatlas/Habitat

California Water Map
Water Education Foundation (916) 444-6240 or
http://www.water-ed.org/store/default.asp?parentid=2

Nautical Charts
San Francisco Bay Southern Part: #18651,



San Pablo Bay: #18654,
Entrance to San Francisco Bay: # 18649,
Suisun Bay: #18656,
West Marine
http://www.westmarine.com

Topographical Map of your area
US Geological Survey,
http://topomaps.usgs.gov/ordering_maps.html

A map of your local area, such as:
East Bay Creeks Map
Oakland Museum (510) 238-3884 or
http://www.museumca.org/shop/store.html

Santa Clara Valley Watershed Poster
Save The Bay (510) 452-9261 or savebay@savesfbay.org

Wild in the City! Past and Present Map of San Francisco, *Marin Headlands Visitor Center (415) 331-1540*

California's Science Content Standards

Grade 6

Standard Set 2.a: water running downhill is the dominant process in shaping the landscape, including California's landscape.
Standard Set 7.f: read topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple scale map.

Grades 9-12

Earth Sciences Standard Set 9.c: the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.
Investigation and Experimentation Standard h: read and interpret topographic and geologic maps.

Teacher Procedure

1. Place maps on desks or tables around the classroom. Tape the appropriate list of questions next to each map. Number each map station to facilitate movement between maps.

2. Divide the class into equal groups according to the number of map stations you have.

3. Instruct each group to stand by a station.

4. Explain that each group will have a few minutes at each station. Tell them to follow the instructions they find at the station, and to <u>write down</u> the answers to the questions. Students should stay at their station until you give everyone the signal to rotate. Tell the students the order in which they will be moving from map to map.

5. Begin the activity, and continue until every group has visited every map.

Follow up

Have each group present one of the maps and discuss their findings. How do their answers compare to those of the rest of the class?

Extension

For older or more advanced students, you may want to use this alternative set-up: instead of placing questions next to each map, give each student or group of students a list of questions to answer, taken randomly from the map questions. Part of the challenge is that students must *find* the map that best answers each question.

Map Questions

Creek & Watershed Map of Oakland and Berkeley

1. Locate your school on this map. Which creek is closest to your school?
2. With your finger, trace the path of that creek as it flows to the Bay. Does it go underground at any point?
3. Use the string and the key on the left side of the map to determine the approximate length of the creek. How long (in miles) is the creek? How many miles are underground? What percentage of the creek is underground?
4. Name three landmarks, buildings, parks, or roads that are built on top of fill land.
5. Name two artificial bodies of water.
6. What kind of water would you expect to find in Lake Merritt (fresh, salty, or brackish)?

Creek and Watershed Map of Hayward and San Leandro

1. Locate your school on this map. Which creek is closest to your school?
2. With your finger, trace the path of that creek as it flows to the Bay. Does it go underground at any point?
3. Use the string and the key on the left side of the map to determine the approximate length of the creek. How long (in miles) is the creek? How many miles are underground? What percentage of the creek is underground?
4. Name three landmarks, buildings, parks, or roads that are built on top of fill land.
5. Name two artificial bodies of water.
6. How is Lake Chabot connected to San Francisco Bay? What kind of water would you expect to find in Lake Chabot (fresh, salty, or brackish)?

Creek and Watershed Map of Fremont & Vicinity

1. Locate your school on this map. Which creek is closest to your school?
2. With your finger, trace the path of that creek as it flows to the Bay. Does it go underground at any point?
3. Locate the areas on the map that are labeled "tidal or fresh water marsh and ponds, circa 1850." What are those areas used for today?
4. Name three creeks that flow into a flood control channel.
5. Locate the artificial bodies of water near points of interest 8, 9 and 11. What were those bodies of water originally used for? What will they be used for now and in the future?

Topographical Map

1. Find a creek on this map. Use the string and the scale on the map to determine the exact length of the creek.

2. What do the contour lines on the map represent? Can you find a flat area and a steep area? Can you find the top of a hill and a valley?

3. What is the watershed for the creek you chose? A 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) which separate it from another creek's watershed.

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

Entrance to San Francisco Bay Nautical Chart

1. Maps can be made to highlight different things. For example, some maps highlight landforms while others highlight roads and highways. What do you think this map highlights?

2. What do the small black numbers on this map represent?

3. Locate the Golden Gate Bridge, Angel Island, and Alcatraz.

4. Notice where it says "Westbound San Francisco Bay Traffic Lane" and "Eastbound San Francisco Bay Traffic Lane." What type of traffic do you think this is referring to?

5. What do you think is the average depth of the Bay? What is the deepest point?

6. What happens at 122° 35' longitude, 37° 45' latitude?

San Francisco Bay Southern Part, Suisun Bay, and San Pablo Bay Nautical Charts

1. Maps can be made to highlight different things. For example, some maps highlight landforms while others highlight roads and highways. What do you think this map highlights?

2. What do the small black numbers on this map represent?

3. What is the average depth of this part of San Francisco Bay?

4. What do you think the white area in the water represents?

5. Locate three different sloughs. Using what you observe on the map, create a definition for the word "slough."

California Satellite Image or Physical Map

1. Locate San Francisco Bay.

2. The watershed of San Francisco Bay includes all the land that water flows over and through on its way to the Bay. It includes about 40% of the state of California. Discuss with your group what exact area you think is included in the watershed of San Francisco Bay. Why did you choose that area?

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

Past and Present Bay Area Eco Atlas

1. List three changes that have occurred in the San Francisco Bay area. Do you think these changes came about naturally, or did they involve humans?

2. Which habitats existed around the Bay in the past but no longer exist today?

3. Which habitats exist now that did not exist in the past?

4. What affect do you think the changes in habitats has had on wildlife in the Bay area?

The San Francisco Bay Area Satellite Image

1. Point to the place where fresh water is coming into the Bay from the Central Valley. Point to where salt water is coming into the Bay. What kind of water would you expect to find in the Bay?

2. What color surrounds most of San Francisco Bay? What does that color represent on this map?

3. What are some things that rainwater and creek water might pick up on their way to the Bay?

4. What do you think the bright green, yellow, and orange areas represent? (If you don't know, try to use another map to figure it out.)

5. When you are on the Golden Gate Bridge, you can see the ocean on one side of the bridge and the Bay on the other. Locate the Golden Gate Bridge on this map.

6. Find the approximate location of your school. What landmarks on this map helped you find it?

California Water Map

1. Name four rivers that are flowing from the Sierra Nevada Mountains towards the San Francisco Bay.
2. What are the names of two rivers that flow from the Central Valley into the Delta and then into San Francisco Bay? Hint: one flows from the north and one flows from the south.
3. Do you think Lake Tahoe is part of the San Francisco Bay watershed? Why or why not?
4. From what river does the Hetch Hetchy aqueduct divert water? To where does the Hetch Hetchy Aqueduct carry water?
5. How does water get from the Delta to Los Angeles?
6. From where does San Diego import most of its water? Do you think it is necessary for San Diego to import water? Why or why not?

San Francisco: Wild in the City!

1. Which areas of San Francisco were under water before 1750?
2. What areas of present day San Francisco used to be Ohlone villages or seasonal camps?
3. What was the landscape of Golden Gate Park before 1750?
4. Locate your home, school or any familiar place on the 1990's map. How do you think that area looked before 1750?
5. What has happened to most of San Francisco's creeks?

Santa Clara Valley Watershed Poster

1. How many creeks enter the Bay south of the Dumbarton Bridge?
2. Trace the flow of Guadalupe Creek and River. How many freeways does it pass under?
3. What might the water in South Bay creeks be carrying to the Bay?
4. Locate your home, school or any familiar place on the map. Which creek would the water from that place flow?

Bay Area Road Map

1. Locate your school on this map. Using roads and highways, find the shortest route to the Bay.

2. Using the map scale, determine how many miles you would need to travel along roads from your school to the Bay. How many miles would you need to travel "as the crow flies"?

3. Locate San Francisco International Airport and Oakland International Airport. How do you think people were able to build these airports so close to the Bay?

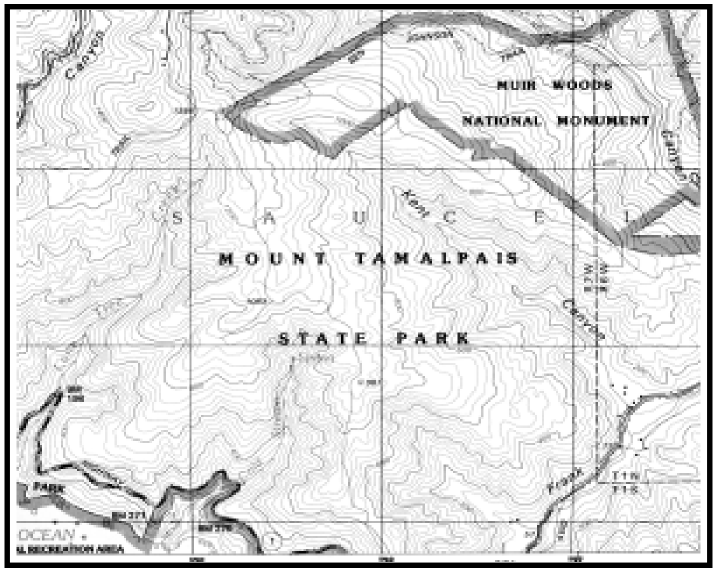
4. The green areas on this map represent parks, wildlife refuges, and preserves. Locate a park, refuge, or preserve that you have visited.

Another California, Bay, or Local Map?

Three Ways to be 3-D

Understanding Topographic Maps

Overview
These three activities are designed to help students visualize how contour lines on a topographical map relate to three-dimensional landforms. In the first activity, students will use a three dimensional model of a landform to create a two dimensional image. In the next two activities, students use an enlarged portion of a topographical map to create accurate three-dimensional models of landforms within the San Francisco Bay watershed. (Note: the second two activities are interchangeable.)



USGS Topographical Map

Estimated Time
Each Part of the activity takes 1 to 1 ½ hours. It is recommended to conduct Part I in one class session and then conduct either Part II or Part III in another class session.

Objectives
Students will be able to:

- Understand contour lines on a topographical map
- Learn to relate contour lines to field elevations
- Use a three-dimensional model to create a two-dimensional representation of a landform
- Use a topographic map to create a three dimensional model of a landform within the San Francisco Bay watershed

Materials
Part I:
For each group of three to five students:

- Photocopy of student pages
- Work surface (table or counter)
- Dough ingredients:
  1 ½ c. table salt
  3 c. all purpose flour
  1 ½ tsp. Vegetable oil
  1 c. water
  mixing bowl
  OR 1 large bag of modeling clay
- washbin or plastic dishpan, preferably with high sides
- masking tape
- food coloring
- water jug or pitcher
- paper
- waterproof marker
- ruler

Additional Resource: USGS: What do maps show?
http://interactive2.usgs.gov/learningweb/teachers/mapsshow_guide.htm

Materials (continued)

Part II

For each group of two to three students:

- Photocopy of student pages
- Topographic map with contour lines, enlarged if necessary so that landforms are 3-4 inches in diameter (there are examples attached).
- Permanent markers
- 8-12 stackable clear food/salad plastic containers approximately 7" by 7" with the lids removed (the lids can also be used if they are clear and stackable). These can be collected at salad bars and cleaned for reuse or purchased at stores such the Center for Creative Reuse or Smart and Final.
- White Paper

Part III

For each group of two students:

- Photocopy of student pages
- Enlarged pieces of a topographic map, 2 photocopies of each (examples attached)
- Thick cardboard or foam core
- Utility knife
- Glue
- Modeling clay
- Pen or pencil

California Science Content Standards

Grade 6

Standard Set 7.f: read a topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple scale map.

Grade 9 – 12

Investigation and Experimentation Standard h: read and interpret topographic and geologic maps.

Background

(Written by Ellen P. Metzger, from *The Best of BAESI*, a collection of 19 hand-on lessons modeled by teacher-participants in the BayArea Earth Science Institute.)

Topographic maps are used extensively by a variety of people including geologists, field biologists, and hikers. A topographic map is the representation, on a flat surface, of part of the Earth's surface drawn to scale.

The features shown on topographic maps may be divided into three groups: (1) relief, which includes hills, valleys, mountains, etc.; (2) water features, including lakes, ponds, and streams; and (3) cultural features, man-made features like bridges, canal, buildings, and roads.

Relief is the difference in elevation between any two points. Where relief is low, the area appears to be relatively flat as in river valleys or broad, flat uplands. When relief is high, the area is steep, as in rugged mountainous terrains. Relief determines the contour interval, which is the difference in elevation between adjacent contour lines. A contour line is an imaginary line on the Earth's surface connecting points of the same elevation. Contour intervals may be large for rugged terrains (80 or 100 feet) or they may be small in areas of low relief (10-20 feet). Contour intervals are consistent for a given map, though they may change from map to map. Usually every fifth contour line (an index contour) is printed heavier than the others and bears the elevation above sea level.

In addition to contour lines, heights of many points occur on the map, such as road intersections, summits of hills, lake shorelines, etc. These are spot elevations and are accurate to within the nearest foot or meter. More precisely located and more accurate in elevation are bench marks, points marked by brass plates fixed permanently on the ground. On a topographic map, bench marks are represented by crosses and the elevation, preceded by the letters "BM", is printed in black on the map.

Rules of Contour Lines.— Some basic rules or facts about contour lines are listed below.

1. Where a contour line crosses a stream or valley, the contour bends to form a "V" that

points upstream or valley. In the upstream direction the successive contours represent higher elevations.
2. Contours near the upper parts of hills form closures. The top of a hill is higher than the highest closed contour.
3. Hollows (depressions) without outlets are shown by closed, hatched contours. Hatched contours are contours with short lines on the inside pointing downslope. The bottom of the hollow is lower than the lowest closed contour.
4. Contours are widely spaced on gentle slopes.
5. Contours are closely spaced on steep slopes.
6. Evenly spaced contours indicate a uniform slope.
7. Contours do not cross or intersect each other, except in the rare case of an overhanging cliff.
8. All contours eventually close, either on a map or beyond its margins.
9. A single higher elevation contour never occurs between two lower ones, and vice versa.
10. A change in slope direction is always determined by the repetition of the same elevation either as two different contours of the same value or as the same contour crossed twice.

<u>Scale</u>: Scale expresses the relationship between distance on the map and the true distance on the Earth's surface. This is generally expressed as a ratio or a fraction, such as 1:24,000 or 1/24,000. The numerator, usually 1, represents map distance, and the denominator, a large number, represents ground distance. Thus, 1:24,000 means that a distance of 1 unit on the map represents 24,000 such units on the ground. The unit here is not important - it could be meters, feet, or inches. What is important is the relationship between the map distance and the true ground distance.

<u>Colors and Symbols</u>.— Each color on a topographic map has significance as follows:
Blue = water features;
Green = woodlands, orchards, etc.;
Red = urban areas, important roads, public-land boundary lines, civil boundaries;
Black = man-made works;
Brown = contour lines.
Purple = new additions in revised versions; usually man-made features

Teacher Procedure

1. Construct the activities you want to do with the students ahead of time so you will have an example to show the students. The activities will run much more smoothly if students can see an end product before they make their own maps and models.
2. Students should be introduced to the concepts of relief, scale, and contour intervals before beginning this activity, using the background information and demonstrating on a transparency of a topographical map.
3. Hand out the materials and photocopies of student pages to small groups of students, and assist them with the creation of their topographical models.

Modifications for Activity III:
To increase the challenge:
1) select a landform near the school with which the students are familiar;
2) select a canyon rather than a hill, or;
3) select a large, complex series of hills and canyons, split up the area between groups in the class to create a 3-D model of a large area. Once models are assembled, cover with paper mache or clay and paint, then add the man-made structures for a more realistic representation of the area modeled.

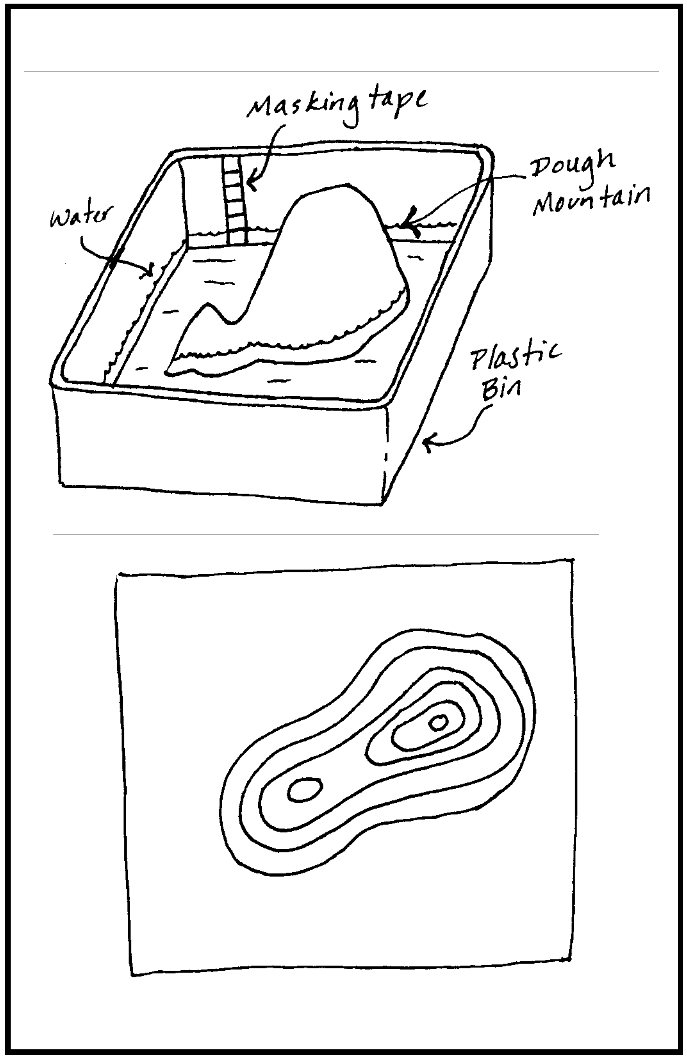
Three Ways to be 3-D

Understanding Topographic Maps

Student Pages

Part I
Making A Topographic Map

INTRODUCTION
Topographic maps show shapes and features of the Earth's surface using contour lines. A contour line shows places on the map which have the same elevation. You can make a topographic map of a model landscape by using colored water to show the shape of the land at different elevations.



Amy Hutzel

MATERIALS
Dough ingredients:
- 1 ½ c. table salt
- 3 c. all purpose flour
- 1 ½ tsp. Vegetable oil
- 1 c. water
  OR 1 large bag of modeling clay
- washbin or plastic dishpan
- masking tape
- food coloring
- water jug or pitcher
- paper
- waterproof marker

PROCEDURE
1. Prepare the model-making dough. Mix flour, salt, and oil together and slowly add enough water to produce a stiff dough. Knead dough to distribute water thoroughly. If mixture is not used immediately, store in an airtight container.
2. On a strip of masking tape, mark off 1cm. intervals. Place end of tape with zero mark at bottom inside edge of basin and stretch tape up to top of basin. (See illustration).
3. Press dough into the bottom of the basin, leaving an area around the "tape measure" clear of dough. Mold landforms such as mountains, valleys, islands, and stream corridors.
4. Sketch what you expect your contour map of the "landscape" to look like.
5. Fill jug or pitcher with water and add 3 to 4 drops of food coloring to make water more visible.

PROCEDURE (continued)

6. Gently pour water into the basin until it is even with the first centimenter mark on the tape.
7. Look straight down at the model and on a piece of paper draw the shape formed where the water line circles your dough landscape. This is your one inch contour line.
8. Add water again to your next tape mark, the 2 inch line. On the same map that you just started to create, draw the contours at the waterline of the same landscape. What changes are you seeing?
9. Continue to add water to the next mark, and draw in shapes of "land" at the water line. When this activity is completed, you will have developed a topographic map of your landscape.

QUESTIONS

1. Compare your final map to your initial one. Are there any differences between your predicted and final maps? What have you learned about how contour lines work?

2. Have you drawn your maps to scale? To verify your answer, take a series of measurements on both your model and your map and then compare them to see whether the proportions between model and map are always the same.

Three Ways to be 3-D

Understanding Topographic Maps

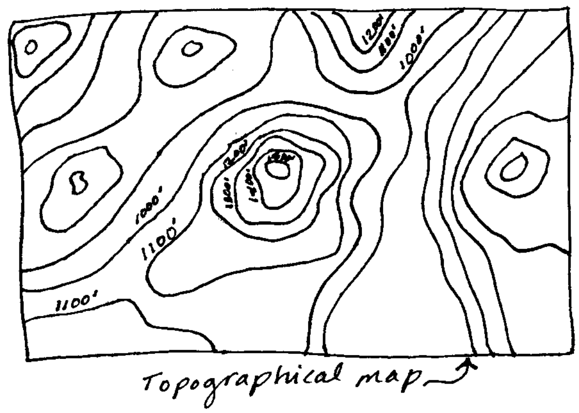
Student Pages

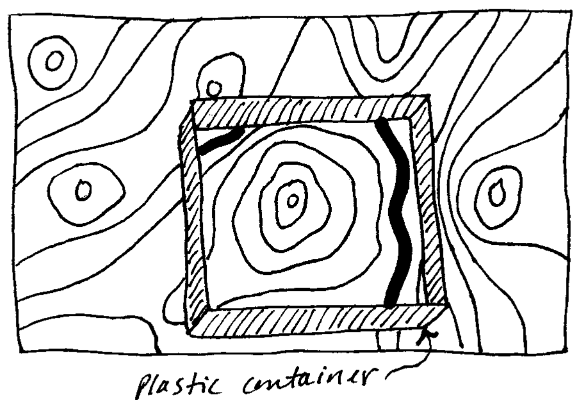
Part II
Drawing a 3-D Topographic Model

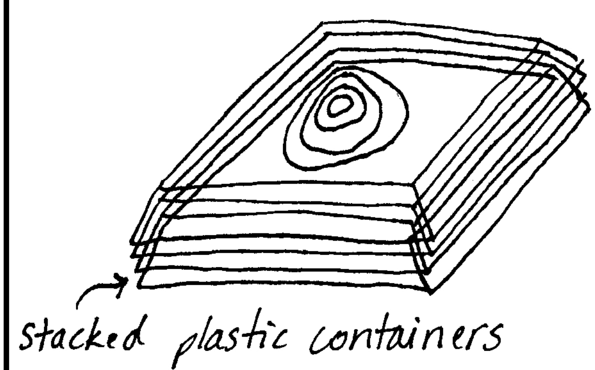
INTRODUCTION
Topographic maps show the shapes and features of the earth's surface using contour lines. Contour lines show places on the map that have the same elevation. By drawing the contour lines of a landform on layers of clear plastic, you can create a 3-D representation of that landform.

MATERIALS
- Topographic map with contour lines, enlarged if necessary so that landforms are 3-4 inches in diameter.
- Permanent markers
- 8-12 clear food/salad containers, lids removed
- Piece of white paper

PROCEDURE
1. Examine your map. On a separate piece of paper, draw or write a description of the landscape.
2. Place a salad container on the map and center the container over a landform.
3. Trace the outline of the container onto the map with a pencil (making a rectangle on the map to mark the spot)
4. With a permanent marker, trace the lowest contour line of the landform onto the plastic container. Set aside.







Amy Hutzel

PROCEDURE (Continued)

5. Place another container on the rectangle outline on the map. Trace the next highest contour line onto the container (note: If your landform has a number of closely spaced lines, draw only the index contours, which are the lines in bold print). Stack this container on top of the first one.
6. Continue tracing contour lines onto separate plastic containers and stacking them on top of each other until you have traced the highest elevation.
7. Cut a piece of white paper to fit inside the container on the bottom. Using the map, trace creeks, rivers, or other landmarks onto the paper. Tape the paper into the bottom container. Now you should be able to see a 3-D image of your landform!

QUESTIONS

1. Compare your initial description of the landscape to your model. Were your predictions accurate? If you predicted anything incorrectly, what did you learn about contour lines from this exercise?

2. Look at the location of creeks and rivers in your landscape. Which topographical features help guide the flow of water? Which features may have been formed by flowing water?

3. How might your area be affected by these different scenarios: heavy rain, agriculture, urban development, deforestation, reforestation, drought? How would these scenarios affect the water that flows to the Bay?

Three Ways to be 3-D

Understanding Topographic Maps

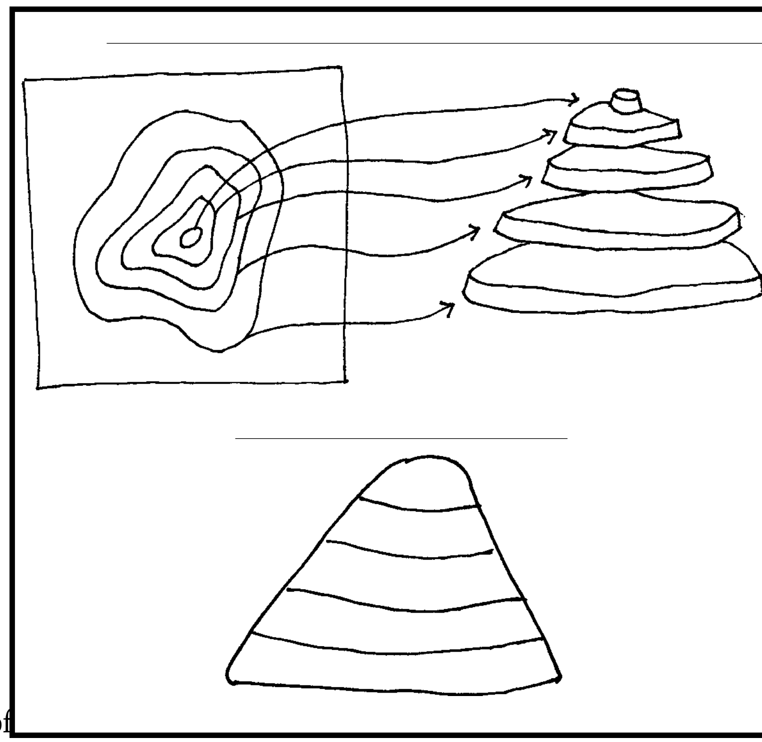
Student Pages

Part III
Building a Topographic Model

INTRODUCTION
Topographic maps show the shapes and features of the Earth's surface using contour lines. Contour lines show places on the map that have the same elevation. Using contour lines as a guide, you can build a three dimensional model of a landform.

MATERIALS
- Enlarged pieces of a topographic map, 2 photocopies of each
- Thick cardboard or foam core
- Utility knife
- Glue
- Modeling clay
- Pen or pencil

PROCEDURE
1. Examine your map. On a separate piece of paper, draw or write a description of the landscape.
2. Cut along the outermost contour line on your enlarged map.
3. Use this as a template to cut a piece of cardboard of the same shape and size.



Amy Hutzel

4. Cut along next inner contour line and use it as a template to cut the next piece of cardboard.
5. Continue this process, stacking the progressively smaller pieces of cardboard.
6. Glue stacked shapes together, then compare them to an uncut version of the map.
7. To smooth the steps between contours, cover edges with modeling clay.
8. Use the map to find the location of creeks and rivers in your landform. Mark them on your model by carving them into the clay with a pencil or by using colored clay or markers.

QUESTIONS

1. Compare your initial descriptions of the landscape to your model. Were your predictions accurate? If you predicted anything incorrectly, what did you learn about contour lines from this exercise?

2. Look at the location of creeks and rivers in your landscape. Which topographical features help guide the flow of water? Which features may have been formed by flowing water?

3. How might your area be affected by these different scenarios: heavy rain, agriculture, urban development, deforestation, reforestation, drought? How would these scenarios affect the water that flows to the Bay?

It Goes with the Flow

Overview

In this activity, students will learn about the various paths that water takes after people use it in the Bay Area. Students will use maps and posters to trace the path of wastewater either through the storm drain system or through the sanitary sewer system. In small groups, students will complete a scenario by selecting cleaning products, writing a short story, and drawing a picture describing the path wastewater takes from their homes to the San Francisco Bay. In their small groups, students will present their story and drawing to the class.

This activity was designed for the South Bay, but can be adapted to other Bay Area locations. However, the city of San Francisco uses a combined sewage and storm drain system, so parts of this activity do not apply.

Objectives

Students will be able to:

- Trace the paths wastewater takes after it goes down the sink or toilet and after it flows down a storm drain.
- Name at least two places effluent goes once it leaves the wastewater treatment plant.
- State at least one reason why recycled water is valuable.
- State at least one thing they can do to reduce the harmful effects of wastewater.
- Name the groups (e.g. residents, small commercial businesses) who are responsible for the largest percentage of water pollution in the Bay Area.

Estimated Time

Part I: 50 minutes — Introduction, small group discussion and product research
Part II: 50 minutes — Small group discussion, begin story writing and drawing
Part III: 50 minutes — Complete story writing and drawing, small group presentations

Materials

- Pictures of animals in and around San Francisco Bay: California clapper rail, salt marsh harvest mouse, red-legged frog, etc.
- *It's Wet, It's Wild, It's Water* Video and *Wastewater Paths* Poster (video and poster available from the City of San Jose, contact information is on the next page)
- Photocopies of scenarios (one per group)
- Flipchart paper
- Pencils, markers, etc.
- Writing paper
- Overhead projector
- 2 transparent overlays of *Wastewater Paths* (photocopies included)
- transparency of *Wastewater Paths from School* (photocopy included)
- Road Map of the San Francisco Bay Area (optional)
- Cleaning products with labels intact (preferably empty):
    - ❖ *ammonia*
    - ❖ *all purpose liquid cleaner*
    - ❖ *borax*
    - ❖ *chlorine bleach*
    - ❖ *"biodegradable" soap*
    - ❖ *automotive degreaser*
    - ❖ *pet soap with flea treatment*
    - ❖ *pet shampoo without insecticide*
    - ❖ *scouring powder*
    - ❖ *tomato juice*
    - ❖ *white vinegar*

Acknowledgments

Thank you to Bruce Frisbey for the idea that gave birth to this project. He wanted to create a way for people to understand the wastewater cycle as clearly as they understand the natural water cycle. Graphic artist, Fred Fortune, took our initial concept and designed a simple, effective poster that shows wastewater paths at a glance. The poster was perfected based on comments from over 300 teachers, who took their time to complete a survey at the California Science Teachers Association conference in 1998.

We especially appreciate the effort and experience of Sandra Spakoff, the environmental education specialist at the Don Edwards San Francisco Bay National Wildlife Refuge in Alviso, for integrating all of the complex issues of our South Bay watershed and creating this pragmatic classroom activity. Thanks as well to middle school science teachers, Hope Oliver and Linda Santone, for giving us the opportunity to work with them and help pilot this classroom activity in all of their science classrooms.

Our thanks to Charlie Roberson for so carefully reviewing and editing the lesson and to Kamala Chandrasekhar for turning a graphic concept into a useful transparency.

And to all the educators who plan to use this material, thank you for helping our youth understand more about the watershed in which we live.

Tamara Gilbert
Project Manager
Youth Watershed Education Team
Fall 1999

Produced by: San Jose/Santa Clara Water Pollution Control Plant
700 Los Esteros Road
San Jose, California 95134
http://www.ci.san-jose.ca.us/esd

The Plant is owned by the cities of San Jose and Santa Clara and is operated by the San Jose Environmental Services Department on behalf of the tributary agencies.

Tributary Agencies
Burbank Sanitary District
City of Campbell
Santa Clara County Sanitation Districts No. 2-3
Cupertino Sanitary District
City of Los Gatos
City of Milpitas
Cities of Monte Sereno & Saratoga
Sunol Sanitary District
West Valley Sanitation District

For questions about this activity, please call the City of San Jose, Environmental Services Department at (408) 277-5533.

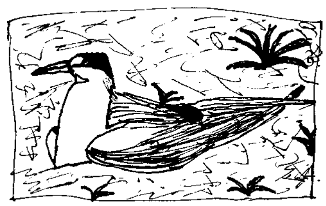
Key Concepts

1. When referring to wastewater, *nothing goes away* — water and whatever is in the water will eventually end up somewhere.
2. Wastewater takes different paths — water used indoors is treated at a wastewater treatment plant, and water from outdoor use flows untreated through the watershed to creeks, rivers, and the San Francisco Bay.
3. Treated wastewater in Santa Clara Valley takes two paths. Most flows into the San Francisco Bay and the rest is recycled and used for landscape irrigation at schools, parks, businesses as well as for industrial processes.

South Bay Issues

Concerns:

1. Preventing pollutants from entering creeks and the Bay
2. Protecting salt marsh (endangered species) habitat



Solutions:

1. Properly dispose of household hazardous wastes
2. Use less toxic alternatives to household hazardous products
3. Conserve water to reduce flows to the Bay
4. Support use of recycled water

California's Science Content Standards

Grades 9 - 12

Earth Sciences Standard Set 9.c: the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

Biology/Life Sciences Standard Set 6:

6.a. biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.

6.b. how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

6.d. how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles via photosynthesis and respiration.

Language Arts Content Standards

Grades 6 - 12: Writing, Listening, and Speaking

History/Social Science Content Standards

Grade 11

Standard Set 11.8.6: the diverse environmental regions in North America, their relation to particular forms of economic life, and the origins and prospects of environmental problems in those regions

Background

Water: Our Source

Most people are aware that water is a limited resource. On the average, about 50% of Santa Clara County's usable water supply comes from local reservoirs and groundwater and about 50% comes from rainfall in the Sierra Nevada Mountains that flows through rivers into the Delta. With a growing population and economy and new laws preserving a portion of the usable water for environmental preservation, available water supplies for people in the South San Francisco Bay (South Bay) are becoming even more limited.

Salt Marshes and their Inhabitants

Salt marshes can be described as transition zones between aquatic and land ecosystems that exhibit some characteristics of each ecosystem. Around the Bay, salt marshes are most noted for the abundant plant life (especially cordgrass and pickleweed) that grows in the salty soil. These plants depend on the salty environment to survive.

A variety of animals are found throughout the salt marsh. The California clapper rail and salt marsh harvest mouse are two endangered species that depend on the South Bay salt marshes for their survival — they are found nowhere else in the world! The clapper rail, a secretive bird, hides and nests in the cordgrass and pickleweed. The salt marsh harvest mouse drinks salt water and uses pickleweed for eating and nesting.

The tremendous volume of fresh water discharged from the wastewater treatment plant to the South San Francisco Bay threatens to convert more South Bay salt marshlands to fresh water marsh. The loss of salt marsh habitat affects the ecosystem and the endangered species (California clapper rail and salt marsh harvest mouse) who depend upon it for their survival.

South Bay Creeks and Rivers

The condition of creeks and rivers draining to the Bay varies widely. Many local creeks start in the Santa Cruz or Diablo mountain ranges as somewhat pristine waters. As they flow through populated areas they become increasingly impacted by human activities and sometimes directly changed. Some creeks are cemented over to prevent them from eroding land that people live on. Some creeks are allowed to follow their natural course and even have some native riparian habitat.

All South Bay creeks drain into the Bay and impact Bay life. But before they reach the Bay, creeks are home to animal life. Even concreted creeks have visiting ducks and other waterfowl. More pristine creeks are home to fish (salmon even return to spawn in some local streams), frogs (the California red-legged frog is endangered), aquatic insects (which are food for fish), birds, and mammals. Apart from sustaining wildlife, some creeks also provide tree-lined strips of nature in our urban environment, called a riparian corridor.

In our paved, urban environment, every street is designed to drain into a nearby creek to minimize the chance of flooding. As water flows down driveways and streets it picks up pollutants along the way. This polluted water goes into a storm drain that flows directly to a creek, and then into the South Bay. This urban runoff does not receive any treatment to remove pollutants.

Two Ways Water Gets Polluted

There are two ways water gets polluted. The first is through indoor water use. Residents use water to wash away soap and dirt, food and human waste. Businesses use water indoors to wash and rinse anything from plates at a restaurant, to cars at a car wash, to printed circuit boards.

The second way water becomes polluted is from outdoor pollutants. These flows can carry a range of pollutants — from natural pollutants (such as leaves) to toxics (such as pesticides). Rain or sprinkler water carry outdoor pollutants to creeks that ultimately flow to the Bay.

Who Pollutes?

For the last 20 years, we've depended on the pollutant reduction efforts of large industries to solve our water pollution problems. It is now recognized that agricultural, residential, and small business sources play a major role in contributing to the pollutants entering our creeks and the San Francisco Bay. We can no longer rely on industry to solve all of our pollution problems. Everyone who uses water — indoors or outdoors — contributes to water pollution.

Wastewater from Indoor Use

Used water or wastewater from taking a shower, washing dishes, and flushing the toilet goes down the drain into the *sanitary sewer system*. Relatively small pipes, called laterals, carry wastewater from homes and other buildings to sewer pipes placed under streets. Through a series of increasingly larger pipes, the sanitary sewer system transports wastewater to the San Jose/Santa Clara Water Pollution Control Plant in Alviso. Here the wastewater is thoroughly cleaned. The water (called effluent) discharged from the treatment plant is nearly as clean as drinking water. However, the treatment plant cannot completely remove some kinds of pollutants, such as heavy metals (mercury, cadmium, lead, selenium, silver, copper, nickel, chromium, and zinc), and toxic compounds, such as pesticides.

The effluent from the wastewater treatment plant will take one of two paths:

1. Over 100 million gallons of effluent are discharged into the South San Francisco Bay every day.
2. During the dry season, up to 8 million gallons per day are distributed as *recycled water*.

Recycled Water: Valuable Resource

Besides diverting a portion of the fresh water flow that would go to the Bay, recycled water is valuable as a water resource. South Bay Water Recycling is a system of pipes and pump stations that carries treated effluent from the wastewater treatment plant to schools, parks, and businesses. Recycled water is used for landscape irrigation, cooling towers (for cooling buildings or equipment), and some industrial processes.

Even in its present limited use, recycled water saves potable water supplies for more important uses than watering plants and lawns. This recycled water is already of high enough quality to be used for indirect potable use through groundwater recharge. (This is already a long standing practice in California.) One day, additional treatment (reverse osmosis) may make recycled water fit for supplementing drinking water reservoir supplies.

Wastewater from Outdoor Use

Not all wastewater makes its way to the wastewater treatment plant in San Jose. Unlike the sanitary sewer system, the *storm drain system* is not connected to a wastewater treatment plant.

Water moving through both the agricultural and urban areas of a watershed picks up pollutants. In urban areas, rain or other water (such as from sprinklers) runs off of paved surfaces or saturated soil. In cities, water flowing down driveways, off lawns and streets picks up pesticides, fertilizers, lawn clippings, soapy water, dripped oil, and antifreeze from cars. This urban runoff flows into gutters, which flow to storm drains. Water that goes into storm drains, along with all the pollutants introduced from our neighborhoods, eventually flows into creeks, rivers, and the Bay, completely untreated. Therefore, if our watershed is polluted, in all probability, the Bay will also be polluted.

Guidelines for Using Household Cleaners

WHERE	WHAT
Outdoors near paved surfaces (e.g., driveways, streets) or lawns or soil that saturates quickly	USE NO CHEMICALS. *Biodegradable* soap is poisonous to aquatic life.
Outdoors away from paved surfaces (e.g., backyards without drainage gutters)	Using a little *biodegradable* soap should be okay. A lot of soap, used regularly, can leach through the soil into groundwater.
Indoors (sinks, toilets, & other drains)	Most cleaning products made for residential consumers are okay because the wastewater treatment plant can treat most pollutants (except heavy metals or toxics).

About Household Cleaners

Outdoors

Any cleaning product, or other chemical, is harmful if used where it can be washed into a gutter. If you put something in water that flows to a storm drain, all of it can end up in the Bay. Even "biodegradable" soap is toxic to fish until it degrades. Also, biodegradable substances feed bacteria that remove oxygen from water as they eat and multiply.

Pest controls can also affect aquatic life. The South San Francisco Bay (and some local creeks) are listed as impaired by the US Environmental Protection Agency due to the insecticide, diazinon. There is also concern about the insecticide, chlorpyriphos. Chlorpyriphos is found in some flea treatments.

Indoors

Wastewater treatment plants are not designed to remove 100% of the pollutants contained in wastewater. Therefore, if something is put in the water that flows to a sanitary sewer, a portion of it will end up in the Bay.

Some products should never be rinsed to indoor drains, especially pesticides, organic solvents, and household hazardous wastes. Organic solvents are commonly found in paints, paint strippers, paint thinners, and lacquers.

Products that contain heavy metals should be avoided. Unfortunately, most products do not list small amounts of heavy metals. Remember: many people, rinsing trace amounts of metals, can make a significant contribution to the heavy metals passing into the Bay.

Here are some tips for preventing heavy metal pollutants from flowing to the Bay:

- Conserve water use indoors to help decrease the amount of copper from indoor piping corrosion that flows to the wastewater treatment plant.
- Use thimerosal-free cleaning solution for contact lenses. (Thimerosal contains mercury.)
- Use merbromin-free germicides and antiseptics. (Merbromin contains mercury.)
- Use selenium-free dandruff shampoos. (Selenium is a heavy metal.)
- Use glazes and artist paints that do not contain heavy metals such as lead, cadmium, chromium, copper, nickel, and zinc.
- Dispose of fixer solution, a chemical used in photography that often contains silver, as a hazardous waste.
- Dispose of solutions from etching metals, like copper, as hazardous wastes.

Some products, which may be dangerous to people if mishandled (e.g. ammonia, harsh soaps, and drain cleaner), are removed at the wastewater treatment plant or are neutralized when they mix with other water. (Drain cleaner is neutralized to become a salt).

Chlorine, while removed at the Water Pollution Control Plant, may convert organic substances into trace amounts of harmful chemicals, which are probably evaporated into the air at the wastewater treatment plant. Based on present knowledge, the amount of these substances in residential wastewater probably does not warrant quitting the use of chlorine containing products. There are much higher priorities, such as: not using products that contain heavy metals, disposing of automotive fluids properly, and keeping chemicals away from paved surfaces that drain to the storm drain (especially insecticides).

Household Hazardous Wastes

Hazardous products are substances that are flammable, toxic, corrosive, or reactive. Since improper use can cause water pollution, they should be used sparingly, only as needed. Household hazardous wastes include unwanted: paint, automotive fluids, garden chemicals, some household cleaners, batteries, aerosols, flammable fluids, pool chemicals, and sharps. Read the labels of the products you use, and call the Santa Clara County Household Hazardous Waste appointment line at (408) 299-7300 for information on proper disposal of any leftover products.

Impacts of Household Cleaners

Cleaners	Use	Stormwater Impact (front yard)	Stormwater Impact (back yard)	Sanitary Sewer Impact	Concerns
plain pet shampoo	dirt, light odors	1	3	4	depletes available oxygen in water for aquatic life
tomato juice	strong odors	1	2	4	depletes available oxygen in water for aquatic life
pet soap with flea treatment	dirt, light odors, kills fleas	1	3	1	depletes available oxygen in water for aquatic life, toxic pesticides (chlorpyriphos),
all purpose cleaner	dirt, light odors, heavy grime, light grease	1	3	4	depletes available oxygen in water for aquatic life, solvents in the cleaner
white vinegar	windows, soap & lime deposits	1	2	4	low pH (acidic)
borax	dirt, light odors, light to medium grime, light grease	1	2	4	heavy metals, boron in the cleaner
bleach	light grime, dirt, clothing stains	1	2	4	chlorine in the cleaner
degreaser	heavy grease	1	3	4	heavy metals from grease, solvents in the cleaner
scouring powder	heavy grime, grease, & dirt	1	2	4	chlorine in the cleaner
water	rinsing dirt & cleaners	1	2	4	sediments & leaves may deplete available oxygen in water for aquatic life
biodegradable soap	dirt, light odors, heavy grime, light grease	1	2	4	depletes available oxygen in water for aquatic life
ammonia	dirt, heavy grime, light grease	1	2	4	depletes available oxygen in water for aquatic life, high pH (alkaline)

Legend

These impacts are based on our current scientific understanding of pollutant effects.

1 May introduce pollutants untreated to creeks or Bay

2 Unlikely to introduce pollutants to creeks or Bay

3 Possible groundwater contaminant, depending on quantity & frequency of use

4 Pollutants sent to wastewater treatment plant, where most can be treated before release to the Bay (The wastewater treatment plant, however, was not designed to remove heavy metals and toxics.)

Method

Preparation

To introduce the lesson, show students the video, *It's Wet, It's Wild, It's Water.* Collect pictures of wildlife found in and around the San Francisco Bay, especially those of the California clapper rail and the salt marsh harvest mouse. Make transparencies of *Wastewater Paths from School* (graphic provided) and a Bay Area road map (optional). Ask students to bring in empty, washed out bottles of cleaning products from the materials list — be sure to have them *leave the labels on and legible.*

Part I

Introduction: Show students pictures of wildlife that are found in and around the San Francisco Bay. Be sure to include pictures of the California clapper rail and the salt marsh harvest mouse, two endangered species. Ask the students to describe the environment these animals need to survive.

Show the class a road map of the Bay Area (use a transparency, if possible). Choose a student to locate your school on the map. Have the student point to the San Francisco Bay. Ask students to figure out the connection that exists between their school and the Bay and its wildlife. At first students may not see any connection. Eventually students will say "roads," but finally realize that creek or rivers are the connection because *all streets drain to a nearby creek or river, and all creeks and rivers in our watershed drain to the Bay.*

1. Using the *Wastewater Paths* poster, call on individual students to trace the paths that wastewater takes.
2. Next, have students name a few ways they use water indoors. (Examples include: drinking, showering/bathing, washing dishes, brushing teeth, flushing toilets.)
3. Show the transparency with the sanitary sewer system.
4. Call on individual students to trace the paths that the wastewater takes after it's used *indoors*.
5. Overlay the transparency that shows what happens to water when it goes down the storm drain.
6. Ask students how they use water in their front yards.
7. Ask students where water goes after it's used *outside* or it rains.
8. Name the creek or river into which your school's storm drain empties.
9. Ask students what lives in and around the creeks.
10. Ask students whether it matters if the water that drains to creeks is clean.
11. Reinforce the different paths wastewater takes using the Wastewater Paths poster and background information.
12. Emphasize that the sanitary sewer system and storm drain system are two separate systems. Water used *indoors will be treated* at the wastewater treatment plant; water used *outdoors will flow untreated* to a creek or river and then to the Bay.
13. Explain the guidelines for using household cleaners indoors and outdoors and the impacts of their use (Background)

Activity: Break the class into small groups of four or five students.

Explain that each group will be given a scenario in which they will need to agree on their course of action. Once the group agrees, they will need to create and write a short story (3 paragraphs) that will be read to the rest of the class. Next they must draw what's happening in their story, illustrating the path that the water takes after it's been used. Let the students know that they will be presenting their story and drawing to the rest of the class.

To model the scenario activity, read the following scenario to the class and use the *Wastewater Paths from School* transparency to illustrate the path that the water takes.

Last year, after the Christmas break, I walked into my classroom and discovered that nobody had cleaned the fish tank while I was away. I could have sworn that I'd asked the custodian to wipe down the glass to keep the algae under control. But there sat the fish tank, looking like a scene from a monster movie. I thought that at any second the creature from the great lagoon was going to emerge from the tank and slime me with green algal ooze. Being the brave person that I am, I decided to take hold of my fear and go after the slime. I put on a pair of rubber gloves, grabbed a bucket and sponge, and attacked the algae. Soon my bucket was filled with a green goo soup. As I continued to wipe down the glass, I could finally see the fish. I think one smiled at me. When I was finished, I dumped the green goo down the sink. This is a picture showing where the water and green goo ended up.

Read aloud the scenario below. Initially, everyone will start from this same scenario.

This year's model of in-line skates are totally awesome and you will "just die" if you can't have them. On the other hand, your parents just don't get it. They want you to use a beat up old pair of hand-me-downs that you wouldn't be caught dead in. As a compromise, your parents told you that if you earned half the money by doing chores around the house and showed them that you were responsible, they would give you the other half for your birthday. Even though you hate doing work around the house, you've agreed to do what your parents have proposed.

1. Tell the class that different groups will finish the story for the different chores they are assigned.
2. Pass out one photocopy of a scenario to each small group, along with the empty cleaning products, so that the students can read teh labels. (Note: if you have more groups than there are scenarios two groups may need to address the same scenario.)
3. Have the groups read their scenario and discuss among themselves how they are going to tackle their chore.

Part II

Have the students get back in their small groups to continue writing their stories and draw their pictures. Remind them that they will be presenting the next day.

Part III

Instruct students to "put the final touches" on their stories and drawings, and to practice their presentations. Have each group present their scenario, story, and picture to the rest of the class. After all groups have finished their presentations, have them consider the following questions:

1. What happened to the cleaning products they used?
2. If the water and cleaning products went through the storm sewer system, what effect will it have on creek and Bay habitats and wildlife?
3. If the water and cleaning products went through the sanitary sewer system, did the Water Pollution Control Plant remove all of the harmful substances before the effluent was discharged into the Bay?
4. What effect will hundreds of millions of gallons per day of fresh water have on an estuary over time? (Recall that an estuary is made up of a mixture of fresh and salt water.)
5. Who pollutes Bay habitats?

Have each group discuss their choice of cleaning product or procedure they followed. If the group determines that they would now prefer to use an alternative product or procedure, have them explain the alternative and why they chose it. Again, the entire group must agree.

Wrap Up

1. Have students summarize the paths that wastewater takes and where it ends up.
2. Discuss the problems associated with urban runoff entering creeks and the Bay.
3. Discuss how "fresh water" might be a "pollutant."
4. Have students identify or research ways in which heavy metals that make their way through the wastewater treatment plant may affect aquatic life.

Extensions

1. To assess student understanding of water pathways and the effect individual behaviors have on San Francisco Bay ecosystems, ask students to write a summary, or journal entry, about what they learned.
2. To increase their understanding of urban runoff pollution, have students monitor and collect data on water flowing over school grounds and into storm drains. To discover where the water goes after it enters the storm drain system, obtain blueprints of the storm drain piping system from your local public works department.
3. Have students inventory the products used in their home. After doing so, have students determine whether or not alternative products are available to substitute for potentially harmful substances. (See Background)
4. Have students keep a log of their water use. Discuss which behaviors could be modified to reduce water consumption. Emphasize that conserving water means conserving the salt marsh ecosystem and protecting endangered species.
5. Brainstorm ways that the whole community could decrease the amount of water flowing to the Bay (e.g., using more recycled water , limiting the number of people who live here, etc.)

Scenarios

Scenario 1

Boy, did you ever make a mistake by entering into this agreement. Who would have thought that in the middle of the city your dog would find a skunk to play with? Well, she did, and she smells like your uncle Joe's feet after he's been out backpacking for a week without a shower. Your father says that she's your dog and has asked you to give her a bath. And, of course, you want to show your father that you're responsible so you can get those skates. Unfortunately, your older brother borrowed the hose a month ago and still hasn't returned it. So, not only do you have to bathe the dog, you also have to wash out the tub when you've finished. The products available for washing the dog and cleaning the tub are: "biodegradable" soap, plain pet shampoo, tomato juice, pet soap with flea treatment, and all-purpose super cleaner.

THE CHALLENGE: It's up to your group to decide which, if any, of the products to use or whether you will use water only. Write a short story (3 paragraphs) describing how you will clean up this mess; and be creative! After you have finish, then draw a picture that shows where the water goes after it flows down the drain.

Scenario 2

Those awesome, and very pricey, athletic shoes your parents bought you, just for being the great kid that you are, look pretty sad. The white leather has taken on a ghoulish green hue, mottled with shades of brown, black, and gray. You had told your parents that you would take really good care of them, but now they look like you use them to mow lawns and clean stalls. If they see these shoes, they'll never let you buy those in-line skates, using the rationale that "you don't know how to take care of your things." You decide that with the miracle of modern chemistry you can get these puppies looking good as new. Taking the project to the laundry room, you find that the cleaning products available are: white vinegar, all-purpose super cleaner, borax, and ammonia.

THE CHALLENGE: It's up to your group to decide which, if any, of the products to use or whether you will use water only. Write a short story (3 paragraphs) describing how you will clean up this mess; and be creative! After you have finish, then draw a picture that shows where the water goes after it flows down the drain.

Scenario 3

Two weeks ago you stayed home from school because you had a fever. While you were channel surfing, you came across a TV program that showed the host learning how to clean and tune up bicycles. You figured if she could do it, so could you. So, today you thought you would clean and tune your own bicycle. If all went well, you could do your brother's and sister's bicycles, for a small fee of course. Cleaning comes first, with the worst part being the greasy, grimy chain. You can't remember what they used to clean the chain on the TV program, so you take an inventory of your options. The cleaning products available are: chlorine bleach, "biodegradable" soap, degreaser, and all-purpose super cleaner.

THE CHALLENGE: It's up to your group to decide which, if any, of the products to use or whether you will use water only. Write a short story (3 paragraphs) describing how you will clean up this mess; and be creative! When you have finished, draw a picture that shows where the water goes after you spray down your bike.

Scenario 4

Your older sister used your parents' brand new truck to drive to the park to play volleyball. While she was playing, her boyfriend asked to borrow the truck to go and pick up pizza. She said "sure," which turned out to be the wrong answer. While he was out getting the pizza, he decided to "see what this baby can do" and took it off-road through a field and the biggest mud hole in San Jose. Your sister knows that you are saving money and she has promised to "pay you the big bucks" if you wash the truck before your parents get home. The truck, which is parked in the driveway, is covered to the roof in black, gooey mud that sort of smells like rotten eggs and cow manure. You spray the truck down with water, but you can still see a slimy brown film on the silver-gray paint. You can scrub the car with a rag using water only, or you can do the job with one the following cleaning products: all-purpose super cleaner, white vinegar, "biodegradable" soap, and borax.

THE CHALLENGE: It's up to your group to decide which, if any, of the products to use or whether you will use water only. Write a short story (3 paragraphs) describing how you will clean up this mess; and be creative! When you have finished, draw a picture that shows where the water goes after it leaves the driveway.

Scenario 5

It been almost a month and this chores scene is really getting old. Dishes at breakfast, dishes at dinner, dishes after dinner — day after day after day after day. And you've made less than half of what you need! When you do the math, you figure that you've earned about two cents a piece for every soggy cornflake you've scraped out of those putrid green cereal bowls and a whopping quarter a piece for each disgusting pan you've had to wash by hand. Your mother wants to help you out. She offers to give you a bonus if you clean out the refrigerator. You agree and get right to work. Everything is going along just fine until you get to the crisper. Nothing is crispy in the crisper.

The fruits and vegetables look like a science experiment in your worst nightmare — blue and green and gray mold are covering what used to be tomatoes, the lettuce has turned to black slime, and the onions have shriveled away. You very cautiously proceed by throwing everything into the sink so that it can be ground up by the garbage disposal. A flick of the switch and voilà the gore is gone.... Well, almost. The blackberries left massive purple stains in the bright white sink. Now you have to figure out how to remove the stains. The cleaning products available are: scouring powder, white vinegar, all-purpose super cleaner, and borax.

THE CHALLENGE: It's up to your group to decide which, if any, of the products to use or whether you will use water only. Write a short story (3 paragraphs) describing how you will clean up this mess; and be creative! After you have finish, then draw a picture that shows where the water goes after it flows down the drain.

Glossary

Adapt — To change or adjust to fit the environment.

Adaptation — An adjustment to environmental conditions; a modification of an organism or its parts that helps the organism survive.

Aquatic — Pertaining to water as distinguished from land.

Brackish – Containing a mixture of seawater and fresh water, resulting in a moderate amount of salt; therefore, less salty than ocean water.

California Clapper Rail – An endangered bird that depends exclusively on the salt marsh for its food and shelter; feeds on mud creatures, spiders, insects, and small mammals; and hides and nests in the pickleweed and cordgrass.

Dilute — To thin or reduce the concentration of a solution (make a solution weaker) usually by the addition of water.

Ecosystem — A natural unit of living and nonliving components that interact to form a stable system; i.e., a system made up of a community of living things and the physical environment with which they interact. Any change in the environment affects all elements of the ecological community.

Effluent — Water flowing from one source to another, such as the treated water discharged from a wastewater treatment plant to a natural body of water, such as the San Francisco Bay.

Endangered Species — Insects, amphibians, reptiles, birds, mammals, and plants that are currently designated by federal and state governments as having declined sufficiently to warrant special protection or monitoring.

Estuary — A place where fresh water from rivers meets and begins mixing with salt water from an ocean.

Habitat — A specific environment in which an animal or a plant lives, including the arrangement of food, water, shelter, and space suitable to the organism's needs.

Potable — Water that is fit to drink.

Riparian Zone — The vegetated area adjacent to a natural course of water (e.g. streams, creeks, headwaters, estuaries).

Salinity — The relative concentration of dissolved salts (primarily sodium chloride) in water.

Salt Marsh Harvest Mouse — An endangered rodent, 2½ to 3½ inches long, found only in the salt marshes of the San Francisco Bay. This nocturnal animal feeds exclusively on pickleweed and can drink saltwater. It's the prey of owls, northern harriers, and red-tailed hawks, as well as herons, egrets, and clapper rails.

Saltwater — Water that contains at least one-half of one percent salt ($0.5 \times 0.01 = 0.005$), or more than 5 parts salt per 1000 parts water.

Scenario — A made-up situation.

Solvent — A substance, usually liquid, that can dissolve another substance.

Terrestrial — Of the land or living on land, as distinguished from water.

Trace amount — An infinitesimal quantity which is barely perceptible, usually measured in parts per billion (ppb). Even trace amounts of some substances may be toxic to human life or the environment.

Urban Runoff – Occurs when the ground around the city environment is unable to absorb water from rainfall, landscape irrigation, and other outdoor use. This surface water then washes street and yard pollutants off paved surfaces into creeks, rivers, storm drains, and estuaries. Runoff pollutants derive largely from motor oil, tires, combustion by-products, and batteries. Other common pollutants include household and garden chemicals, sediments, and waste from commercial yards.

Wastewater – Water that has been used.

Watershed – A region of land that water flows across or under on its way to a stream, river, lake, or other body of water.

Resources

Curricula

South Bay Water Recycling Middle School Curriculum. 1998

Project WET Curriculum & Activity Guide. 1996. Activities: Rainy-Day Hike, A-maze-ing Water, Sum of the Parts, Water Meter, and Every Drop Counts.

Websites

San Jose Environmental Services Department
http://www.ci.san-jose.ca.us/esd

Don Edwards San Francisco Bay National Wildlife Refuge
http://desfbay.fws.gov/environ.htm

Santa Clara County Household Hazardous Waste Program http://www.hhw.org/

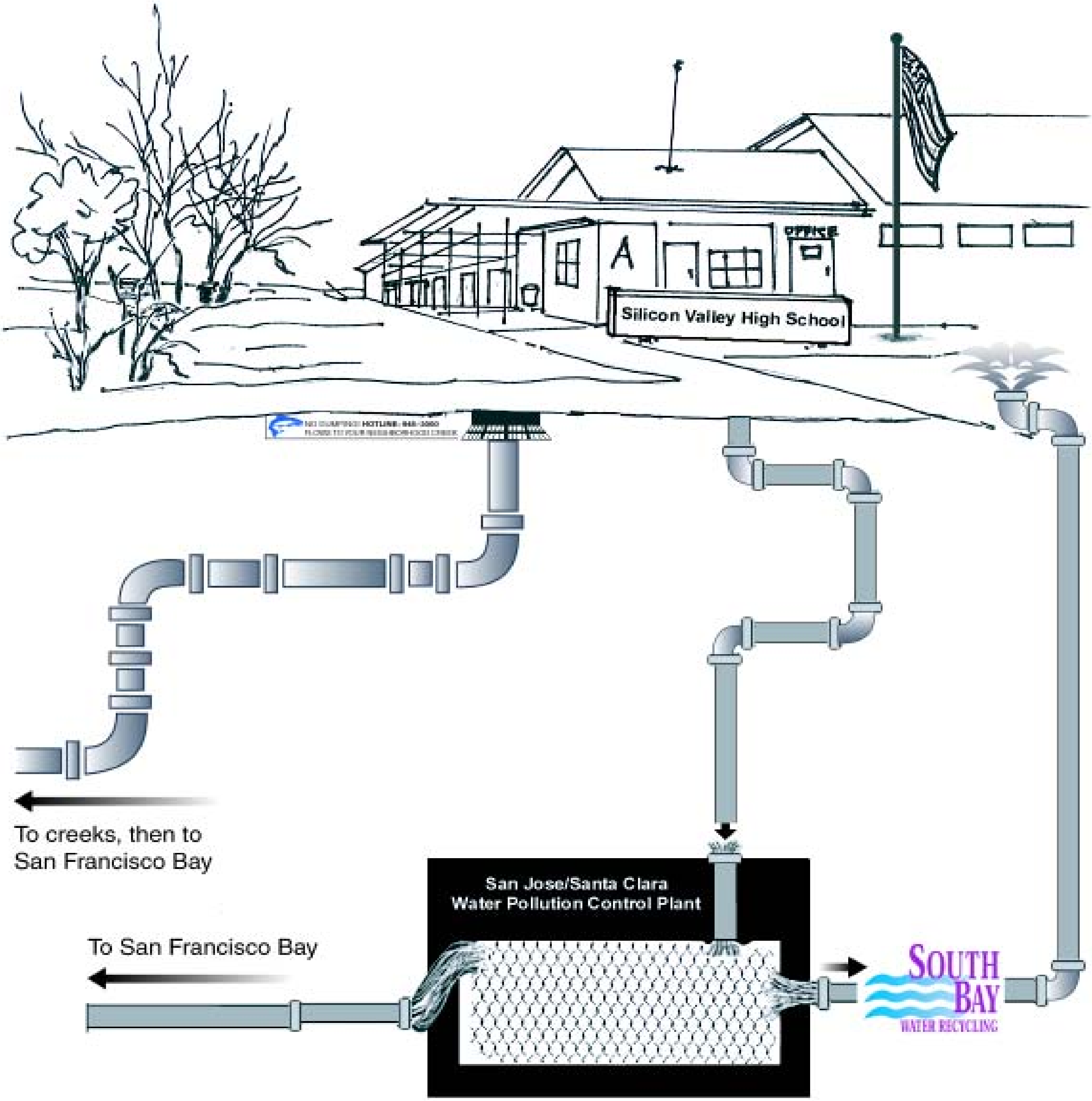
Santa Clara Valley Water District
http://www.scvwd.dst.ca.us/

San Francisco Estuary Institute
http://www.sfei.org/

Know Your Watershed
http://www.ctic.purdue.edu/KYW/

Clapper Rail Photos
http://desfbay.fws.gov/Archives/Clapper/carail.htm

Salt Marsh Harvest Mouse
http://desfbay.fws.gov/Archives/Salty/salty.htm



WASTEWATER PATHS FROM SCHOOL

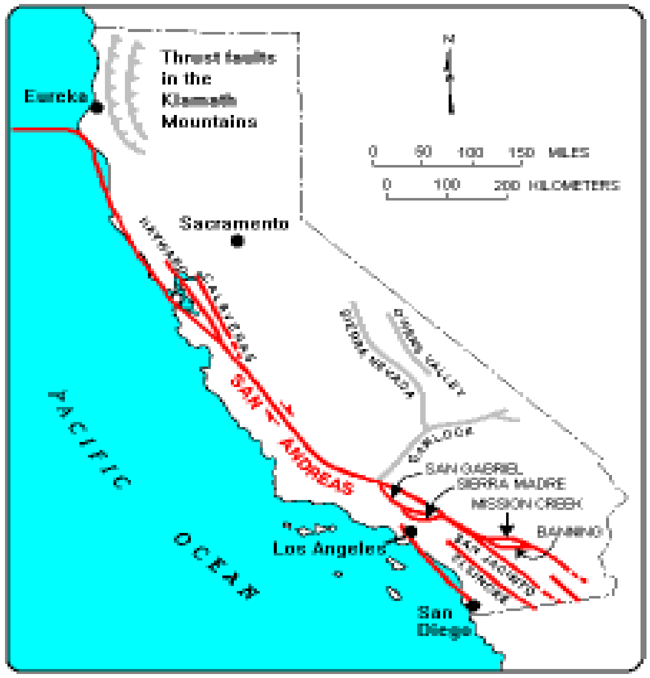
Peanut Butter and Jelly Geology

A Study of Faults and Geologic Activity

TEACHER'S PAGES

Overview

California's diverse landscape and complex geology can be attributed to tectonic faulting. Earthquakes, volcanoes, erosion, uplift--all have played a role in shaping our landscape. In this activity students explore the connections between the topography of the Bay Area and the geological processes that underlie it. They will learn about sediment types, plate tectonics, and how they affect the topography of the Bay Area and its surrounding landscape.



Estimated Time

1 hour

Objectives

Students will be able to:

- Describe various faults and their movements
- Define and describe plate tectonics
- Explain folding and faulting forces of various plate boundaries and their impacts on the geology of the Bay

Materials

Part I: Introduction to Geology
For each student

- 1 oreo cookie
- 1 napkin

Part II: Plate Tectonics and Peanut Butter
Make groups of 4-5 students, for each group

- 1 copy of the Student Pages of Peanut Butter and Jelly Geology for each student
- 1 small paper cup of peanut butter
- 1 small paper cup of jelly
- 4 slices of bread
- 1 flat paper plate
- 1 clear plastic straw
- 1 plastic knife
- 1 small paper cup of mixture of food items such as raisins, oats, cereal, etc. (optional)

Vocabulary

Blocks, core, crust, fault, normal fault, strike-slip fault, graben fault, subduction, plate tectonics, rocks, sediments, core sampling

California Science Content Standards

Grade 6

Standard Set 1.e: major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate motions.

Standard Set 1.f: how to explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes).

Grade 7

Standard Set 4.a: Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.

Grade 7 (continued)

Standard Set 4.c: the rock cycle includes the formation of new sediment and rocks. Rocks are often found in layers with the oldest generally on the bottom.

Standard Set 4.f: how movements of the Earth's continental and oceanic plates through time, with associated changes in climate and geographical connections, have affected the past and present distribution of organisms.

Grades 9-12

Earth Sciences Standard Set 9.a: the resources of major economic importance in California and their relation to California's geology.

Additional Resources

This activity was adapted from "Estuarine Encounters" by Friends of the San Francisco Estuary.
http://www.abag.ca.gov/bayarea/sfep/programs/ested/index.html#estenc
USGS Quake Info
http://quake.wr.usgs.gov/
Kids GeoZone
http://www.consrv.ca.gov/CGS/information/kids_geozone/index.htm
Paper Models from USGS
http://interactive2.usgs.gov/learningweb/teachers/paper_models.htm

Background

A fault is a fracture along which there is movement. Some faults are actually composed of several fractures called fault branches. Collectively the branches are a fault zone. (see map on front page of activity)

California's diverse landscape and complex geology can be attributed to faulting. Many of the State's valleys, mountain ranges, and desert areas show the effects of faulting. Faults create underground traps in which valuable reservoirs of petroleum form, and spaces in which underground waters deposit valuable metals in the form of veins and masses of ore. Faults are distinguished by abrupt changes in rock structure or composition. Sometimes a fault can be recognized by the displacement of a particular feature such as a bed or a vein. The best places to observe faults are usually in roadcuts, quarries, and sea cliff exposures.

Fault Classification

Faults and fault zones are classified by how the rocks on each side of the fault or fault zone move past each other. There are two main types of movement along faults: 1) a sideways movement called strike slip, and 2) an up or down movement called dip slip.

Strike-Slip Faults

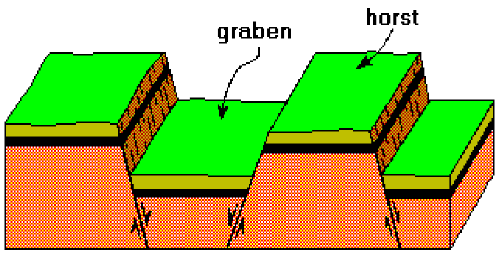
The movement along a strike-slip fault is approximately parallel to the strike of the fault, meaning the rocks move past each other horizontally.

The San Andreas is a strike-slip fault that has displaced rocks hundreds of miles. As a result of horizontal movement along the fault, rocks of vastly different age and composition have been placed side by side. The San Andreas fault is a fault zone rather than a single fault, and movement may occur along any of the many fault surfaces in the zone. The surface effects of the San Andreas fault zone can be observed for over 600 miles (1,000 km).

Dip-Slip Faults

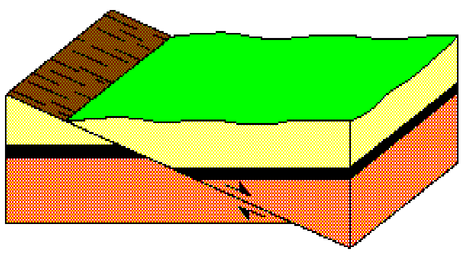
Dip-slip faults are faults on which the movement is parallel to the dip of the fault surface. Normal faults are dip-slip faults on which the hanging wall (the rocks above the fault surface) move down relative to the footwall (the rocks below the fault surface). Normal faults are the result of tension (forces that pull rocks apart).

Where the dip of a normal fault's surface is steep, it is called a high-angle normal fault, or simply a normal fault. The Owens Valley and the Sierra Nevada fault zones are examples of high-angle normal faults. Together they produce a down-dropped block which forms the Owens Valley. This type of fault-bounded valley is called a graben. A fault-bounded ridge is called a horst.



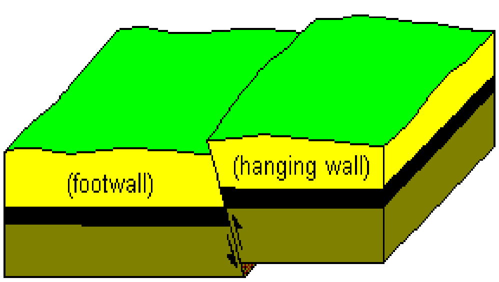
HORST AND GRABEN

Where the dip of a normal fault's surface is very gentle or almost flat, it is referred to as a detachment fault or low-angle normal fault. Detachment faults are common in the desert areas of California.



DETACHMENT FAULT

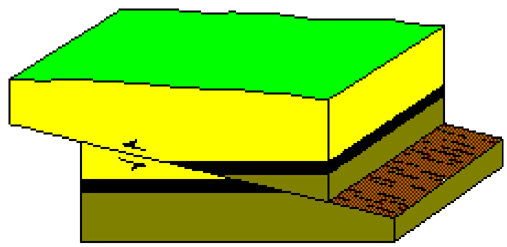
Reverse faults are dip-slip faults in which the hanging wall moves up relative to the footwall. Reverse faults are the result of compression (forces that push rocks together).



REVERSE FAULT

The Sierra Madre fault zone of southern California is an example of reverse-fault movement. There the rocks of the San Gabriel Mountains are being pushed up and over the rocks of the San Fernando and San Gabriel valleys. Movement on the Sierra Madre fault zone is part of the process that created the San Gabriel Mountains.

A thrust fault is a reverse fault with a gently-dipping fault surface. Thrust faults are very common in the Klamath Mountains of northern California.



THRUST FAULT

Notes

The terms *normal* and *reverse* were first used by English coal miners to describe faults. When working a flat coal bed where it was dislocated by a normal fault, the miners continued the workings either upward or downward on the fault surface in the same, or *normal*, direction. The workings in a seam dislocated by a reverse fault were also continued upward or downward on the fault, but in the opposite, or *reverse*, direction (Ojakangas, 1991).

The terms *hanging wall* and *footwall* are also old mining terms. These terms were originally used in inclined underground passageways to refer to the rock "hanging" overhead (the hanging wall) and the floor beneath the miners' feet (the footwall) (Ojakangas, 1991).

This background information was taken from the California Conservation web site at http://www.consrv.ca.gov/cgs/information/publications/teacher_features/faults.htm

Teacher Procedure
Part I: Introduction to Geology

1. You can start off by asking the students some simple questions:
- Do you know how landscape around the Bay such as mountains is formed?
- What is a fault?
- Have you ever heard of the term plate tectonics? Do you know what it means?

2. Tell your students that they will be using everyday items to represent the earth and explore how natural forces alter and shape the geology of the San Francisco Bay and its surrounding landscape. Their model will help them answer these questions about earth science.

3. Pass out one oreo cookie to each student.

4. Tell the students to carefully twist off the top part of the cookie so that they have the two pieces separated and one piece has all of the cream on it.

5. Demonstrate this procedure to the class.

6. Explain to them that they are going to pretend that these two pieces of cookies are tectonic plates of the Earth and that they are going to study the movement of these plates and how they changed the sediments and geology in the Bay Area.

7. Tell them that the process they are going to learn is called subduction and it occurs when one plate moves under the other and the top plate scrapes sediments off the bottom plate while the bottom plate is diving under.

8. Demonstrate the process of subduction while explaining that the Earth's plates have different types of movements that create different types of structures. Take the oreo cookie with the cream on top (cream side up) and slowly push it below the other piece of cookie so that the cream scrapes onto the top cookie piece.

9. Now let your class try it.

10. Tell the class that the process of one plate sliding beneath another is called subduction and that much of the land around the Estuary is composed of rocks that were altered during subduction. This mixture of rocks that were formed from a scraping of the plates and from subduction make up the bedrock found around much of the Estuary.

11. Explain that although subduction no longer affects the geology of the Bay Area, it affects other areas in the world, and often leads to volcanoes and tsunamis.

12. Now let your class eat the cookies!

Part II: Plate Tectonics and Peanut Butter

1. Tell your class that they are going to perform another experiment to help demonstrate other ways that plates and faults move and learn how that has shaped the Bay. Divide the students into groups of 4 or 5.

2. Pass out the materials and the student pages to each group. (The following directions are also on the student pages). Assist the students as they follow their written instructions and ask discussion questions.

3. Each group will start by spreading peanut butter on two bread slices and jelly on the other two slices (without joining the slices together).
*Optional: Students can also add small foods like raisins, oats, cereal, etc. to represent different rocks and minerals.

4. When all the groups are ready, instruct the students to put their sandwiches together

by alternating peanut butter and jelly slices (plain bread sides facing out).

5. Explain to the students that the stack is the bottom of the Pacific Ocean long ago, and that the stack represents the different layers of sediment that have accumulated over thousands of years.

6. Explain the theory of plate tectonics, that the Earth's crust is made up of 12 different plates that move against each other. The boundaries of these plates is where rock deformation occurs. Tell the class that they are going to use their stack to help them visualize some of the effects of plate tectonics.

7. Ask "What happens to rocks when they are exposed over time to pressure and heat?" Explain that as the ocean floor sediments were scraped against the continent, pressure and heat caused the rocks to metamorphose/deform. Also that deformations occur along plate boundaries. Introduce this concept of folding and faulting due to heat and pressure.

8. Tell them to demonstrate this by applying compressional pressure to the outsides of the sandwich stack, causing the stack to fold and buckle, creating small ridges and valleys. The Student Pages contain a diagram illustrating this and explaining it to the students. This process created many mountain ranges around the world.

9. Now have the students cut their sandwich stacks in half lengthwise. They can demonstrate the strike-slip movement between two blocks by sliding the two blocks towards each other and then horizontal to each other, following the diagrams in their Fault Activity Demo Sheet. The San Andreas Fault has this type of motion.

10. Next the students should cut one of the halves of their sandwich stack in half again, creating two blocks. They can use these to demonstrate a normal fault by pushing the two blocks against each other and having one block slide downwards against the other(normal fault). Then have one slide upwards against the other (reverse fault). The Owens Valley and Sierra Nevada fault zones are examples of normal faults. The Sierra Madre fault zone is an example of a reverse fault movement.

11. The graben fault is a special type of normal fault. The graben fault can be shown by cutting the remaining sandwich stack into thirds and exerting force on the outer thirds to push the inner third downward. Point out which sections are the graben and horst.

12. Now show your students a core sample by taking a clear straw and inserting it carefully through the stack of bread slices. Twist the straw as you insert it into the densest part of the sandwich. After removing the straw, discuss the profile, showing the pattern of materials (the alternating layers of peanut butter and jelly represent the different layers of rock).

13. Explain how the stratified sediments represent the layers of sedimentary rock that were scraped off from the ocean bottom to the continental margin, then moved, through faulting and folding to their present locations around the Estuary. Some of these rocks deposited along the coast of California and created the Coastal Mountain range.

14. Have them take a core sample of their stacks.

15. Discuss with your students that rock layers are laid down horizontally. Let the groups discuss which layers in their model are the oldest and youngest layers of rock. Review

their answers and teach them that "If rock layers are not disturbed the oldest layers are on the bottom and the youngest layers are on the top." Explain to them that this helps geologists chronologically date rock layers and formations.

Class Discussion/Wrap Up

1. Begin a discussion that summarizes what has occurred. Review:

- Subduction and how it forms new earth
- How faults and plate boundaries create mountains and valleys
- The differences between the 3 faults we studied
- Significance of core samples and what they teach us

2. Divide the sandwiches and serve.

3. You can build paper fault models with your class as well. Research the "Mapping Our Faultlines" Activity on the USGS web site from USGS Learning Web, U.S. Department of Interior, U.S. Geological Survey, Reston, VA. USA. http://www.usgs.gov/education/

Peanut Butter and Jelly Geology

A Study of Faults and Geologic Activity

Student Pages

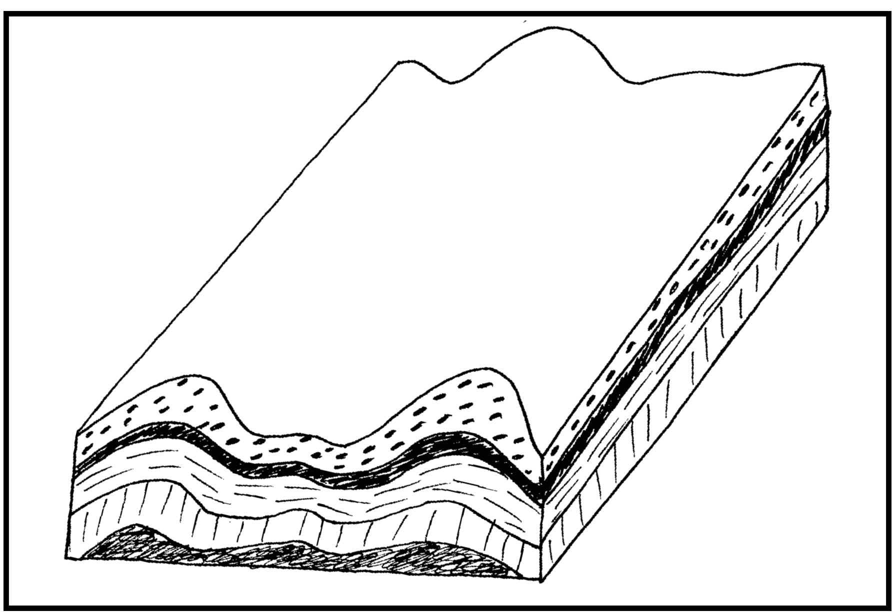
INTRODUCTION

Throughout history, geology has shaped and changed the landscape of the San Francisco Bay Area. Natural forces such as plate tectonics, sediment movement, and water flow have formed the land into the mountains, valleys, creeks, and rivers we see today. Look at the area around your home or your school; what natural forces might have shaped the features we see today? In this activity you will get a chance to explore the geologic forces that have created not only the San Francisco Bay as we know it, but also a lot of the landscape we see surrounding the Bay Area, such as the Sierra Nevada mountains and the Central Valley. You will use everyday food items to represent various tectonic plates in order to learn about how the plates move and how this movement has created our local landscape. Finally you will get to eat your "plate tectonic models" and enjoy a tasty treat!

MATERIALS

Your group will need

- 4 slices of bread
- 1 paper plate
- 1 plastic knife
- 1 plastic cup of peanut butter
- 1 plastic cup of jelly
- 1 plastic cup of snack mixture (optional)



PROCEDURE

1. Spread peanut butter on two slices of bread and spread jelly on the other two slices. DO NOT PUT SLICES TOGETHER YET!

2. You may sprinkle some of the snack mixture on the slices if you have some. (optional)

3. When your teacher tells you to, put your slices together. Alternate the slices between peanut butter and jelly and put them together as you would a normal sandwich.

4. Discuss among your group: "What happens to rocks when they are exposed over time to pressure and heat?" How would expect your sandwich model of rock layers to change in appearance if subjected to heat and pressure?

5. Observe your teacher demonstrate the process of folding and faulting.

6. Then try it with your group. (Refer to your Fault Activity Demo Sheet.) Slowly bend the stack up toward the center; push in from the edges to mimic the process of folding. Folding and faulting created the Himalayan mountain range and many other ranges in the world.

7. Now cut the stack in half through the middle, forming 2 blocks and slide them to show strike-slip movements of the Earth's crust. Demonstrate the strike-slip movement between two blocks by sliding the two sandwich blocks against each other and then horizontal to each other, following the diagrams on the Fault Activity Demo Sheet. The San Andreas Fault has this type of motion.

8. Cut one of your sandwich stack halves in half and show the vertical motion of the plates when pushed against each other. Use these sandwich blocks to demonstrate a normal fault by pushing the two blocks against each other and having one block slide downwards against the other (normal fault). Then have one slide upwards (reverse fault) against the other. The Owens Valley and Sierra Nevada fault zones area examples of normal faults. The Sierra Madre fault zone is an example of a reverse fault movement.

9. Then cut another of your stacks in thirds to show the formation of a valley, a graben fault movement. The graben fault is a special type of normal fault. The graben fault can be shown by cutting the remaining sandwich stack half into thirds and exerting force on the outer thirds to push the inner third downward. A fault-bounded ridge is called a horst, a fault-bounded valley is called a graben.

10. Take a core sample of one of your blocks by twisting a straw as you insert it into the densest part of the sandwich. After removing the straw, discuss the profile with your group, showing the pattern of materials (the alternating layers of peanut butter and jelly represent the different layers of rock). One of the basic rules of geology states that rock layers are laid down horizontally. Discuss with your partners which layers are the oldest and which the youngest in your model/core sample. Discuss your answers with your teacher and classmates.

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A Study of Faults and Geologic Activity

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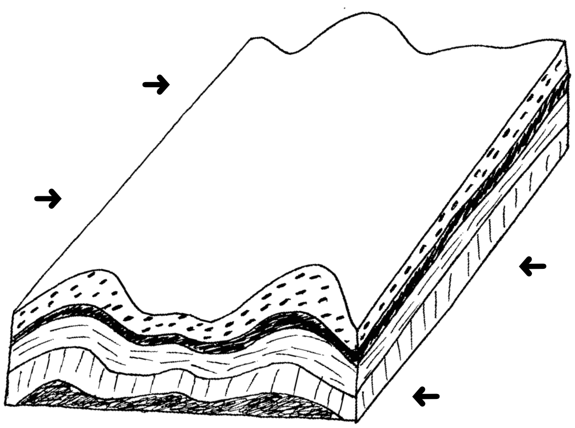
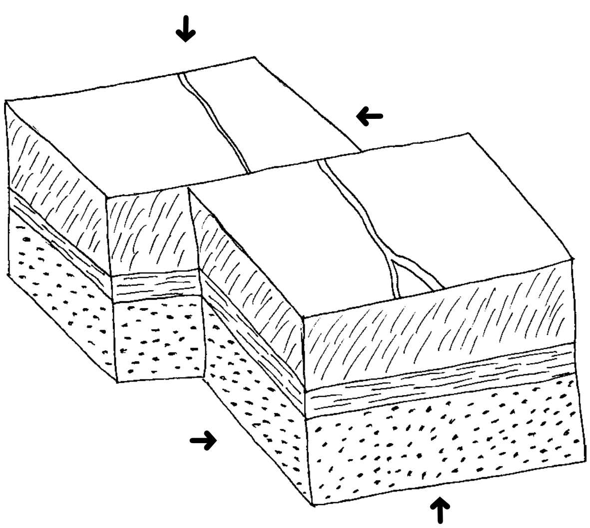
FAULT ACTIVITY DEMO SHEET

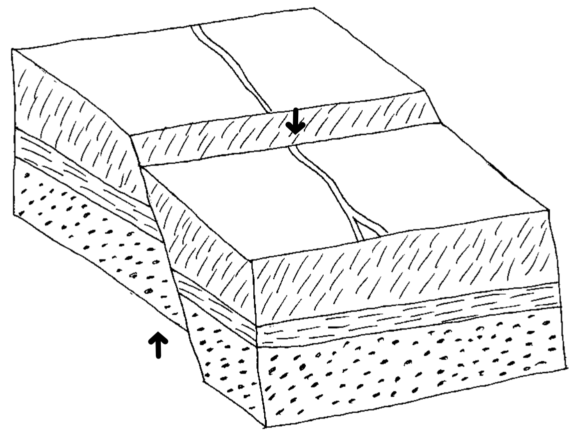
1. Slowly bend the stack up toward the center; push in from the edges to mimic folding. Folding and faulting created the Himalayan mountain range and many other ranges in the world.



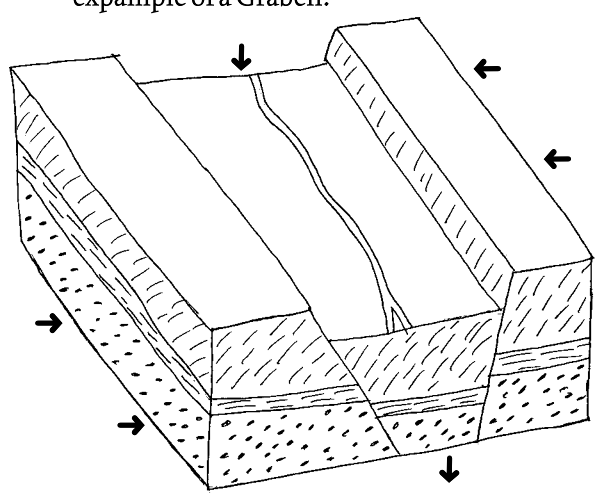
2. Cut the stack in half through the middle, forming 2 blocks and slide them together vertically, then horizontally to show strike-slip movements of the Earth's crust. The San Andreas Fault has this type of motion.



3. Demonstrate a normal fault by cutting one of your sandwich stack halves in half and show the movement of a normal fault. Push the two blocks against each other and have one block slide downwards against the other(normal fault). Then have one slide upwards (reverse fault) against the other.



4. Then cut another of your stacks in thirds to show the formation of a valley, a graben fault movement. Push the outer blocks towards the inner block, forcing the inner block downward. The Owens Valley is an expample of a Graben.



Liquefaction in Action

Bay Fill and Earthquakes: The Hidden Dangers

Overview

This activity will address issues regarding wetland development and bayfill and will demonstrate the dangers of building on land prone to liquefaction. The students will create a simple and fun model of a structure built upon wetlands and observe the impact of earthquakes on bay mud and landfill. Students will use common food items to represent the bay mud, soil, and developments, and then test the impacts of an "earthquake" on their structure. Finally, they can eat their delicious experiment.

Estimated Time

Approximately one hour

Objectives

Students will be able to:

- Define liquefaction
- Describe the impacts of earthquakes on landfills and developed wetlands
- Learn about the dangers of developing wetland areas
- Build a model to understand natural processes in conflict with human developments

Materials

For entire class:

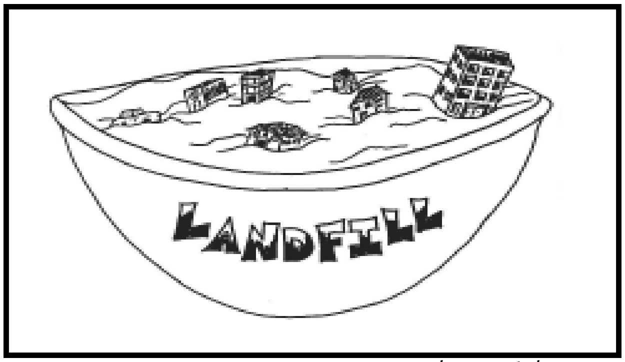
- sample of Bay mud, if possible

For every 3-4 students:

- 1 regional past and present map of the San Francisco Bay: http://www.sfei.org/ecoatlas/Habitat/maps/SFBay/pastpresinfo1.html

For each student:

- 1 small paper bowl, filled halfway with chocolate pudding



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- 1 small paper plate, taped to the bottom of the bowl with duct tape
- half a bowl's worth of chocolate pudding
- 4-5 oreo cookies
- 3-4 graham crackers or wafer cookies
- 3-4 pretzel sticks
- 3-4 banana slices
- 3-4 marshmallows
- 1 plastic spoon
- 1 napkin
- copies of Student Pages

California Science Content Standards

Grades 6

Standard Set 2.d: earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

Grade 7

Standard Set 7.d: construct scale models, maps and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

Grades 9-12

Earth Sciences Standard Set 9.a: the resources of major economic importance in California and their relation to California's geology.

Additional Resource

Loma Prieta Quake Liquefaction Photos
http://www.es.ucsc.edu/~es10/fieldtripEarthQ/Damage1.html

Background

Liquefaction is an important problem, typical of earthquakes. One possible definition of liquefaction would be: "When a saturated granular soil is shaken over a period, the pore-water pressure will tend to increase. When this pressure reaches the confining pressure the soil will suffer a sharp drop in strength, its behavior becoming close to that of a liquid." This results in ground deformation and settlement, tipping of buildings, landslides, failure of earth dams, or other hazards.

Liquefaction is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Liquefaction and related phenomena have been responsible for tremendous amounts of damage in historical earthquakes around the world.

Liquefaction occurs in saturated soils, that is, soils in which the space between individual particles is completely filled with water. This water exerts a pressure on the soil particles that influences how tightly the particles themselves are pressed together. Prior to an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other.

When liquefaction occurs, the strength of the soil decreases and, the ability of a soil deposit to support foundations for buildings and bridges is reduced. Increased water pressure can also trigger landslides and cause the collapse of dams.

Because liquefaction only occurs in saturated soil, its effects are most commonly observed in low-lying areas near bodies of water such as rivers, lakes, bays, and oceans. The effects of liquefaction may include major sliding of soil toward the body of water, or more modest movements that produce tension cracks.

Port and wharf facilities are often located in areas susceptible to liquefaction, and many have been damaged by liquefaction in past earthquakes. Most ports and wharves have major retaining structures, or quay walls, to allow large ships to moor adjacent to flat cargo handling areas. When the soil behind and/or beneath such a wall liquefies, the pressure it exerts on the wall can increase greatly - enough to cause the wall to slide and/or tilt toward the water.

Liquefaction also frequently causes damage to bridges that cross rivers and other bodies of water. Such damage can have drastic consequences, impeding emergency response and rescue operations in the short term and causing significant economic loss from business disruption in the longer term. Liquefaction-induced soil movements can push foundations out of place to the point where bridge spans lose support or are compressed to the point of buckling.

Where is liquefaction likely to occur? Two conditions must exist for liquefaction to occur: (1) the soil must be susceptible to liquefaction (loose, water-saturated, sandy soil, typically between 0 and 30 feet below the ground surface) and (2) ground shaking must be strong enough to cause susceptible soils to liquefy.

The most susceptible soils are generally along rivers, streams, and lake shorelines, as well as in some ancient river and lake deposits. Wetland soils are highly susceptible to liquefaction.

Teacher Procedure

1. If you have a sample of bay mud put it out in front of the class and encourage your students to observe and even touch it. Introduce the topic of wetland development and ask the students questions like:
   - Do you think that the Bay looks exactly the same as it did years ago?

- What changes do you think have happened that have affected the size and shape of the Bay?
- Have you ever experienced an earthquake?
- What kind of effects do you think earthquakes have on land developments?
- What are some things you know about wetland development?

2. Pass out the past and present maps of the San Francisco Bay and have the students look at what the Bay shoreline used to look like and what it looks like now. Have them estimate how much of our wetlands are left.

3. Explain that only 10% of our wetlands are left and discuss bayfill with them. Explain that most of San Francisco, Oakland airport, etc. are built on bayfill and point out those areas on the maps. What dangers do you foresee when we build on wetlands and bayfill?

4. Pass out materials to each student and explain that we are going to test some of the problems of building structures on wetlands and bayfill by building our own models and observing what will happen when there is an earthquake.

5. Tell the students that we are going to simulate building a structure on wetlands and bayfill. The chocolate pudding in their bowl is going to represent bay mud because it is soft and squishy.

6. Have the students put their oreo cookies on their plates and crush them up into tiny pieces and crumbs. This will represent the bayfill or dirt that we need to put on top of the mud for our development. Have them sprinkle the crumbs on top of the mud, covering the top of the mud, then place their bowls on their empty plates.

7. Next tell them the rest of their materials are their building materials and that they should build some sort of structure on their landfill. Let them be creative and have fun!

8. Now they will simulate the earthquake and see how many of their structures will stand. Have them carefully shake their plates with their bowls on them. (Make sure they shake the plate and not the bowl.) Explain that this is very similar to what happens when we really have an earthquake. Time the shaking and at 20 seconds explain that that is how long the Loma Prieta earthquake in 1989 lasted. Have them make a mental note of the "damage" in their bowl. After one minute, tell them that that was how long the 1906 San Francisco earthquake lasted and have them notice the "damage."

9. Ask them what their bowls looked like at 20 seconds versus what they looked like at one minute. Explain that the length of the earthquake affects the amount of damage done, and that much of the Bay Area that has been filled in by bayfill would respond to earthquakes in the same way their bowls did.

Class Discussion/Wrap Up

1. Discuss the concept of liquefaction. Explain that it occurs mainly in soils that are saturated with water and that the movement causes the water pressure to increase and the soil particles to move freely.

2. Brainstorm ways to prevent liquefaction and discuss wetland development issues.

3. Conduct the San Francisco Airport Debate in the History of Human Impacts section of this curriculum.

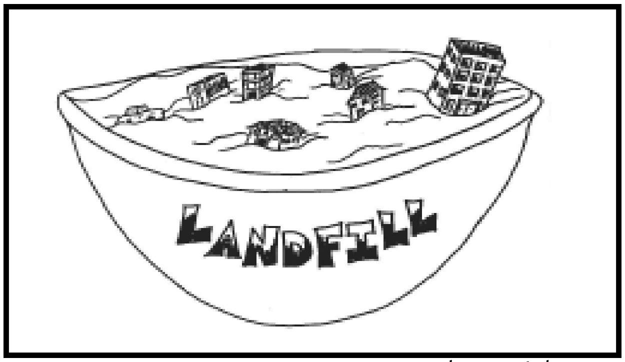
Liquefaction in Action

Bay Fill and Earthquakes: The Hidden Dangers

Student Pages

INTRODUCTION

Liquefaction is a common problem around the San Francisco Bay Area. It occurs when soils that contain a lot of water undergo pressure or impact, such as an earthquake. You will create a simple and fun model of a structure built upon wetland soils and observe the impacts of earthquakes on bay mud and landfill. You will use common food items to represent the bay mud, soil, and developments, and then test the impacts of an “earthquake” on your structure. Finally, you can eat your delicious experiment!



Sharón Friedner

MATERIALS

For every 3-4 students:

- 1 regional past and present map of the San Francisco Bay (from Oakland Museum or San Francisco Estuary Institute)

For each student:

- 1 small paper bowl filled halfway with chocolate pudding
- 1 small paper plate taped to the bottom of the bowl with duct tape
- 4-5 oreo cookies
- 3-4 graham crackers or wafer cookies
- 3-4 pretzel sticks
- 3-4 banana slices
- 3-4 marshmallows
- 1 plastic spoon
- 1 napkin
- Student Pages

PROCEDURE

1. If your teacher has a sample, observe the bay mud and touch it if you like. What does it feel like? Does it look and feel like other mud? If not, how is it different?

2. Working in groups of three or four look at the past and present maps of the Bay Area. What do you notice about the Bay? How has it changed? Estimate how much of our original wetlands remain today.

3. Locate your school on the map. Is it built on wetlands? What about your house?

4. What percentage of our wetlands remain in the Bay Area today?

5. List 3 reasons why we have lost so much of our wetlands.

a.

b.

c.

6. Name 2 places from the maps that are built on landfill.

a.

b.

7. Define liquefaction.

8. After your teacher passes out all the materials, begin building your structures built on bay fill. First start by crushing up your oreo cookies on your plates. Sprinkle your "fill" on your "wetlands" or "bay mud" and then use the rest of your materials to build structures on your "fill".

9. Now you are ready to simulate an earthquake. Carefully put your bowl on your plate and follow your teacher's instructions. Begin gently shaking your plate (not your bowl!). When your teacher calls out 20 seconds for the 1989 Loma Prieta Earthquake, make a note of the "damage" done to your structure, but don't stop skaking your plate! Continue shaking until your teacher calls one minute for the 1906 San Francisco Earthquake. Now look at the "damage".

10. Describe the results of "the Loma Prieta quake".

11. Describe the results of "the 1906 quake".

12. List 2 ways to avoid liquefaction.

a.

b.

13. When you're finished, you can eat your liquefaction model! Then clean up your work area.

Dirt All Around

A Study of Erosion and Sedimentation

TEACHER'S PAGES

Overview

In this activity students will learn about the processes of erosion and sediment transport through water systems. They will perform an experiment that will help them to visualize how different sized sediments settle out of the water and learn the source of the Estuary's sediments.

Central Question

What natural processes transported sediments and created the deep sand and mudflats that are common throughout the shores of San Francisco Bay?

Estimated Time

Part I and II—1-2 class periods
Part III—1 class period and a half-day field trip (optional)

Objectives

Students will be able to:

- Define erosion and understand the natural forces that create different sediment types
- Visualize how sedimentation has changed the shape of the Bay
- Predict how the Bay will look in the future
- Participate in a hands-on experiment in an outdoor setting

Materials

Part I: Erosion and Sediment Types
For the class:

- 1 soft rock
- 1 hammer
- 1 pair protective glasses
- 1 short, clear plastic or glass jar with lid
- a mixture of soil, sand, and gravel
- alum
- water
- eye droppers
- stereoscope or hand lens for each 3 to 4 students
- Copies of Student Pages with Sediment Sizing Chart

Part II: Sedimentation and Core Samples
For entire class:

- 1 box vanilla cupcake mix
- 1 box chocolate cupcake mix
- 1 box strawberry cupcake mix OR 1 box vanilla cupcake mix with a little red food coloring
- non-see-through cupcake holders (enough cupcakes for entire class)
- 1-2 cupcake pans
- frosting for cupcakes
- colored sprinkles
- 1 bag chocolate chips
- 1 bag raisins or M&Ms
- clear plastic straws (enough for each student)
- napkins
- 1 razor blade or small knife (for teacher)
- Copies of Student Pages

Part III: Scientific Sampling
For each group of 3 to 4 students:

- writing surface (such as clipboards)
- 1 pencil
- 1 piece of graph paper
- 1 trowel, coffee can, or small shovel
- 1 flat tray or cookie sheet
- 1 hand lens
- Copies of Student Pages

For the class:

- 1 yardstick

(This activity was adapted from "Estuarine Encounters" curriculum by Friends of the San Francisco Estuary.)

California Science Content Standards

Grade 4

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

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

Grade 6

Standard Set 2.a: water running downhill is the dominant process in shaping the landscape, including California's landscape.

Standard Set 2.b: rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.

Standard Set 2.c: beaches are dynamic systems in which sand is supplied by rivers and moved along the coast by wave action.

Grade 8

Standard Set 8.d: how to predict whether an object will float or sink.

Background

Erosion, a natural physical and chemical process by which the earth's rocks and soil are continuously worn down, has many different causes. Weathering begins the erosion of rock, changing its surface layers. The sun's heat contributes to the expansion and eventual breakup of rocks. Tiny rock fragments are then carried away by wind or washed away by rain. Rain also erodes rocks itself. It absorbs carbon dioxide from the atmosphere and forms carbonic acid, which dissolves some minerals and decomposes others. In cold climates frost breaks up rocks when freezing water expands in the rock's cracks and pores.

Running water is also a major cause of erosion. Stones carried with a river's current scour and abrade the banks and beds. A glacier removes all loose material in its path and grinds the solid rock over which it travels, using rock fragments embedded in its bottom and sides. Ocean waves and currents erode rocky cliffs and sandy beaches, especially during storms. When an area receives more water than the ground can absorb, the excess flows to the lowest level, carrying loose soil with it. Often, especially in arid areas with little vegetation, rivulets create a pattern of gulleys. Some of the eroded soil carried by rivulets is deposited in valleys, but much of it reaches the sea through streams and rivers.

The sediments in the San Francisco Bay reflect this erosion and sedimentation process. As water flows from the mountains in the Sierra Nevada range and travels out to the Bay the sediments in river channels break down from rocks to pebbles to gravel to dirt and sand and eventually to fine silts and clays called bay mud. Melted snow flows down the Sierra Nevada, Tehachapi, and Coastal mountain ranges and eventually funnels into the Sacramento and San Joaquin Rivers. These rivers come together in an intricate tangle at the Delta, where the water begins to slow. Sand deposits on the Delta bottom, and as the freshwater hits the salt water coming in from the Pacific Ocean the silt undergoes a chemical reaction called flocculation.

Flocculation is the process of charged minerals and sediment particles suspended in fresh water reacting with charged salt ions in salt water, causing the sediments and minerals to clump up, become heavy, and then fall to the bottom of the estuary floor. This flocculation process explains the formation of bay mud and is often used as a chemical process to separate out various particles from water in places such as sewage treatment plants.

Waves crash into the shoreline and landforms, thus eroding soils. Some of the resulting sediments are transported by tides throughout the Estuary where they settle as mudflats and sandflats. Sandflats of course are composed primarily of sand grains, with smaller percentages of silt, clay, and shell fragments.

Mudflats consist primarily of clay sediments with lesser amounts of silt, sand, and shell particles. The black slippery mud usually contains little oxygen, if any, in comparison to gray-green, yellow-brown, or brown samples which contain more plant material. This is because black mud contains bacteria that use up much of the oxygen as they process plant material.

Erosion causes constant changes in land, but the ultimate tendency of erosion is to reduce the land to sea level. Opposing this tendency are volcanic eruptions and crustal movements that raise mountains and new islands. Without human activities, soil loss through erosion would probably be balanced by new soil formation. On undeveloped land, soil is protected by vegetation. Human activities partially or wholly destroy protective vegetation and greatly speed up soil erosion.

Human activities during the Gold Rush greatly increased erosion and sedimentation and drastically altered the geology of the channel of the San Francisco Bay. Hydraulic mining, diking for agriculture, bayfill, and dredging over the years have severely changed the ocean floor as well as the natural habitats in the Bay. The collective term for gradual filling of the Bay is sedimentation or siltation. This process is augmented by other processe, such as the slow breakdown of plants, tides and currents, and human-related processes.

Core sampling is a process used by scientists to take a sediment sample that will show the soil column. Core sampling can give information on various historical and geological processes by indicating the different depths of different sediments. Geologists can analyze the sediment samples to illustrate erosion, sedimentation, volcanic, and plate tectonic processes.

Part I: Erosion and Sediment Types

Preparation

1. Gather the required materials, and collect soil samples from a variety of sites, including mudflats, beaches, and uplands (you need sediment of various sizes).

2. Demonstrate in front of the class, as an introduction, the process of sediment formation by using a hammer to break a soft rock (such as sandstone) into smaller pieces. Be sure to wear protective glasses.

3. Ask the students if they know of any natural forces that create sediments. Discuss the different types of erosion such as wind, water, rain, ice, and roots.

4. Then ask them questions about sediment transport and review transport through water, glaciers, and wind. Discuss background information material. Mention that the hammer symbolizes the natural forces that erode rock.

5. As a class, pour a mixture of water, fine and coarse sediment (a combination of mud, sand, and gravel) into a short, clear jar. Cap the jar and shake well.

6. Ask students to observe which sediments settle first. You can add a little bit of alum to speed up the process or leave the experiment overnight. After 30 minutes, do they form layers on the bottom of the jar? If so, what does this process suggest about where certain sediment types may be found throughout different areas of the Bay?

7. Arrange students in groups of three or four, hand out the worksheets and ask one student from each group to carefully remove samples (using an eyedropper) from the different layers of sediments that have settled in the jar and return to their group.

8. Ask students to test sediment size using the Sediment Sizing Chart to classify some of the sediments. Remember that sand is

the largest sediment and feels gritty. Silt grains have a smaller diameter but are not sticky, whereas clay sediments have the smallest diameter and feel smooth and sticky.

9. Have students use stereoscopes or hand lenses to see the sediments and identify the size differences between sand, silt, and clay sediments, using the sediment sizing chart. They should then answer the remaining questions in Part I of the worksheet.

Part II: Sedimentation and Core Samples

Preparation

1. Make or have a student make cupcakes for class the night before the activity.

2. For cupcakes: Make three different cupcake batters: vanilla, chocolate, and strawberry. (You can use food coloring if can't find strawberry.) The batters need to be different colors.

3. Add chocolate chips to the vanilla batter, nuts or raisins to the chocolate batter, and coconut flakes or shreds to the strawberry or colored batter; each batter should have some sort of different addition. You can choose to use different additions if you like.

4. Make cupcakes by layering the batters, so each cupcake has three different colored layers, putting batter with chocolate chips on bottom, then batter with raisins or M&Ms. *****Make sure to use non-see-through cupcake holders.*****

5. Bake cupcakes according to package directions. When cupcakes are cool, frost them. Add sprinkles on top of frosting.

Teacher Procedure

1. Pass out one cupcake and one clear straw to each student.

2. Explain to the students that their cupcake represents a sample of the Bay's floor and that first they are going to learn about natural processes and at the end they will get to eat them.

3. Give the students some background information about erosion, sedimentation, siltation, and flocculation in the San Francisco Bay Area and how that has affected the sediments that make up the bottom of San Francisco Bay.

4. Ask your students if they know what erosion, sedimentation, or siltation mean.

5. Explain that our earth is made up of many different layers and that these layers have formed over the years as a result of plate tectonics and erosion and sedimentation.

6. Discuss Bay geology and have students recall from Part I how different size sediments settled out of the water at different rates and depths.

7. Ask the students if they can think of some natural things that cause erosion or sedimentation (wind, water, plate tectonics, etc.).

8. Ask the students if they can think of some things we humans have done or continue to do which cause erosion or sedimentation and affect the Bay floor (dredging, hydraulic mining, deforestation, construction, etc.).

9. Now tell your students that they are going to be scientists and learn how scientists study geology of the Bay floor and rock formations in the San Francisco Bay Area.

10. Explain core sampling, its techniques, and what it can tell you. (from Background section)

11. Tell the students that they are going to use their straw as a core sampler and they are going to investigate the geology of the Bay

floor through their cupcake.

12. Show them how to take the sample by inserting the straw cleanly into the cupcake all the way to the bottom, then carefully removing the straw.

13. First have the students simply look at the contents of their sample, noticing the layers through the clear plastic straw.

14. Then come around to each student and make a vertical slice in the straw from top to bottom so your students can clearly see the contents of their sample.

15. Have the students answer the questions on

Part III: Scientific Sampling

Preparation

1. Part III can be done either on the school campus in an open field or area of land or as a field trip activity. Clear the activity with school custodians and gardeners if you plan to do Part III on school campus. If it is possible to take a field trip, make arrangements to take your students to a local wetland or riparian area. Again, clear this activity with the landowners or managers.

2. Get the materials together for this activity, and if it is part of a field trip, prepare the students for the trip.

Teacher Procedure

1. Mapping your sample area: Try to select a small plot that contains several sediment types. Lay out a grid of one square foot plots in the study site by drawing lines in the soil with a stick. Use a yardstick to measure off your plots. The total plot should be large enough so that each group of 3 to 4 students has a 1' X 1' section. Involve the students in figuring out this part of the activity.

2. Divide students into groups of 3 or 4 and assign each group to a specific segment within the plot. Hand out clipboards, pencils, graph paper, and the worksheets.

3. The students need to draw their section of the plot on the graph paper. They need to designate each small square on the graph paper to represent a constant distance. This may take some time to figure out how best to graph their plot.

4. Have each group draw their sample site on the map of the plot, examine the surface of the ground, record observations on their worksheet, then use a coffee can or trowel to extract a profile of the sediment. To do this, place the opening of the can upside down and level on the mudflat. Push the can almost entirely into the ground, stepping on it for added strength, if necessary. (An easy alternative is to use a small shovel or trowel to scoop a soil sample from the ground surface.)

5. Now pull out the can and dump the contents onto the cookie sheet or flat tray.

6. Have the groups bring the sediment sample profiles to flatter, higher ground so they can easily examine the soil. Discuss: What does the sample look like? What type of sediments do you see in your sample? Is your sample made of dead, decomposed plant material; a combination of clay, silt, and sand; or is it primarily clay or mud? What are some possible sources of these sediments? Did we find different sediments in the different plots? If so, why? Record this information on the worksheets.

7. Have the groups piece their individual maps together to create one large map of the entire test plot and compare results from the sediment sampling. Using the collected data, analyze the sediment of the entire plot. What types of sediments exist? Does the plot contain a mix of sediments?

8. When finished with the discussion, return sediments to the area where they were sampled and clear up your sampling area.

Class Discussion/Wrap Up

1. Begin a discussion asking students to summarize what they learned about natural processes and geology. Review:
   - Erosion
   - Sedimentation/Siltation
   - Some of the different types of sedi ments
   - Different modes of sediment transports
   - Why do we expect to see different sediments in different elevations of the watershed?
   - What are some human actions that are affecting erosion and sedimentation processes today?

2. Have the students draw a picture of and/or describe what they predict the shape of the Bay will look like in the future if there is increased erosion and sedimentation due to human impacts on natural processes. Compare their pictures and/or descriptions.

3. As an extension, conduct the River Cutters Activity, developed by the Lawrence Hall of Science. See "River Cutters" GEMS guide for more information, available from the Lawrence Hall of Science (510) 642-7771.

Additional Resource

NASA Images
http://www.kidsinfolink.com/index.cfm?page=Con.Goto&link=235347

Dirt All Around

A Study of Erosion and Sedimentation

Student Pages

INTRODUCTION

In these activities you are going to learn about the processes of erosion and sediment transport through water systems. You will perform experiments to show how different sediments travel through the watershed and to the San Francisco Bay.

PROCEDURE

PART I: Erosion and Sediment Types

After your group has collected a soil sample from the jar your class has prepared, work together to classify the sediments according to the sediment sizing chart, using hand lenses if available.

1. What types of sediment did you find in the sample?

2. What is erosion? How does it affect the health of a creek or river?

2. List 3 natural causes of erosion.

a.

b.

c.

3. List 3 non-natural causes of erosion.

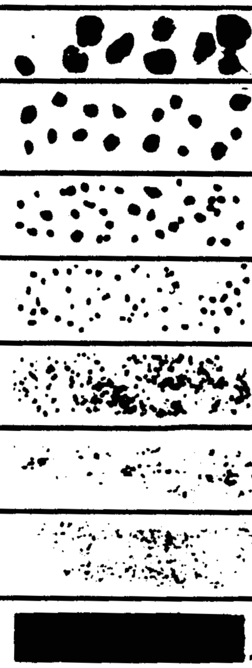
a.

b.

c.

Sediment Sizing Chart

Pebbles (64-4 mm) use ruler



Granules (4-2 mm)		**particle roundness/ angularity determined easily by eye**
Sands	**Very Coarse (2-1 mm)**	
	Coarse (1-0.5 mm)	
	Medium (0.5-0.25 mm)	
	Fine (0.25-0.125 mm)	**each particle easily distinguished by eye**
	Very Fine (0.125-0.063 mm)	**somewhat gritty**
Silt (0.063-0.0039 mm)		**smooth, not sticky**
Clay (below 0.0039 mm)		**smooth and sticky**

The sediment sizing chart is a standardized way of determining particle size.

PART II: Sedimentation and Core Samples

Take a core sample of your cupcake and answer the following questions about your sample.

1. What is core sampling and what can it teach us?

2. Describe 3 observations you made about your "core sample".

a.

b.

c.

3. What natural and human factors could have impacted these layers?

PART III: Scientific Sampling

As a group, you will be graphing the sediment of an area. After working together to plot the land, you will be assigned to an individual plot. Use your graph paper to map your plot and answer the following questions.

1. Examine the surface of your plot. List 3 observations.

a.

b.

c.

2. Examine your soil sample. What does your sample look like?

3. What type of sediments do you see in your sample?

4. Is your sample made of dead, decomposed plant material; a combination of clay, silt, and sand; or is it primarily clay or mud?

5. What are some possible sources of these sediments?

6. Did we find different sediments in the different plots? If so, why?

7. Were there living organisms in your sample? If so, can you identify the organisms?

"What Happened Here Before"

TEACHER'S PAGES

Creating a Bay Timeline

Overview
In this activity students will begin by reading a poem by Gary Snyder and completing a homework assignment to learn about his presentation of the history of California. Students will then read about the geological history of the San Francisco Bay and will work in groups to create an artistic representation of a timeline of the Bay.

Central Questions
What were some of the major events in the history of California that affected its natural resources and physical characteristics? What is the geological history of the San Francisco Bay and its watershed? What role have plate tectonics, sedimentation, volcanoes, and climate change played in the formation of the Bay?

Estimated Time
Part I: Poetic Review
1 homework assignment
Part II: Artistic Interpretation
1 reading assignment, 1-2 class periods to create mural

Objectives
Students will be able to:
- Interpret a poem, identifying and defining key words and phrases, describing a theme, and linking the structure to the content.
- Describe the history of California and its wealth of natural resources.
- Comprehend that geology is a dynamic process.
- Understand how plate tectonics, sedimentation, climate change, and volcanic activity have shaped the Bay.
- Explain the formation of specific landscapes around the Bay.

Materials
Part I: Poetic Review
For each student:
- 1 copy of student worksheet with Gary Snyder's poem "What Happened Here Before"

Part II: Artistic Interpretation
For each student (for reading assignment):
- 1 copy of "Bay Today, Gone Tomorrow"

For each group (for mural):
- 1 blown-up copy of picture of the Bay
- Ruler
- Pencils
- Art supplies (crayons, color pencils, paints, etc.)

California Science Content Standards
Grade 6
Standard Set 1.e: major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate motions.
Standard Set 1.f: how to explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes).
Standard Set 2.a: water running downhill is the dominant process in shaping the landscape, including California's landscape.
Standard Set 2.b: rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.
Standard Set 2.d: earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.
Grade 7
Earth and Life History (Earth Science)
Standard Set 4.a: Earth processes today are similar to those that occurred in the past and slow geologic processes have large

cumulative effects over long periods of time.

Standard Set 4.b: the history of life on Earth has been disrupted by major catastrophic events, such as major volcanic eruptions or the impact of an asteroid.

Standard Set 4.c: the rock cycle includes the formation of new sediment and rocks. Rocks are often found in layers with the oldest generally on the bottom.

Grades 9 - 12

Earth Sciences Standard 9.a: the resources of major economic importance in California and their relation to California's geology.

Language Arts

Grades 6 - 12

Reading

Students read and understand grade-level-appropriate material. *(See Standards for details)*

Teacher Procedure

Part I: Poetic Review

1. Pass out copies of Gary Snyder's poem "What Happened Here Before" and worksheets as a homework assignment.

2. Tell students that they are to read the poem carefully at least two times through before beginning the assignment. Then they should fill out the worksheet accompanying the poem. The worksheet requires the students to find one key word from each time frame in the poem and do a little research in the library or on the internet to define their key word.

3. Give the your class some examples of appropriate key words, citing a few words from the vocabulary list. The key words should be words describing the Earth's physical characteristics or natural resources (examples: slate, schist, manzanita, blacktail hare, etc.).

4. Each student should answer the following questions about the poem regarding its meaning and the meaning of the key phrase "WE SHALL SEE/WHO KNOWS/HOW TO BE."

Questions:

- What did you think of the poem?
- How did the poem make you feel?
- What are some of the key words you found and what are their definitions?
- Which key words did you not know before the presentations and how do they play a part in the poem?
- What specific images from the poem teach us about the history of California?
- What do you think is the poet's message?
- What does the poet seem to think about how we treat the Earth today?
- What do you predict California will look like in the future and how would you write a verse of the poem for the future time period? (Have the students read some verses aloud.)

5. The next day in class, lead a discussion about the poem before collecting the students' homework assignments.

Part II: Artistic Interpretation

Teacher Procedure

1. Pass out "Bay Today, Gone Tomorrow" article to students the day before and tell them to read it for homework.

2. Tell the students to pay special attention to the geologic processes that shaped today's Bay and to create a list of geologic processes mentioned in the article that have shaped the Bay.

3. In class the next day, divide class into 4 groups.

4. Pass out art materials to groups.

5. Explain that they are to read the article and create a free-form artistic mural detailing the history of the formation of today's San Francisco Bay. Their pictures should show the changes in their time period.

6. Assign each group to a specific time period/ era in the formation of the Bay and have the

group brainstorm the most important parts of their time period. Then each group will design and create their mural on the blown-up picture of the Bay.

- Group 1: volcanic eruption and plate tectonics, Bay Block
- Group 2: river systems, siltation, and sedimentation process
- Group 3: glaciation and end of ice age processes, sea level rise and drop
- Group 4: predictions of future changes....

7. Tell the groups that each group should create their mural to explain visually the processes they are assigned. They may use specific words, phrases, and quotes from the article. Also, ask them to label their time period on their mural.

8. When students are ready, have them display their murals in the room so they can see the other groups' work. Ask them what order the murals should go in to create a timeline for the history of the formation of today's Bay.

9. Have each group present their murals to the class, explaining what geologic processes occurred during their time period, etc.

Class Discussion/ Wrap-Up

1. Relate the article by Glen Martin to the poem by Gary Snyder. Each deals with almost incomprehensible amounts of time. How does each writer give us perspective on our place in geologic time? What are the similarities and differences between the poem and the article?

2. Ask the students to make predictions of what the Bay may look like thousands of years from now.
   - What changes may take place?
   - What geologic processes might cause these changes?
   - What are some things that we humans are doing that are affecting the Bay and its natural resources? (bay fill, wetland development, water diversion from the Delta, water pollution)
   - What are some things that we can do to protect our resources and prevent the types of changes we have caused?

Additional Resources

Geologic Bay History
http://squall.sfsu.edu/courses/geol103/labs/estuaries/partII.html

"What Happened Here Before"

Student Pages

Part I: Literary Comprehension

1. Read the poem "What Happened Here Before" by Gary Snyder carefully at least two times before beginning the assignment. On a separate sheet of paper write out one key word from each time period within the poem. Do a little research either in the library, on the internet, or in encyclopedias or dictionaries to define the terms you selected. The terms selected should be key words within that section of the poem, describing the Earth's physical characteristics, natural resources, or wildlife. (examples: schist, manzanita, blacktail hare, etc.)

Part II: Literary Analysis

Answer the following questions on a separate sheet of paper.

1. What do you think is(are) the overall theme(s)/message(s) of this poem?

2. What do you think the poet was trying to achieve by separating the poem into segments of time?

3. What are the Feather, Bear, and Yuba?

4. What historical event do you think the phrase "tossed up trees and boulders with big hoses" is referring to?

5. What could "sunlight grown heavy and tasty/ while moving up food-chains/ in search of a body with eyes and a fairly large/ brain" mean?

6. What do you think the phrase "the land belongs to itself./'no self in self: no self in things'" means?

7. Interpret the phrase "WE SHALL SEE/ WHO KNOWS/ HOW TO BE."

8. How did the timeline presented in this poem make you feel?

9. Did you like or dislike the poem? Why?

WHAT HAPPENED HERE BEFORE

by Gary Snyder

— 300,000,000—
First a sea: soft sands, muds, and marls
— loading, compressing, heating, crumpling,
crushing, recrystallizing, infiltrating,
several times lifted and submerged,
intruding molten granite magma
deep-cooled and speckling,
gold quartz fills the cracks—

— 80,000,000—
sea-bed strata raised and folded,
granite far below.
warm quiet centuries of rains
(make dark red tropic soils)
wear down two miles of surface,
lay bare the veins and tumble heavy gold
in streambeds
slate and schist rock-riffles catch it –
volcanic ash floats down and dams the streams,
piles up the gold and gravel—

— 3,000,000—
flowing north, two rivers joined,
to make a wide long lake.
and then it tilted and rivers fell apart
all running west
to cut the gorges of the Feather
Bear, and Yuba.

Ponderosa pine, manzanita, black oak, mountain yew,
deer, coyote, bluejay, gray squirrel,
ground squirrel, fox, blacktail hare,
ringtail, bobcat, bear,
all came to live here.

—40,000—
And human people came with basket hats and nets
winter-houses and underground
yew bows painted green,
feasts and dances for the boys and girls
songs and stories in the smoky dark.

—150—
Then came the white man: tossed up trees and
boulders with big hoses,
going after that old gravel and gold.
horses, apple-orchards, card-games,
pistol-shooting, churches, county jail.

We asked, who the land belongs to.
And where one pays the tax.
(two gents who never used it twenty years,
and before them the widow
of the son of the man
who got him a patented deed
on a worked-out mining claim,)
laid hasty on the land that was deed and acorn
grounds of the Nisenan?
Branch of the Maidu?

(they never had a chance to speak, even,
their name.)
(and who remembers the Treaty of Guadalupe Hidalgo.)

the land belongs to itself.
"no self in self: no self in things"
Turtle Island swims
in the ocean-sky swirl-void
biting its tail while the worlds go
on-and-off
winking

& Mr. Tobiassen, a Cousin Jack,
assesses the county tax.
(the tax is our body-mind, guest at the banquet
Memorial and Annual, in honor
of sunlight grown heavy and tasty
while moving up food-chains
in search of a body with eyes and a fairly large
brain—
to look back at itself
on high.)

now,

we sit here near the diggings
in the forest, by our fire, and watch
the moon and planets and the shooting stars—

my sons ask, who are we?
drying apples picked from homestead trees
drying berries, curing meat,
shooting arrows at bales of straw.

military jets head northeast, roaring, every dawn.
my sons ask, who are they?

WE SHALL SEE
WHO KNOWS
HOW TO BE

Bluejay screeches from a pine.

BAY TODAY, GONE TOMORROW

S.F. region's defining feature is just a transitory puddle in geologic time

by Glen Martin, San Francisco Chronicle Staff Writer
Monday, December 20, 1999

If you had planned to stroll to Ocean Beach 17,000 years ago, you would have been well advised to pack a lunch. And maybe dinner and the next day's breakfast, too.

That's because the coast was very far away. From where San Francisco sits, the beach was 26 miles west, about six miles past today's Farallon Islands.

The islands themselves, of course, were not islands at all — they were peaks.

And San Francisco Bay? Well, there was no bay. And that would remain the case for several thousand years.

The site of the present bay was a series of broad valleys, each with a tributary stream that poured into a mighty, sediment-swollen river that originated in the Sierra Nevada. This river drained through the Central Valley, the Carquinez Strait, Raccoon Strait and the stony ramparts that are now the Golden Gate.

A bay, in fact, is something of an anomaly for the San Francisco region.

"During the past 600,000 years, the bay has only existed during three brief periods totaling about 15,000 years," observes Ken Lajoie, a senior geologist with the U.S. Geological Survey in Menlo Park who counts the Bay Area's geology among his specialties.

"The present bay has existed near its (current) size only for the last 4,000 years," he says. And if the past is any indication, it will be around for only another 1,000 years or so.

5,000-YEAR LIFE-SPAN

The geological history of San Francisco Bay is really the story of several bays — each of which lasted only about 5,000 years — and of the tens of thousands of years between, when the land supported big rivers and lovely valleys.

It is a story that involves the cataclysmic raising and lowering of the Pacific Ocean, stupendous volcanic eruptions, the creation of mountains through the grinding, compressing and upheaval of tectonic plates and the inundation of entire landscapes by vast floods.

It is also a story of life — of primeval forests of cedar and pine, of great Pleistocene mammals such as mammoths and giant ground sloths, and of the people who hunted them with nothing more than flint-pointed spears.

The very dimensions of the story can't help but give one a certain perspective, observes Lajoie, who notes that even the most dramatic of the Earth's features — bays, rivers, mountains — are ephemeral in the context of geologic time.

'NOTHING IS PERMANENT'

"We tend to think that the Earth's features don't change, but geologically speaking, the fact is that nothing is permanent, or even around very long," he says.

Today's bay formed when the last ice age waned. At the height of the last glaciation about 17,000 years ago, large amounts of water evaporated from the oceans and fell as snow, not rain, compacting into huge continental glaciers. Sea level lowered by about 300 feet, and big expanses of the present continental shelf were exposed.

As the glaciers retreated, sea levels began rising, with rates ranging from three feet per century to 15 feet per century. About 10,000 years ago, the ocean began sneaking through the Golden Gate, forming the nascent San Francisco Bay.

"The bay only reached its present size within the last few hundred years," says Lajoie.

Even while the melting glaciers worked to form a large bay, other factors conspired to restrict its size. "The bay would be about twice its present size if sediments hadn't partially filled the subsiding basin it now occupies," Lajoie observes.

But to understand the forces that shaped the bay, you have to go further back in time — close to a million years further.

The sedimentary record indicates that the interior of California didn't always drain through the bay basin, as is now the case. Minerals from the Sierra Nevada began appearing in the basin somewhat less than 600,000 years ago — a blink in the context of geological time.

Prior to that, a vast inland sea called Corcoran Lake occupied much of the Central Valley, draining through the Salinas River into Monterey Bay.

VOLCANIC ERUPTION

About 760,000 years ago, a tremendous volcanic eruption occurred in what is now the Bishop area. A great caldera was created, and massive amounts of volcanic ejecta were deposited in the lake.

But this ash didn't make it into the bay until tectonic shifting in the Earth's crust caused the Bay Area to subside and the south end of the lake to rise about 560,000 years ago.

This caused the lake to spill over the ridge that separated it from the bay basin. The flow carved the Carquinez Strait and drained the lake. It could have happened so fast that it would have been a single, catastrophic event, says Lajoie — a great gush of water roaring to the sea.

Since then, tectonic activity — upthrusting of the Earth's crust — has plugged the Central Valley's outlet through the Salinas River. Now, everything that flows into the Sacramento and San Joaquin valleys ultimately pours out the bay.

Another eruption, this from Mount Lassen and much smaller than the Long Valley Caldera near Bishop, also contributed sediments to the bay.

"This occurred about 435,000 years ago," says Lajoie. "Sediments from the event are called the Rockland Ash, and can be seen clearly in the sea cliffs at Fort Funston on the San Francisco coast."

As the ice from the last glaciation melted, the Sacramento and San Joaquin rivers became great, braided streams choked with sediment.

"All that glacial outwash was dumped in the Central Valley and the Delta," says Lajoie. "There was so much sediment that huge dune fields blew out of the river near Antioch about 15,000 years ago. The same thing happened where Oakland now sits."

Oakland, in fact, is built over a deposit of dune sand known as the Merritt Sand. There was no bay at that time, but those sediments ultimately covered much of the bay basin.

SOURCES OF SILT

A good deal of fine silt and clay still comes into the bay from the Sacramento-San Joaquin river system. But the lion's share of sediment — mostly sand and gravel — issues from Alameda Creek, which drains Livermore Valley through Niles Canyon.

"Many people find that surprising," says Lajoie, "because the biggest source of ongoing bay sedimentation isn't even directly adjacent to the bay — it's Livermore Valley. There's a huge alluvial fan of sediment deposited by Alameda Creek that spreads out beneath the bay from the Coyote Hills to the shore of Palo Alto."

Other things have helped the bay become a prime sediment trap — things of a tectonic nature. Mountains have built on both the San Andreas and Hayward faults, sharply defining the limits of the estuary. The process continues today, with the continuing uplifting of the Santa Cruz Mountains, which straddle the San Andreas Fault.

Simultaneously, the land just west of the Hayward Fault is subsiding; meanwhile, structural rock underlying the South Bay is slowly sinking and gradually tilting eastward.

As the Santa Cruz Mountains and the Berkeley Hills ascend, they are squeezing the zone of bedrock between them, known as the Bay Block.

"The interesting thing about the Bay Block is that it is basically free of faults at this point," observes Lajoie. "But as it continues to be compressed, it might eventually develop new fault lines."

CHANGES CONTINUE

The change has been dizzying — and it won't abate. It will continue, regardless of the level of human activity. Erosion and plate tectonics will grind on inexorably. And another ice age is not merely likely, Lajoie observes — it is inevitable.

Lajoie says there is increasing evidence to indicate that ice ages are triggered by perturbations in the Earth's orbit, subtle movements caused by the gravitational effects of Jupiter and our moon.

MASSIVE AMOUNTS OF DUST

"The planets formed by sweeping up massive amounts of dust and debris when the solar system formed, but a lot was left over," says Lajoie. "It appears concentrated in a disk around the sun."

The Earth's orbital plane tips through this debris disk every 100,000 years or so, Lajoie observes. The dust occludes sunlight, reducing the amount of thermal energy that reaches the planet's surface.

That probably isn't enough to start an ice age by itself, he says.

"The oceans distribute solar energy globally, but the margins are very fine," he said. "The orbital parameters can't do it by themselves — but they're triggers. When the balance is finally thrown off in the oceans, glaciation can occur very quickly."

But what about global warming? Couldn't the ongoing atmospheric loading of heat-trapping gases like carbon dioxide forestall another ice age and guarantee the longevity of the bay, orbital wobbles notwithstanding?

Lajoie doesn't think so.

"I'd prefer that we maintain a cautious attitude about releasing greenhouse gases, but I don't think they could overcome the orbital signal," he says. "I think it's just too strong."

Our distant descendants, then, might well have to forgo bay views if they plan to live in San Francisco.

"When glaciation occurs, the bay drains, and everybody ends up walking to the Farallones," Lajoie says.

THE MAKING OF A BAY

Three geological processes have shaped San Francisco Bay: the rise and fall of sea level, the shifting of tectonic plates and the deposition of sediment from rivers. All work in concert to form an estuary that is in constant flux — and that periodically disappears for tens of thousands of years.

— Sea Level Rise

During the height of the last Ice Age 17,000 years ago, sea level dropped by 300 feet, and there was dry land west of what is now the Farallon Islands.

Melting glaciers caused sea levels to rise, and the current bay began to form around 10,000 years ago. It has existed near its current size only for the the last 4,000 years.

—The Bay Block

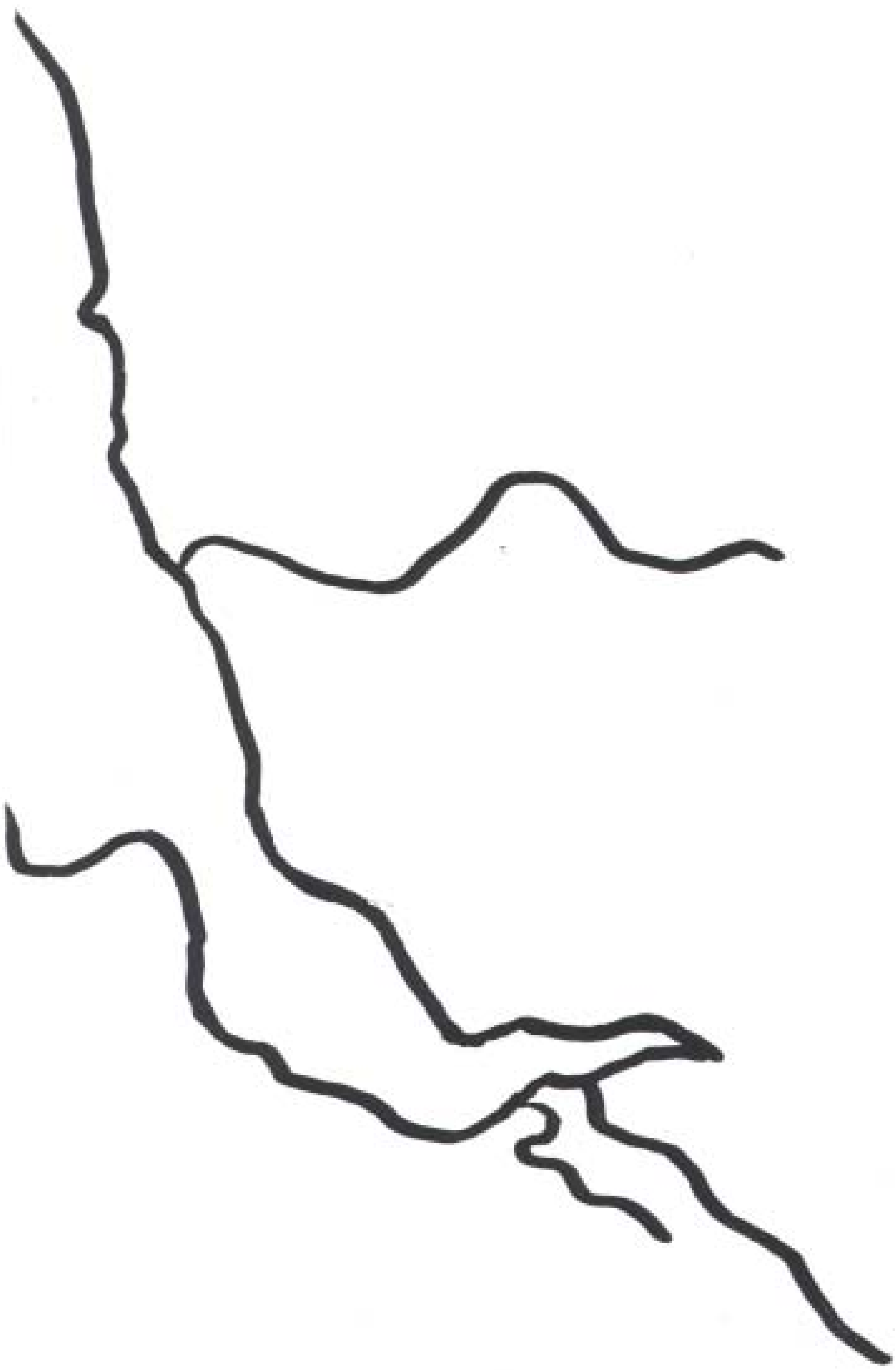
Shifting tectonic blocks continue to shape the bay. The rising Santa Cruz Mountains and Berkeley Hills are compressing the Bay Block, a vast slab of Franciscan rock underlying the south bay and its sediments. Though the Bay Block is essentially free of faults, it is expected that this compression will ultimately cause new faults to form.

CORCORAN LAKE

About 760,000 years ago, much of California's Central Valley was a great freshwater inland sea known as Corcoran Lake. The lake's outlet was the Salinas River, ultimately draining to Monterey Bay.

Then about 560,000 years ago, tectonic uplifting allowed the lake to rise sufficiently to cut through the soft soils of what is now the Bay Area. The Carquinez Strait was rapidly carved.

The uplifting also plugged the Salinas Valley outlet, leaving San Francisco Bay as the Central Valley's only outlet. Sediment deposited by Central Valley rivers limits the size of the bay.



A Healthy Bay is a Wealthy Bay

Natural Resources and the Environment

TEACHER'S PAGES

Overview

In this activity students will study and understand how humans have used California's wealth of natural resources and the San Francisco Bay. Students will learn of the different human impacts and demands on the San Francisco Bay Area's environment through a historical context. This activity will also bring students up-to-date with current environmental issues surrounding the health of the Bay and its resources.

Central Questions

Part I: The Value of California's Water

What are some of the different reasons Californians value water? What happens when people disagree over how to use the natural resources in the Bay Area?

Part II: California Land-Water Relationships/ What Are Our Priorities?

What are some of the natural resources we have in the San Francisco Bay-Delta System? How can we prioritize these resources?

Estimated Time

Part I: 1 homework assignment, 2-3 classroom periods

Part II: 1 research assignment and essay

Objectives

Students will be able to:

- Read and highlight key points from the given articles
- Use critical thinking to answer questions from the articles and evaluate current situations

(President Theodore Roosevelt and John Muir in Yosemite)

- Form opinions on controversial issues based on fact
- Learn of the different roles involved in natural resource usage decision-making
- Learn about the relationships between natural resources, economics, and the environment
- Develop strong arguments and present their opinions to the class

This activity was adapted from the Library of Congress Lesson Two, Case Study: Should the Hetch Hetchy be Dammed?

Materials

Part I:
For each student:
- 1 copy of Ken Chowder's "Can We Afford the Wilderness?" article*
- 1 copy of John Muir's "The Hetch Hetchy Valley" article*
- 1 copy of the Hetch Hetchy Timeline*
- 1 copy of the article "Gifford Pinchot and the Damming of the Hetch Hetchy" from the USDA Forest Service*
- 1 copy of the article "The Ghosts of Hetch Hetchy" by Gene Rose*
- 1 copy of information page from San Francisco Public Utilities Commission*

* All articles are attached to the end of this write -up

Part II:
For each student:
- 1 copy of the four essay topics

California Science Content Standards Grades 9-12

Earth Science Standard 9.a: the resources of major economic importance in California and their relation to California's geology.

Earth Science Standard 9.c: the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

Biology/Life Sciences Standard 6.a: biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.

Biology/Life Sciences Standard 6.b: how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

California History/Social Science Standards Grade 8

Standard 8.8.4: the role of the great rivers and the struggle over water rights

Standard 8.12.1: patterns of industrial and agricultural development as they relate to climate, natural resource use, markets, and trade

Standard 8.12.5: the location and effects of urbanization, renewed immigration, and industrialization (e.g., effects on the social fabric of cities, wealth and economic opportunity, and the conservation movement)

Grades 9-12 Analysis Skills

Chronological and Spatial Thinking

1. Students compare the present with the past, evaluating the consequences of past events and decisions and determining the lessons that were learned.

Historical Interpretation

3. Students interpret past events and issues within the context in which an event unfolded rather than solely in terms of present-day norms and values.
4. Students understand the meaning, implication, and impact of historical events and recognize that events could have taken other directions.
5. Students analyze human modifications of landscapes and examine the resulting environmental policy issues.

Grade 11

Standard 11.6.4: Analyze the effects and controversies of New Deal economic policies and the expanded role of the federal government in society and the economy since the 1930's (e.g., Works Progress Administration, Social Security, National Labor Relations Board, farm programs, regional development policies and energy development such as the Tennessee Valley Authority, California Central Valley Project, Bonneville Dam).

Standard 11.11.5: Trace the impact of, need for, and controversies associated with environmental conservation, expansion of the national park system, and the development of environmental protection laws, with particular attention to the interaction between environmental protection and property rights.

Grade 12

Standard 12.3.2: Explain how civil society

elections.

makes it possible for people, individually or in association with others, to bring their influence to bear on government in ways other than voting and elections.

California English/Language Arts Standards Grades 6-12 Reading, Writing, Speaking

Please refer to standards.

Part I: The Value of California's Water

Vocabulary

Raker Bill, conservationist, preservationist

Background

Read through the Hetch Hetchy Timeline and the articles provided for the students. (attached at the end of this write up)

Teacher Procedure

1. Pass out one copy of "The Ghosts of Hetch Hetchy," "Gifford Pinchot and the Damming of Hetch Hetchy," the Hetch Hetchy Timeline, and the San Francisco Public Utilities Commission information sheet.

2. Explain to the students that they will be reading this material at home to get acquainted with the real-life controversy that occurred in Hetch Hetchy Valley of Yosemite National Park.

3. Tell them that they should read the articles as homework and be prepared to discuss what they learned about the situation in Hetch Hetchy Valley.

4. (Next class period) Introduce this lesson by informing students that they will be re-creating a Congressional debate over the Hetch Hetchy Valley in California's Yosemite National Park, a debate which served to clarify the issues and divide the conservation movement clearly into "preservationist" and "conservationist" camps.

5. In full class discussion or interactive lecture, review the reasons for setting aside Yosemite as a national park. Students should notice during this review the mixture of reasons, some "preservationist" and some "conservationist", used by various advocates. Discuss the difference between conservationists and perservationists. Conservationists believe in using natural resources to benefit all groups involved (including humans) and preservationists believe that resources should be preserved so as not to disrupt nature.

6. Divide the students into these 5 groups:

- City of San Francisco officials
- Sierra Club members
- members of the House Committee on Public Lands (HCPL was the committee which began holding hearings on the damming of the Hetch Hetchy in 1908)
- local Citizens Action Coalition living upstream from the dam site
- Employees of PG&E

7. Tell each group to choose one spokesperson to play the role of the leading figure of the group:

- Mayor James D. Phelan of San Francisco/ City of San Francisco officials
- John Muir/ Sierra Club members
- Chairperson of HCPL/ members of the House Committee on Public Lands
- Leader of the Action Coalition/local Citizens Action Coalition
- Executive Director of PG&E/PG&E

8. Students in each group will research their arguments and compile what they consider to be the best arguments for their position in the public hearing. The groups should record four main points supporting their argument. HCPL members should discuss and record at least 3 questions they will have for each group on the day of the hearing.

Option #1

a. Tell students to read through the homework articles and extract information to support their group's view on the Hetch Hetchy controversy. They should use the articles and select quotes and specific points of information to support their position.

Option #2:

a. Have students meet in their groups to identify their group's main points on the issue and discuss where they would like to begin researching (library, internet, etc.). Tell students to research the Hetch Hetchy issue and find information that would support their arguments. Each student should find at least 2 articles and copy down their URLs. Point students with internet access to the Library of Congress web site at: http://learning.loc.gov/learn/lesson97/conser1/lesson2.html and tell them to look through the links at the extension section of the activity.

b. Students should read through the articles and extract information to support their group's view on the Hetch Hetchy controversy. They should use information in the articles to formulate their arguments.

9. Once students have formed their arguments the class can perform the mock debate. On the day of the mock hearing, each spokesperson will be given 3 to 5 minutes to make a statement, after which s/he will stand for at least 3 questions from the committee. After each group has presented, the committee can ask each group if they would like to give one rebuttal or additional comment. At the close of the hearing, the committee will vote on whether to send the Raker Bill (to build the dam) to the full House.

10. The teacher will follow up the vote with a review of the principal arguments advanced by each side, identifying the preservationist and conservationist arguments, and exploring the main differences that emerged between the two groups through the controversy over Hetch Hetchy.

PART II: California Land-Water Relationships/ What are Our Priorities?

1.After the mock hearing have the students research and write individual 2-3 page essays on one of the following subjects:

- Research an alternative approach to the Hetch Hetchy Dam and supplying water to the San Francisco population and write an informative essay on it, citing all sources.
- Research and develop a comparison between the establishment of Yosemite and another California National Park, such as Trinity, Kings Canyon, Sequioa, Inyo, Death Valley, etc. What, if any, local controversies did the parks encounter? How are they different or similar?
- Research and write an essay on the environmental and biological effects dams have on the aquatic habitat. What main impacts do dams have on river habitats? What species have been affected by the Hetch Hetchy Dam and how has the dam affected their populations?
- Research and write an informative article on the Cosumnes River, the last "wild" (undammed) river in Northern California. What are some ways people are using the river and the land around it? What are some dangers the river faces due to the increasing human population?

Extensions:

- Obtain a copy of the Delta Debate from the Water Education Foundation and perform the debate with your class. Continue the theme of various uses of water as a natural resource and the complications that can arise as a result of the limited amounts of water. Water Education Foundation: http://www.watereducation.org/ or (916) 444-6240

Additional Resource

SF Public Utilities Commission
http://sfwater.org/orgDetail.cfm/MO_ID/20

A Healthy Bay is a Wealthy Bay

Natural Resources and the Environment

Student Pages

Can We Afford the Wilderness?

The Battle still rages at the heart of the conservationist movement

by Ken Chowder

"The present flourishing triumphant growth of the wealthy wicked, the Phelans.... and their hirelings, will not thrive forever.... we may lose this particular fight, but truth and right must prevail at last." - John Muir

"He [John Muir] is a poetical gentleman. I am sure he would sacrifice his own family for the sake of beauty. He considers human life very cheap." - James D. Phelan

They were both good men. John Muir, a self-described "poetico-trampo-geologist-bot," was the first great American advocate for wilderness, the first president of the Sierra Club, a nationally popular writer and naturalist. James D. Phelan, the reform mayor of San Francisco, was the fiery opponent of monopolies, a champion of the public good. They were good men - and they were vitriolic enemies.

In fact, the dispute between Muir and Phelan still rages today, in only slightly altered form. There are still two conflicting answers to the question What is wilderness for?

The particular argument between Muir and Phelan concerned a remote mountain valley more than 150 miles from San Francisco with the odd name of Hetch Hetchy. San Francisco, a city on the end of a dry peninsula, was in chronic need of fresh water; in 1901 Mayor Phelan proposed damming the valley to create a reservoir for San Francisco. At the time, only a few hundred people had ever seen Hetch Hetchy but it was, not so coincidentally, in Yosemite National Park.

John Muir had spent many years in Yosemite, climbing its mountains, exploring its most remote corners, and Hetch Hetchy was one of his favorite places on Earth. It is "one of Nature's rarest and most precious mountain temples," he wrote. "Dam Hetch Hetchy! As well dam for water- tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man."

Muir and the Sierra Club raised enough of a protest to have Phelan's proposal turned down. Undaunted, Phelan tried again in 1903, again in 1905, again in 1907. To his way of thinking, a dam in Hetch Hetchy would provide drinking water and electricity, and, crucially, free San Francisco from the monopoly of the Spring Valley Water Company. The idea that preserving scenery was more important than saving his city from economic injustice infuriated Phelan. "John Muir loves the Sierras and roams at large, and is hypersensitive on the subject of the invasion of his territory," Phelan wrote. "The 400,000 people of San Francisco are suffering from bad water and ask Mr. Muir to cease his quibbling."

Subduing the wild

Actually it was far from quibbling. The debate over Hetch Hetchy concerned the very definition of conservation. At the time conservation was still very new. For the first European settlers the wild continent had been a wolfish, godless enemy to be subdued; the mark of Satan, the Puritans thought, was on all things wild. As naturalist Aldo Leopold put it, "A stump was our symbol of progress." But as wilderness slowly became both less dangerous and less infinitely vast, it began to seem more valuable, more attractive.

By 1901 the new conservation movement was already a house divided. The "utilitarian" school of conservation believed in "wise use" of the land: husbanding the resources of wilderness to provide the greatest benefit to the greatest number of people. The "preservationist" school believed that wilderness should be left exactly as is, untouched, like a cathedral of god. Which should have priority, the needs of man or those of wilderness itself? The debate began early and persists to this day.

The first national debate over the use of wilderness in U.S. history, the Hetch Hetchy struggle lasted 12 years. To most people the conflict seemed one between two Gods: water and light for San Francisco versus saving the beauty of the wild mountain valley. But both sides saw it as simple Right vs. Wrong, and the invective flowed. Muir wrote of "James Phelan, Satan and company." He described the dam's proponents as "mischief-makers and robbers," as "temple destroyers, devotees of ravaging commercialism." Dam supporter William Kent wrote of Muir that he was "a man entirely without social sense. With him, it is me and god and the rock where god put it, and that is the end of the story." San Francisco's city engineer called the preservationists "short-haired women and long-haired men"; the pro-dam San Francisco Chronicle called them "hoggish and mushy esthetes." Muir said of his critics: "They all show forth the proud sort of confidence that comes of a good sound irrefragable ignorance."

The 1906 earthquake, causing a fire that destroyed much of San Francisco, seemed to underline the city's need for water. But in the nation at large Muir and the Sierra Club, using articles, pamphlets and broadsides, successfully whipped up public opinion in favor of preserving the valley. Letters began to pour into Congress by the thousand; most major newspapers published editorials condemning the dam. "The people are now aroused. Tidings from far and near show that almost every good man and woman is with us," Muir wrote in 1913. "Therefore be of good cheer, watch, and pray and fight!"

On December 6, 1913, after 12 years of fighting, the Hetch Hetchy question came to a final vote. The U.S. Senate passed the bill authorizing the dam with a 43-25 vote. The New York Times wrote, "The American people have been whipped in the Hetch Hetchy fight."

"I'll be relieved when it's settled, for it's killing me," Muir has written. In fact, he did become sick not long after the bill's passage, and died of pneumonia in December 1914.

But John Muir had his revenge. The Hetch Hetchy defeat did wonders for his cause. The grassroots nature of the anti-dam protest widened preservationist support tremendously; a vague general approval of wilderness hardened into a movement capable of sustained political action. "The conscience of the whole country," as Muir put it, was "aroused from sleep."

The case of the sinister dam

The Hetch Hetchy decision was the beginning, not the end. Curiously, many of the great wilderness struggles since Hetch Hetchy have had the same general outline: the argument is often about a dam proposed for a site in a national park or protected area. "In the view of the conservationists, there is something special about dams," wrote author John McPhee, "Something ... metaphysically sinister." David Brower, longtime head of the Sierra Club, put it succinctly: "I hate all dams, large and small. If you are against a dam, you are for a river."

In 1913, the time of the Hetch Hetchy decision, only a handful of conservation organizations existed; 40 years later the number was over 300. And in 1954 they all mobilized for war.

This time the dam was proposed for Echo Park, part of the Dinosaur National Monument on the Colorado-Utah border. Again the integrity of the National Park system was at stake. Again the dam's opponents, led by David Brower of the Sierra Club, took their case directly to the public. The wilderness advocates saturated the presss with anti-dam advertisements, produced a cautionary film (Two Yosemites), and a book (This is Dinosaur). The public- relations campaign was massive and the public response unparalleled. Mail to members of Congress ran 80-1 against the dam.

This time the preservationists won. After five years of public pressure, the project's backers caved in. Ironically, it was the well-honed political skills of the environmentalists - in theory the group without political clout - that carried the day. A member of the House Committee on Interior and Insular Affairs said the proponents of the dam had "neither the money nor the organization to cope with the resources and mailing lists" of the preservationists.

The Dinosaur debate had many familiar elements. Congressmen constantly expressed ambivalence, citing the difficulty of choosing between two Goods. The wild canyon was undoubtedly a good thing; but so were water, light and food for the desolate southwest. Similarly, preservationists were reluctant to denigrate dams in general, or dismiss the whole of progress. What had come to the surface again was a characteristically American duality. Paired contradictions such as Beauty and Utility, or Religion and Science can often occupy twin places of honor in the American pantheon. One pair that has much affected wilderness in the 20th century is the will to master the wild yoked to the desire to worship it; progress and preservation. As author and environmentalist Wallace Stegner wrote, "No other nation on Earth so swiftly wasted its birthright; no other, in time, made such an effort to save what was left."

After Dinosaur, preservationists began to press for an umbrella bill that would create a national system of wilderness protection. The Wilderness Act had a rough passage, with Congress spending eight years debating and revising the measure. The final enactment was largely the result of one man's tireless devotion: Howard Zahniser of the Wilderness Society plugged the initial idea, wrote the original draft, saw the bill through no fewer than 66 rewrites, spoke to all 18 hearings only to die four months before his beloved brainchild became law.

The struggles continue

The Wilderness Act of 1964 did not, of course, close the book on struggles between utilitarians and preservationists. During the 1960s dams were proposed for two sites in the Grand Canyon itself. The Central Arizona Project had the support of the President, but in a result that would have been almost unimaginable in 1913, environmentalists, led by David Brower, defeated the dams and preserved the canyon. Today, the broad concept of wilderness has achieved a certain sanctity; wilderness, in its dotage, has become hallowed. "For it can be a means," Wallace Stegner wrote, "of reassuring ourselves of our sanity as creatures, a part of the geography of hope."

Still, there are at any given time numerous firestorms over wilderness raging in this country. Some of the hottest of the moment: the (first) Bush Administration, despite the huge Exxon Valdez oil spill, still hopes to open the Arctic National Wildlife Refuge in Alaska to oil development; the U.S. Forest Service is under fire for logging 450 million board feet of timber annually from Alaska's Tongass National Forest; and environmentalists in the Pacific Northwest are pushing hard to save old-growth National

Forests and protect the imperiled spotted owl.

The battle sites change, but the basic problem remains the same: "the very old problem," as Roderick Nash wrote in Wilderness and the American Mind, "of whether parks, reserves and wildernesses are for man ... or for nature." In conservation, as in everything else, some things never change. But what has changed, in the 77 years since the Hetch Hetchy decision, is the face of the land itself. So much less wild land remains that the reasons for developing it need to be that much stronger before they begin to make sense. In short, we need wilderness more because there is less of it.

As the next century gallops closer, a second change in the ongoing Man vs. Nature argument grows increasingly clear: One of the species that has become endangered by the rush of progress is humankind itself. The accidental but terrifying byproducts of modernity such as nuclear waste and acid rain have made preservation, in the end, perhaps the most utilitarian stance of all. So the old duality of Nature and civilization is, in some sense, no longer a duality; the two have become an environmental version of the Odd Couple — their fortunes curiously but inextricably linked, from now on.

History, of course, is the playground of irony. It is certainly true that the steady growth of the preservationist cause is John Muir's revenge for the Hetch Hetchy defeat; but I've recently discovered that Muir's revenge has a second, more private side.

Exploring the grounds of Villa Montalvo — James D. Phelan's lovely Saratoga, California, estate, I found a bust of John Muir, of all people, in a central place. So the craggy visage of John Muir himself now lords it over James Phelan's garden, gazing out from atop the steps. Meanwhile, the former utilitarian mayor no doubt turns ceaselessly, furiously, and uselessly in his grave.

Hetch Hetchy Timeline

- 1871 - John Muir first visits Hetch Hetchy
- 1873 - John Muir writes in Overland Monthly of the beauty of Hetch Hetchy Valley.
- 1882 - City of San Francisco begins searching for cheap, plentiful water to serve its growing population, and begins to consider Hetch Hetchy Valley as the location of a reservoir.
- 1890 - Yosemite National Park is established, including Yosemite Valley's less famous cousin, Hetch Hetchy.
- 1890 - San Francisco Mayor James Phelan first proposes damming the valley to create a reservoir for San Francisco.
- 1903 - Mayor Phelan applies to the Interior Department for rights to Hetch Hetchy's water. Secretary of the Interior Ethan Hitchcok denies the request.
- 1905 - Mayor Phelan again applies for water rights to Hetch Hetchy, and the permit is once again denied. John Muir and William E. Colby launch 8 - year campaign to prevent Hetch Hetchy from being dammed for a reservoir.
- 1906 - The San Francisco earthquake and fire gives new impetus to the idea of enlarging the city's water supply.
- 1907 - Sierra Club submits a resolution to the Secretary of the Interior opposing damming of Hetch Hetchy Valley.
- 1908 - Muir writes in the Sierra Club Bulletin that to dam Hetch Hetchy one "may as well dam for water-tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man." Nonetheless, the City's permit is approved by the Interior Department. Eighty-six percent of the voters in San Francisco authorize the Hetch Hetchy project and to provide $600,000 to purchase the "lands, rights, and claims" of Hetch Hetchy.
- 1909 - When the Taft administration takes office, new Secretary of the Interior Richard Ballinger suspends the Interior Department's approval for the Hetch Hetchy right-of-way.
- 1910 - Poll of Sierra Club members votes 589 - 161 (79%) in support the Club's position on Hetch Hetchy.
- 1912 - Woodrow Wilson is elected President, and appoints former San Francisco City Attorney Franklin Lane as Secretary of the Interior.

- 1913 - Congress passes the Raker Bill, allowing flooding of Hetch Hetchy Valley, but stipulating that the city could not sell water or power for resale. President Woodrow Wilson signs the bill on December 19.

- 1914 - Last Sierra Club outing to Hetch Hetchy Valley. John Muir dies on December 24.

- 1923 - Construction of O'Shaughnessy Dam completed, at a cost of $100 million and the lives of 67 men and one woman. The project transports water 160 miles by gravity alone to customers in San Francisco and 32 other Bay Area communities.

- 1924 - San Francisco voters approve a bond proposition for $10 million to pay for a series of tunnels that would deliver water through the Sierra and Coast Range Mountains.

- 1938 - The O'Shaughnessy Dam is raised to its current 430-foot height.

- 1961 - San Francisco voters approve $115 million in bonds to expand the existing Hetch Hetchy system.

- 1970 - Sierra Club board of directors recommends removal, rather than an expensive restoration or reconstruction, of both O'Shaughnessy Dam and Eleanor Dam. The Board also states: "The question of how to remove O'Shaugnessy Dam, and the problems of how to restore Hetch Hetchy Valley to its once magnificent grandeur, should be studied in depth. The studies should include the problem of plant succession as the valley is drained, the removal of silt, and the practical alternatives available to San Francisco if the Hetch Hetchy water supply is lost."

- 1987 - Secretary of the Interior Don Hodel suggests removal of O'Shaughnessy Dam and the restoration of Hetch Hetchy Valley. Sierra Club Board reaffirms its 1908 policy, and adopts a further policy supporting taking a "long view" of the issue, and endorsing feasibility studies. Sierra Club establishes a Hetch Hetchy Task Force with Sally Reid as chair.

- 1988 - Bill to study restoration of Hetch Hetchy is defeated in Committee.

- 1994 - Republican congressmen propose that the City of San Francisco pay the federal government $25 million per year, since the city generates an average of $38 million annually from selling hydroelectric power from Hetch Hetchy to other municipalities. California Democrats in Congress kill the proposal.

- 1998 - The Sierra Club Hetch Hetchy Task Force creates a website devoted to the restoration of Hetch Hetchy on the World Wide Web.

- 1999 - Representatives from several environmental organizations in addition to the Sierra Club join together to form a new non-profit organization to focus exclusively on the goal of restoring Hetch Hetchy, and establish a website at http://www.hetchhetchy.org/.

A Healthy Bay Is a Wealthy Bay

Natural Resources and the Environment

Student Pages

"Gifford Pinchot and the Damming of Hetch Hetchy "

Gifford Pinchot was a man of strong opinions, opinions that perhaps, as his daughter-in-law once suggested, forged his vision into black and white, particularly when he was younger. Such might have been the case during the debate over the damming of the Hetch Hetchy Valley in California. The sister of Yosemite, and included within its park boundaries, Hetch Hetchy set the stage for one of our country's most famous environmental controversies. And Gifford Pinchot, true to form, was smack dab in the middle of it.

The city of San Francisco wanted water. They already had it, of course, but their primary supplier, the Spring Valley Water Company, charged exorbitant rates. So, after years of frustration and fruitless attempts to buy the company, San Francisco went looking elsewhere. There were several potential alternatives for an adequate supply of water to the city, but one in particular, on further examination, showed the most promise: the Hetch Hetchy Valley. It was perfect! Pure water deep in the Sierra Nevada mountains, perpendicular canyon walls, a narrow outlet at the downstream end—a natural water tank. Who could ask for more?

There was just one problem—the valley sat within a national park. But that detail actually added to the valley's desirability. Hetch Hetchy's cleanliness applied to more than just its water—there were no troublesome water right disputes to deal with. It also provided the largest site with the most possibilities for storage.

Since most of the watershed feeding it fell within forest reserve boundaries, the surrounding landscape was virtually uninhabitable and pollution free. According to city engineers, Hetch Hetchy, of all the sites surveyed, held the most unrivaled advantages. Maybe so, at least from an engineering viewpoint, but only if the incredible scenic and recreational values were discounted, which they were.

Enter John Muir, William Colby and the Sierra Club, who took up the fight for Hetch Hetchy's priceless beauty. But their foes were formidable. The city of San Francisco had powerful friends and used them to full advantage. Some of their forces were Sierra Club members who supported the damming, further weakening the club's stance. In those days, few of the general public had seen Yosemite, and many who had were wealthy. And Hetch Hetchy was even more remote, in rugged country without road access. Only a handful of people, relatively speaking, had been there. Then came the earthquake and subsequent fire in 1906 which, because of a shortage of water, destroyed much of San Francisco. The earthquake, as it turned out, proved to be a very convenient boost for the city's case.

As Gifford Pinchot said: "The delight of the few men and women who would yearly go into the Hetch Hetchy Valley should not outweigh the conservation policy, to take every part of the land and its resources and put it to that use in which it will best serve the most people." And there was the rub. Pinchot initially favored other sources and believed the Hetch Hetchy should only be used as a last resort. But he soon changed his mind. Why he did is uncertain, but some speculate it may have been politically motivated, to throw a bone to the powerful special interests, so that if he gave a little here he might gain a little more acceptance there of his conservation policies, especially from lumber barons and other monopolists. President Roosevelt, who had high regard for Muir, decided to accept San Francisco's position as well, although with some uncertainty.

In 1909, Theodore Roosevelt left office. His successor, William Howard Taft, fired Gifford Pinchot from the Forest Service for insubordination in 1910. But the Forest Service and Pinchot continued to favor damming the valley, contributing significantly to the outcome. On December 6, 1913, those on the side of the Hetch Hetchy went down to defeat. But hope still persisted; sources indicated President Woodrow Wilson might veto the bill. Although supposedly recognizing the views of the preservationists, Wilson chose to go along with the dictates of his party and cabinet. On December 19, 1913, he signed the Raker Act, allowing the damming of the Hetch Hetchy Valley.

A few years later, a bill was passed to insure that what had happened in the Hetch Hetchy Valley would never occur again. "Nothing that we can do on the side of justice can be wholly lost."

Nevertheless, the battle over Hetch Hetchy caused the environmental community to split into two philosophical camps—preservation and conservation. This disparity still continues today.

Initially, Muir and Pinchot had been good friends, beginning when Pinchot was just getting his feet wet in the forestry profession. The two once spent a memorable time together at the Grand Canyon and corresponded regularly. Muir was an occasional guest at the Pinchot family home. The older of the two by nearly thirty years, Muir served as one of several mentors for the young forester. But, as sometimes happens with mentors, Pinchot eventually had to choose his own path, a path that did not always please his teachers. Hetch Hetchy effectively ended their relationship.

Gifford Pinchot never wrote down his reasons for his position on the damming of the Hetch Hetchy Valley, at least not that anyone has yet discovered. And of his relatives still or until recently living, none who knew him have ever been able to recall his speaking of it. One thing they do say, however, is that Gifford Pinchot was a forward thinking man, and although he had an appreciation for history, he rarely looked back.

But Pinchot delighted in Yosemite. When a State Commissioner then overseeing the park recommended the systematic cutting of all young trees in the Valley, Pinchot agreed with Frederick Law Olmstead who "wisely observed [such action] would have been a calamity to the civilized world." Olmstead, incidentally, was another of Pinchot's mentors and one who gave him his first forestry job.

Did Gifford Pinchot ever actually see the Hetch Hetchy Valley? Probably not. Perhaps a clue to his feelings over this great controversy can be found in his final book, *Breaking New Ground*, where he writes: "One of the great mistakes of a long and misspent life is that I saw the Yosemite Valley only after the Grand Canyon had dulled my sense of wonder. Everything is tame after that." Maybe that's the closest Gifford Pinchot could come to admitting he might have made a mistake.

"The Ghosts of Hetch-Hetchy"

by Gene Rose

If you listen quietly -- and with a little imagination -- you can hear the ghosts of Hetch-Hetchy.

At first there's the sound of silence, reflecting the aeons of creation, then the inexorable grinding and polishing that carved out what we know today as the Grand Canyon of the Tuolumne River.

Next you will hear the quiet step ones, the Native Americans who first occupied this great canyon. They bestowed the name Hetch-Hetchy on the valley -- for a wild grass that grew there.

Now listen for the echoes of the "Forty-niners" and those that followed them, the gold seekers.

The oddly named Nathan Screech apparently was the first Euro-American to see this valley. We don't know the particulars of his reaction, but we do know that he fell in love with the area. He claimed it for his own in 1850, a year before the first white pioneers entered nearby Yosemite Valley.

It's not hard to visualize other newcomers venturing into the canyon. John Muir came this way a few years later. The wandering Scotsman left no evidence of his visit, beyond his expressions of reverence and admiration for what he saw as a rival to Yosemite Valley itself. Muir's appreciation for Hetch-Hetchy no doubt prompted, in part, his 1890 efforts to protect the area surrounding the Yosemite Grant as a national park.

Try to imagine the other sounds emanating from the canyon by the end of the 1890s. For several years the city of San Francisco had been casting about for a source for municipal water. Several other watersheds were examined, but the city kept coming back to Hetch-Hetchy. The prime advantage was not the copious water supply but the fact that the canyon was situated on public land. The sounds were those of base water politics.

The Sierra Club, not yet a decade old, issued rallying calls, ready to protect the ramparts of the national park. The fight for Hetch-Hetchy resounded throughout the west, with major battles being waged in Washington, D.C. At issue was the sanctity, the integrity of a national park.

In the early 1900s our nation's government had not yet distinguished, on a policy level, between preservation and conservation. Many Americans did not differentiate national parks and national forests. The very idea of national parks as preserves had not yet made its way into the American ethos. But over time Hetch-Hetchy became a crucible in which echoed voices as the nation debated the costs and benefits of treating all its natural areas as usable resources.

In 1901, the Secretary of the Interior asked Congress to define special use easements through national parks. Eventually a bill was approved that authorized the Secretary of Interior to allow within "Yosemite, Sequoia and General Grant National Parks ... canals...reservoirs ...for supply of water for domestic, public, or any other beneficial uses."

One of the strongest voices to be heard in the Hetch-Hetchy battle was that of Gifford

Pinchot. At the time, Pinchot was regarded as the nation's foremost conservationist. Pinchot lent his reputation to Teddy Roosevelt as a member of his staff, and helped develop Roosevelt's image as the "Conservation President."

In 1905, Pinchot was appointed the head of the re-organized Forest Service. It was his management philosophy that all of the nation's natural resources were available for human development -- so long as that use was prudent and sustainable. His position on the availability of public forests was quite clear. "In the administration of the Forest Reserve it must be clearly borne in mind that all land is to be devoted to its most productive use for the permanent good of the whole people and not for the temporary benefit of individuals or companies. The continued prosperity of the agricultural, lumbering, mining, and livestock interests is dependent upon a permanent and accessible supply of water, wood, and forage, as well as upon the present and future use of these resources under business-like regulations enforced with promptness, effectivenes and common sense. When conflicting interests must be reconciled, the question will always be decided from the standpoint of the greatest good of the greatest number in the long run."

John Muir, a passionately eloquent opponent of the project, saw the issue differently and was fierce in his defense of areas like Yosemite National Park. He felt the national parks should be sacrosanct -- that they should be left alone, inviolate. He articulated the difference in value between national forest resources and national parks.

Even after Pinchot had been fired from his Forest Service post by Roosevelt's successor, William Howard Taft, Pinchot remained in the public light. He left little doubt where he stood regarding Hetch-Hetchy, backing the city's effort to build the dam. When the issue came down to the wire, Muir's last hope rested in a presidential veto. But Pinchot had the ear of the President, and in 1913 Wilson signed the measure.

Now imagine Hetch-Hetchy filled with the noise of construction. Eventually the backed-up waters of the Tuolumne River drowned out the natural sounds that had been so common and familiar for centuries. All that Muir and his followers heard at Hetch-Hetchy represented a national tragedy -- a preservationist's Waterloo -- a national man-caused tragedy.

The concrete in the original O'Shaughnessy Dam was barely cured when the city decided, unilaterally, that it needed to raise the height of the dam to increase water storage. More park land was appropriated. Once again the valley reverberated with the clatter of construction.

Some of the promised sounds from Hetch-Hetchy never occurred. Early on, the city had painted a glowing picture of the reservoir as a recreational center, with people boating and amusing themselves on the lake. In fact, the reservoir was closed to public use and its recreational potential never realized.

Sounds coming from the canyon occasionally took on strange overtones, born of new controversies. In the 1950s, for instance, the Sierra Club's David Brower produced a film on the reservoir, calling for removal of the dam and restoration of the valley.

In 1985 a group of individuals apparently aligned with Earth First! slipped onto the walkway and draped a jagged strip of black plastic down the face of the dam. The visual effect suggested that the dam had cracked. Once again, Hetch-Hetchy was on the tongues of the American people.

About the same time, Rep. Rick Lehman, whose district then embraced Hetch-Hetchy, steered legislation through Congress prohibiting the construction of any more dams in Yosemite or other national parks.

The Hetch-Hetchy issue resurfaced in 1988 when then Interior Secretary Don Hodel proposed that the City of San Francisco undertake a feasibility study to determine if the dam could be removed and the valley restored. His suggestion generated cries of outrage and some intense media coverage for a few weeks, then quietly disappeared.

Today, as park visitation surges toward the 4 million mark, the debate over Hetch-Hetchy resurfaces from time to time. Visitors to the area number about 40,000 persons. However, if the dam were removed the area could accommodate an estimated 1 million persons a year, a 1988 study by the Assembly Office of Research suggests.

It's not likely we'll be hearing the din of workmen tearing down the dam any time soon. Environmental restoration would take decades and cost megadollars. The state concluded that it would cost approximately $825 million to restore Hetch-Hetchy and compensate the city for the loss of water and power generation.

For now, the predominant sound in the great canyon will remain the lapping of the tamed waters of the Tuolumne River muffling the cries of the ghosts of Hetch-Hetchy.

Hetch Hetchy Water and Power System
Daily Operating Summary: Scheduled Releases Into the Tuolumne River

The Hetch Hetchy Water and Power system is a conglomerate of dams, hydroelectric plants, reservoirs, aqueducts, pipelines and transmission lines operated by the SFPUC which provide drinking water to the City of San Francisco and several Bay Area counties. The system also provides hydroelectric power for San Francisco municipal uses and for sale to irrigation districts and public utilities.

Mission Statement

The SFPUC's Hetch Hetchy Water & Power's (HHWP) mission is to provide a reliable, clean, adequate water supply to SFPUC customers. HHWP's business is conducted in accordance with the following priorities: to protect and maintain water rights; to assure availability of water conveyance and storage through effective infrastructure maintenance, power generation, system controls and support facilities; to ensure the reliability of operations and effective servicing of infrastructure; to promote system efficiency and profitability; and to promote the health, safety, diversity and professional development of its employees.

Service Overview

Eighty-five percent of San Francisco's drinking water starts out as snow falling on more than 650 square miles of watershed land in Yosemite National Park and the Stanislaus National Forest. As the snow melts, it collects in Hetch Hetchy's three storage reservoirs. The water is pure enough to be exempted from costly water filtration requirements -- only a few systems in the country meet this federal government standard. Water flows by gravity through 150 miles of pipelines and tunnels from the crest of the Sierras to San Francisco. As it flows, HHWP puts the water to work. It turns the turbines in four hydroelectric powerhouses, generating approximately 1.6 billion kilowatt hours of renewable energy each year. Hundreds of miles of transmission and distribution lines move the electricity from the powerhouses to the San Francisco Bay Area. Some of the power is used for City and County of San Francisco offices and services, including MUNI and the International Airport. Surplus power is sold to Central Valley irrigation districts and public agencies.

Water Distribution System

- Collects and stores water from watersheds in Yosemite National Park and Stanislaus National Forest.
- Transports the water to the Bay Area through pipelines and tunnels -- more than a 150 miles long.
- Relays water to SFPUC facilities in eastern Alameda County, from where it is distributed to the City of San Francisco and wholesale water customers throughout the Bay Area.

Power Service

- Provides electric power for all San Francisco municipal uses, such as MUNI and the International Airport.

- Sells surplus power at cost to Modesto and Turlock Irrigation Districts, according to long-term contracts.
- When applicable, sells further surplus power on the wholesale market to other public utilities.
- Purchases power from the open market to meet seasonal needs, as necessary.

High Quality Water

- HHWP water is so pristine, it exceeds federal and state quality standards, and as a result is not filtered.
- San Francisco has the largest unfiltered water supply on West Coast, and it is one of a small number of unfiltered city water supplies in the nation.

Reservoirs, Dams and System Capacity

- Major Reservoirs: O'Shaughnessy (360K acre feet); Eleanor (27K acre feet); Cherry (270K acre feet).
- Number of dams: Five.
- Hydroelectric Plants: Four (total capacity of 380,000 kw).
- Total storage capacity: 659,600 acre feet. (The SFPUC maintains an additional 238,700 acre feet of additional storage in the Bay Area).
- Holds exchange storage rights of 570,000 acre feet in the New Don Pedro Reservoir, which is owned by Modesto and Turlock Irrigation Districts.
- HHWP system is designed to meet a peak demand of 400 million gallons a day.

Federal Law, Fees and Contributions
San Francisco holds its Hetch Hetchy water rights under California law. However, authorization to build reservoirs on federal land required an act of Congress - the 1913 Raker Act. The Raker Act requires the SFPUC to recognize prior water rights of the Modesto and Turlock Irrigation Districts and obligates the release of water into the upper Tuolumne for fishery purposes (according to various agreements with the U.S. Dept. of Interior). The Raker Act also prohibits the sale of water or power to private entities for resale. Although the act calls for an annual use fee of $30,000, the SFPUC contributes over $1 million a year to Yosemite National Park for a variety of maintenance and improvement programs. The SFPUC is also currently paying over $3 million to rebuild the sewer system that serves the Tuolumne Meadows area of the Park. In addition, the SFPUC pays at least $3.5 million each year for environmental mitigations around the Tuolumne River.

The Hetch Hetchy Valley

by John Muir
(Sierra Club Bulletin, January 1908)

It is impossible to overestimate the value of wild mountains and mountain temples as places for people to grow in, recreation grounds for soul and body. They are the greatest of our natural resources, God's best gifts, but none, however high and holy, is beyond reach of the spoiler. In these ravaging money-mad days monopolizing San Francisco capitalists are now doing their best to destroy the Yosemite Park, the most wonderful of all our great mountain national parks. Beginning on the Tuolumne side, they are trying with a lot of sinful ingenuity to get the Government's permission to dam and destroy the Hetch-Hetchy Valley for a reservoir, simply that comparatively private gain may be made out of universal public loss, while of course the Sierra Club is doing all it can to save the valley. The Honorable Secretary of the Interior has not yet announced his decision in the case, but in all that has come and gone nothing discouraging is yet in sight on our side of the fight.

As long as the busy public in general knew little or nothing about the Hetch-Hetchy Valley, the few cunning drivers of the damming scheme, working in darkness like moles in a low-lying meadow, seemed confident of success; but when light was turned on and the truth became manifest that next to Yosemite, Hetch-Hetchy is the most wonderful and most important feature of the great park, that damming it would destroy it, render it inaccessible, and block the way through the wonderful Tuolumne Cañon to the grand central campground in the upper Tuolumne Valley, thousands from near and far came to our help, — mountaineers, nature-lovers, naturalists. Most of our thousand club members wrote to the President or Secretary protesting against the destructive reservoir scheme while other sources of city water as pure or purer than the Hetch-Hetchy were available; so also did the Oregon and Washington mountaineering clubs and the Appalachian of Boston and public-spirited citizens everywhere. And the President, recognizing the need of beauty as well as bread and water in the life of the nation, far from favoring the destruction of any of our country's natural wonder parks and temples, is trying amid a host of other cares to save them all. Within a very short time he has saved the petrified forests of Arizona and the Grand Cañon, and in our own State the jagged peaks of San Benito county known as "The Pinnacles," making them national monuments or parks to be preserved for the people forever. None, therefore, need doubt that everything possible will be done to save Hetch-Hetchy.

After my first visit, in the autumn of 1871, I have always called it the Tuolumne Yosemite, for it is a wonderfully exact counterpart of the great Yosemite, not only in its crystal river and sublime rocks and waterfalls, but in the gardens, groves, and meadows of its flower park-like floor. The floor of Yosemite is about 4,000 feet above the sea, the Hetch -Hetchy floor about 3,700; the walls of both are of gray granite, rise abruptly out of the flowery grass, and are sculptured in the same style. In both, every rock is a glacial monument.

Standing boldly out from the south wall is a strikingly picturesque rock called "Kolana" by the Indians, the outermost of a group 2300 feet high, corresponding with the Cathedral Rocks of Yosemite both in relative position and form. On the opposite side of the Valley, facing Kolana, there is a counterpart of the El Capitan of Yosemite rising sheer and plain to a height of 1800 feet, and over its massive brow flows a stream which makes the most graceful fall I have ever seen. From the edge of the cliff it is perfectly free in the air for a thousand feet, then breaks up into a ragged sheet of cascades among the boulders of an earthquake talus. It is in all its glory in June, when the snow is melting fast, but fades and vanishes toward the end of summer. The only fall I know with which it may fairly be compared is the Yosemite Bridal Veil; but it excels even that favorite fall both in height and fineness of fairy-airy beauty and behavior. Lowlanders are apt to suppose that mountain streams in their wild career over cliffs lose control of themselves and tumble in a noisy chaos of mist and spray.

On the contrary, on no part of their travels are they more harmonious and self-controlled. Imagine yourself in Hetch Hetchy on a sunny day in June, standing waist-deep in grass and flowers (as I have oftentimes stood), while the great pines sway dreamily with scarce perceptible motion. Looking northward across the Valley you see a plain, gray granite cliff rising abruptly out of the gardens and groves to a height of 1800 feet, and in front of it Tueeulala's silvery scarf burning with irised sun-fire in every fiber. In the first white outburst of the stream at the head of the fall there is abundance of visible energy, but it is speedily hushed and concealed in divine repose, and its tranquil progress to the base of the cliff is like that of downy feathers in a still room. Now observe the fineness and marvelous distinctness of the various sun-illumined fabrics into which the water is woven; they sift and float from form to form down the face of that grand gray rock in so leisurely and unconfused a manner that you can examine their texture, and patterns and tones of color as you would a piece of embroidery held in the hand. Near the head of the fall you see groups of booming, comet-like masses, their solid, white heads separate, their tails like combed silk interlacing among delicate shadows, ever forming and dissolving, worn out by friction in their rush through the air. Most of these vanish a few hundred feet below the summit, changing to the varied forms of cloud-like drapery. Near the bottom the width of the fall has increased from about twenty-five to a hundred feet. Here it is composed of yet finer tissues, and is still without a trace of disorder — air, water and sunlight woven into stuff that spirits might wear.

So fine a fall might well seem sufficient to glorify any valley; but here, as in Yosemite, Nature seems in nowise moderate, for a short distance to the eastward of Tueeulala booms and thunders the great Hetch Hetchy Fall, Wapama, so near that you have both of them in full view from the same standpoint. It is the counterpart of the Yosemite Fall, but has a much greater volume of water, is about 1700 feet in height, and appears to be nearly vertical, though considerably inclined, and is dashed into huge outbounding bosses of foam on the projecting shelves and knobs of its jagged gorge. No two falls could be more unlike — Tueeulala out in the open sunshine descending like thistledown; Wapama in a jagged, shadowy gorge roaring and plundering, pounding its way with the weight and energy of an avalanche. Besides this glorious pair there is a broad, massive fall on the main river a short distance above the head of the Valley. Its position is something like that of the Vernal in Yosemite, and its roar as it plunges into a surging trout-pool may be heard a long way, though it is only about twenty feet high. There is also a chain of magnificent cascades at the head of the valley on a stream that comes in from the northeast, mostly silvery plumes, like the one between the Vernal and Nevada falls of Yosemite, half-sliding,half-leaping on bare glacier polished granite, covered with crisp clashing spray into which the sunbeams pour with glorious effect. And besides all these a few small streams come over the walls here and there, leaping from ledge to ledge with birdlike song and watering many a hidden cliff-garden and fernery, but they are too unshowy to be noticed in so grand a place.

The correspondence between the Hetch Hetchy walls in their trends, sculpture, physical structure, and general arrangement of the main rock-masses [and those of the Yosemite Valley] has excited the wondering admiration of every observer. We have seen that the El Capitan and Cathedral rocks occupy the same relative positions In both valleys; so also do their Yosemite Points and North Domes. Again that part of the Yosemite north wall immediately to the east of the Yosemite Fall has two horizontal benches timbered with golden-cup oak about 500 and 1500 feet above the floor. Two benches similarly situated and timbered occur on the same relative portion of the Hetch Hetchy north wall, to the east of Wapama Fall, and on no other. The Yosemite is bounded at the head by the great Half Dome. Hetch Hetchy is bounded in the same way though its head rock is far less wonderful and sublime in form.

The floor of the Valley is about three and a half miles long and from a fourth to half a mile wide. The lower portion is mostly a level meadow about a mile long, with the trees restricted to the sides, and partially separated from the upper forested portion by a low bar of glacier-polished granite across which the river breaks in rapids.

The principal trees are the yellow and sugar pines, Sabine pine, incense cedar, Douglas spruce, silver fir, the California and gold-cup oaks, balm of Gilead poplar, Nuttall's flowering dogwood, alder, maple, laurel, tumion, etc. The most abundant and influential are the great yellow pines, the tallest over two hundred feet in height, and the oaks with massive rugged trunks four to six or seven feet in diameter, and broad arching heads, assembled in magnificent groves. The shrubs forming conspicuous flowery clumps and tangles are manzanita, azalea, spiraea, brier-rose, ceanothus, calycanthus, philadelphus, wild cherry, etc.; with abundance of showy and fragrant herbaceous plants growing about them or out in the open in beds by themselves — lilies, Mariposa tulips, brodiaeas, orchids — several species of each,— iris, spraguea, draperia, collomia, collinsia, castilleia, nemophila, larkspur, columbine, goldenrods, sunflowers, and mints of many species, honeysuckle, etc. etc. Many fine ferns dwell here also, especially the beautiful and interesting rock-ferns — pellaea, and cheilanthes of several species — fringing and rosetting dry rock-piles and ledges; woodwardia and asplenium on damp spots with fronds six or seven feet high; the delicate maidenhair in mossy nooks by the falls, and the sturdy, broad-shouldered pteris beneath the oaks and pines.

It appears therefore that Hetch-Hetchy Valley, far from being a plain, common, rock-bound meadow, as many who have not seen it seem to suppose, is a grand landscape garden, one of Nature's rarest and most precious mountain mansions. As in Yosemite, the sublime rocks of its walls seem to the nature-lover to glow with life, whether leaning back in repose or standing erect in thoughtful attitudes, giving welcome to storms and calms alike. And how softly these mountain rocks are adorned, and how fine and reassuring the company they keep —their brows in the sky, their feet set in groves and gay emerald meadows, a thousand flowers leaning confidingly against their adamantine bosses, while birds, bees, and butterflies help the river and waterfalls to stir all the air into music — things frail and fleeting and types of permanence meeting here and blending, as if into this glorious mountain temple Nature had gathered her choicest treasures, whether great or small, to draw her lovers into close confiding communion with her.

Strange to say, this is the mountain temple that is now in danger of being dammed and made into a reservoir to help supply San Francisco with water and light. This use of the valley, so destructive and foreign to its proper park use, has long been planned and prayed for, and is still being prayed for by the San Francisco board of supervisors, not because water as pure and abundant cannot be got from adjacent sources outside the park - for it can, — but seemingly only because of the comparative cheapness of the dam required.

Garden- and park-making goes on everywhere with civilization, for everybody needs beauty as well as bread, places to play in and pray in, where Nature may heal and cheer and give strength to body and soul. This natural beauty-hunger is displayed in poor folks' window-gardens made up of a few geranium slips in broken cups, as well as in the costly lily gardens of the rich, the thousands of spacious city parks and botanical gardens, and in our magnificent National parks — the Yellowstone, Yosemite, Sequoia, etc. — Nature's own wonderlands, the admiration and joy of the world. Nevertheless, like everything else worth while, however sacred and precious and well-guarded, they have always been subject to attack, mostly by despoiling gainseekers, — mischief-makers of every degree from Satan to supervisors, lumbermen, cattlemen, farmers, etc., eagerly trying to make everything dollarable, often thinly disguised in smiling philanthropy, calling pocket-filling plunder "Utilization of beneficent natural resources, that man and beast may be fed and the dear Nation grow great." Thus long ago a lot of enterprising merchants made part of the Jerusalem temple into a place of business instead of a place of prayer, changing money, buying and selling cattle and sheep and doves. And earlier still, the Lord's garden in Eden, and the first forest reservation, including only one tree, was spoiled. And so to some extent have all our reservations and parks. Ever since the establishment of the Yosemite National Park by act of Congress, October 8, 1890, constant strife has been going on around its borders and I suppose this will go on as part of the universal battle between right and wrong, however its boundaries may be shorn or its wild beauty destroyed. The first application to the Government by the San Francisco Supervisors for the use of Lake Eleanor and the Hetch Hetchy Valley was made in 1903, and denied December 22nd of that year by the Secretary of the Interior. In his report on this case he well says: "Presumably the Yosemite National Park was created such by law because of the natural objects, of varying degrees of scenic importance, located within its boundaries, inclusive alike of its beautiful small lakes, like Eleanor, and its majestic wonders, like Hetch-Hetchy and Yosemite Valley. It is the aggregation of such natural scenic features that makes the Yosemite Park a wonderland which the Congress of the United States sought by law to preserve for all coming time as nearly as practicable in the condition fashioned by the hand of the Creator — a worthy object of national pride and a source of healthful pleasure and rest for the thousands of people who may annually sojourn there during the heated months."

The most delightful and wonderful campgrounds in the Park are the three great valleys — Yosemite, Hetch-Hetchy, and Upper Tuolumne; and they are also the most important places with reference to their positions relative to the other great features — the Merced and Tuolumne Cañons, and the High Sierra peaks and glaciers, etc., at the head of the rivers. The main part of the Tuolumne Valley is a beautiful spacious flowery lawn four or five miles long, surrounded by magnificent snowy mountains. It is about 8500 feet above the sea, and forms the grand central High Sierra camp ground from which excursions are made to the noble mountains, domes, glaciers, etc.; across the Range to the Mono Lake and volcanoes and down the Tuolumne Cañon to Hetch Hetchy. But should Hetch Hetchy be submerged, as proposed, not only would it be made utterly inaccessible, but the sublime cañon way to the heart of the High Sierra would be hopelessly blocked. None, as far as I have learned, of all the thousands who have seen the park is in favor of this destructive water scheme.

My last visit to the Valley was made in the autumn of last year [1907], with William Keith, the artist. The leaf-colors were then ripe, and the great godlike rocks in repose seemed to glow with life. The artist, under their spell, wandered day after day along the beautiful river and through the groves and gardens, studying the wonderful scenery; and, after making about forty sketches, declared with enthusiasm that in picturesque beauty and charm Hetch Hetchy surpassed even Yosemite.

That any one would try to destroy such a place seemed impossible; but sad experience shows that there are people good enough and bad enough for anything. The proponents of the dam scheme bring forward a lot of bad arguments to prove that the only righteous thing for

Hetch-Hetchy is its destruction. These arguments are curiously like those of the devil devised for the destruction of the first garden — so much of the very best Eden fruit going to waste; so much of the best Tuolumne water. Very few of their statements are even partly true, and all are misleading. Thus, Hetch Hetchy, they say, is a "low-lying meadow." On the contrary, it is a high-lying natural landscape garden.

"It is a common minor feature, like thousands of others." On the contrary, it is a very uncommon feature; after Yosemite, the rarest and in many ways the most important in the park.

"Damming and submerging it 175 feet deep would enhance its beauty by forming a crystal-clear lake."

Landscape gardens, places of recreation and worship, are never made beautiful by destroying and burying them. The beautiful lake, forsooth, should be only an eyesore, a dismal blot on the landscape, like many others to be seen in the Sierra. For, instead of keeping it at the same level all the year, allowing Nature to make new shores, it would, of course, be full only a month or two in the spring, when the snow is melting fast; then it would be gradually drained, exposing the slimy sides of the basin and shallower parts of the bottom, with the gathered drift and waste, death and decay of the upper basins, caught here instead of being swept on to decent natural burial along the banks of the river or in the sea.

Thus the Hetch Hetchy dam-lake would be only a rough imitation of a natural lake for a few of the spring months, an open mountain sepulcher for the others.

"Hetch Hetchy water is the purest, wholly unpolluted, and forever unpollutable." On the contrary, excepting that of the Merced below Yosemite, it is less pure than that of most of the other Sierra streams, because of the sewerage of camp grounds draining into it, especially of the Big Tuolumne Meadows campgrounds, where hundreds of tourists and mountaineers, with their animals, are encamped for months every summer, soon to be followed by thousands of travelers from all the world.

These temple destroyers, devotees of ravaging commercialism, seem to have a perfect contempt for Nature, and, instead of lifting their eyes to the mountains, lift them to dams and town skyscrapers.

Dam Hetch-Hetchy! As well dam for water-tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man.

Life in the Bay

Getting to know the Bay's plants and animals

Overview
In this activity students will become acquainted with a plant or animal that lives in the San Francisco Bay. Students will research their plant or animal and create an informational poster. They will then use their poster to make a presentation to the class.

Estimated Time
2-3 weeks

Objectives
Students will:
- Become an "expert" on a plant or animal that lives in the Bay
- Use reference books and the Internet to do research
- Document both quoted and paraphrased information using an accepted form of source citation
- Create a clear and eye-catching informational poster
- Deliver a focused, well-organized presentation

Materials
- Reference books featuring plants and animals of the Bay (see appendix A)
- Computer with internet access (optional, see Appendix B for websites)
- Printer (optional)
- Poster board
- Colored construction paper
- Markers, colored pencils, paint, letter stencils, other art supplies

Vocabulary
Adaptation, ecosystem, native species, non-native (introduced) species

California Science Content Standards
Grade 6

Standard Set 5.b: over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment.
Standard Set 5.c: populations of organisms can be categorized by the functions they serve in an ecosystem.
Standard Set 5.d: different kinds of organisms may play similar ecological roles in similar biomes.
Standard Set 5.e: the number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.
Standard Set 7.d: communicate the steps and results from an investigation in written reports and verbal presentations.

Grade 7

Standard Set 3.a: both genetic variation and environmental factors are causes of evolution and diversity of organisms.

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

Standard Set 7.b: utilize a variety of print and electronic resources (including the World Wide Web) to collect information as evidence as part of a research project.

Grades 9-12

Biology/Life Sciences Standard 6.a: biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.

Biology/Life Sciences Standard 8.b: a great diversity of species increases the chance that at least some organisms survive large changes in the environment.

California English/Language Arts Standards

Grades 6-12 Reading, Writing, Speaking

Please refer to standards.

Background

The mixture of salty and fresh water, nutrient rich mud, and mild climate found in and around the San Francisco Bay makes it an ideal habitat for an abundance of plants and animals. Located along the Pacific Flyway, the San Francisco Bay is one of the most important resting places in the world for migrating birds. The Bay is also home to several endangered species, including the Salt Marsh Harvest Mouse, the California Least Turn, the Peregrine Falcon, and the California Clapper Rail. These endangered animals depend on marsh plants such as pickleweed and cordgrass for food and shelter. This activity gives students the chance to become an expert on a plant or an animal that lives in the Bay. Students who have done this activity will be able to recognize "their" plants and animals when they visit the Bay.

Teacher Procedure

Part I

1. Before you begin, review the following concepts:

- Adaptation
- Ecosystem
- Native/ Non-native species

2. Have students choose or assign students a marsh plant or animal to research.

3. Explain that they are going to become "experts" on their plant or animal. Talk about how researchers ask questions, and then use books, magazines, the internet, etc. to find answers to their questions. You may want to brainstorm to get a list of questions students could ask about their plant or animal, for example "what does the animal eat?" You can either assign questions for all students to answer, or allow them to choose their own, however they should research at least five questions. Here is a list of possibilities:

Animal Questions:

- What is its habitat (where in the Bay does it live)? What adaptations help it survive there?
- What does it eat? Where does it find its food? What adaptations help it get food?
- Who are its predators?
- What do your animal's look like?
- What sounds (if any) does your animal make?
- What does the animal's tracks look like?
- How does it reproduce?
- What are some cool facts about your animal?

Plant Questions:

- What is its habitat (where in the Bay does it live)? What adaptations help it survive there?
- What animals eat it? What animals use it for shelter or protection?
- How have humans used it (medicine, food, building, etc.)?
- Is it a native or introduced species? (if introduced, how did it get here?)
- What does your plant look like?
- How does it reproduce?
- What are some cool facts about your plant?

2. Explain how students will use the Research Worksheet to record their research and to keep track of their sources. The worksheets are designed to help students organize their data. Students should use a separate

worksheet for each research question. They will need several copies of the worksheet, preferably double sided.

3. Allow students several class periods to research their plant or animal.

Part II

1. Explain that students will now be using their research to create an informational poster about their plant or animal. An informational poster is:
   - eye-catching
   - visible from a distance
   - illustrated with large drawings or photos
   - contains clearly written facts
   - gives credit to sources of information

Show some examples if you have them.

2. If your students are less experienced in visual art, you may want to give them some poster-making tips. Here are some ideas:
   - Outline plant and animal drawings with marker. Use crayons or colored pencil to create shading and detail.
   - Use the background color to offset words and drawings. Experiment with light and dark backgrounds and lettering. Use colored paper borders around drawings or sections of text. Experiment with different shapes and sizes.
   - Use letter stencils or a printer to create titles and headings. Use a ruler to make sure lettering is straight.
   - Put bibliographical information in a place that is inconspicuous.

Part III

1. Explain to students that they will be giving a five-minute presentation to the class about their plant or animal. Tell them that they will be using their poster to help illustrate their presentation.
2. If your students are less experienced in presenting, you may want to give them some guidelines. Here are some ideas:
   - Review the facts you have learned about your plant or animal. Decide on a logical order in which to present them.
   - Practice your presentation with a friend. Have your friend time you. Your presentation should last about five minutes. If it is too long, decide on some details you can leave out. If it is too short, you may want to add some details or speak more slowly.
   - Use your poster to help you remember what you want to say and to illustrate some of your points.
   - Look out at your audience and speak in a loud, clear voice. Imagine you are talking to a person in the back of the room.
   - Relax and have fun! Remember – you're the expert.

Resources

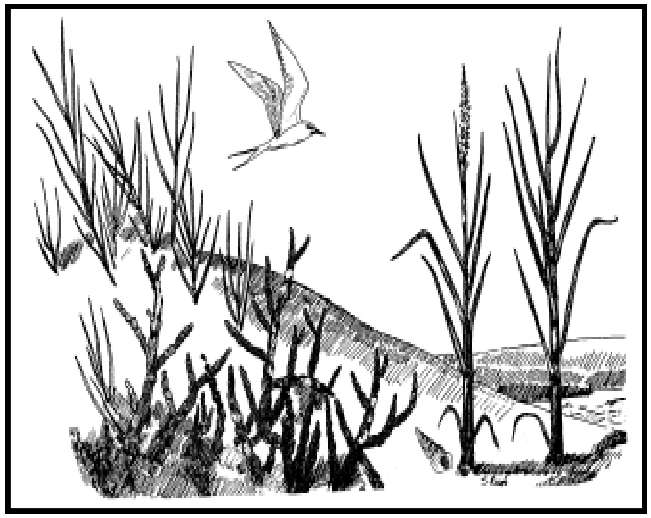
- Bibliography Guidelines http://www.english.uiuc.edu/cws/wworkshop/index.htm
- Salt Pond Wildlife Photos http://www.johncangphoto.com/articles/saltpond.htm
- Birds of San Francisco and the Bay Area, Chris Fisher and Joseph Morlan, Lone Pine Publishing, 1996.
- Suisun Vegetation Guidebook, A Field Identification Guide, Suisun Resource Conservation District, 2544 Grizzly Island Rd., Suisun, CA 94585. 707-425-9302.
- Common Riparian Plants of California and Common Wetland Plants of California, by Phyllis M. Faber, Pickleweed Press. ISBN 0-9607890-1-4 and 0-9607890-0-6.
- Common Wetland Plants of Central California, by Peggy L. Fielder, U.S. Army Corps of Engineers, Sacramento District.
- Field Guide to the Birds of North America, National Geographic Society, Washington, D.C.

Life in the Bay

Getting to know the Bay's plants and animals

Student Pages

INTRODUCTION



Think back to the last time you were near San Francisco Bay. You may have been in a car, driving over one of the Bay's many bridges, or you may have been closer – at a shoreline park or marina. Did you happen to notice the wildlife? Maybe you saw some birds flying overhead or feeding on the mudflats. Maybe you noticed some tall grass or some bushy shrubs. What you probably didn't see is that beneath the surface of the water, thousands of fish and invertebrates (animals without a backbone) swim, crawl, burrow, and cling. Under the cover of tall grass, small birds, mammals, and insects hide.

San Francisco Bay is teeming with life. The nutrient-rich bay mud, the warm shallow water, the marsh plants, and the mild climate provide excellent habitat for migrating birds as well as for animals that live in the Bay year-round. The animals and plants live in delicate balance with one another, each taking their place in the food web.

In this activity, you will have a chance to get to know an organism (plant or animal) that lives in the bay and how it functions as part of the ecosystem. Once you have researched your organism, you will create an informational poster to illustrate what you have learned. You will then use your poster to help you present your organism to the class.

PROCEDURE

1. Choose a plant or animal that lives in San Francisco Bay. Write the name of your organism below:

COMMON NAME: ____

LATIN NAME: ____

2. Choose at least five research questions. You can either use the questions from the following list or make up your own. Write your questions on your research worksheets. Use a separate sheet for each question so you have plenty of room to record your research.

Animal Research Questions

- What is its habitat (where in the Bay does it live)? What adaptations help it survive there?
- What does it eat? Where does it find its food? What adaptations help it get food?
- Who are its predators?
- What does your animal look like?
- What sounds (if any) does your animal make?
- What do the animal's tracks look like?
- How does it reproduce?
- What are some cool facts about your animal?

Plant Research Questions

- What is its habitat (where in the Bay does it live)? What adaptations help it survive there?
- What animals eat it? What animals use it for shelter or protection?
- How have humans used it (medicine, food, building, etc.)?
- Is it a native or introduced species? (if introduced, how did it get here)?
- What does your plant look like?
- How does it reproduce?
- What are some cool facts about your plant?

3. Begin your research. Use books, magazines, newspapers, field guides, encyclopedias, and the Internet to find answers to your research questions. This may take a few days or even a few weeks. Don't panic if you can't find the answers right away. Try using a different source, or asking a different question. Record your findings on your research worksheets. Remember to write down your sources!

4. Create an informational poster featuring your organism. An informational poster is:

- educational
- eye-catching
- visible from a distance
- illustrated with large drawings or photos
- contains clearly written facts
- gives credit to sources of information

Here are some ideas for designing an effective poster:

- Outline plant and animal drawings with marker. Use crayons or colored pencils to create shading and detail.
- Use the background color to offset words and drawings. Experiment with light and dark backgrounds and lettering. Use colored paper borders around drawings or sections of text. Experiment with different shapes and sizes.
- Use letter stencils or a printer to create titles and headings. Use a ruler to make sure lettering is straight.
- Put bibliographical information in small type in a place that is inconspicuous.

5. Prepare a five minute oral presentation of your organism, using your poster as a visual aid. Here are some tips for making an effective presentation:

- Review the facts you have learned about your plant or animal. Decide on a logical order in which to present them.
- Practice your presentation with a friend. Have your friend time you. Your presentation should last five minutes. If it is too long, decide on some details you can leave out. If it is too short, you may want to add some details or speak more slowly.
- Use your poster to help you remember what you want to say and to illustrate some of your points.
- Look out at your audience and speak in a loud, clear voice. Imagine you are talking to a person in the back of the room.
- Relax and have fun! Remember you're the expert.

Research Worksheet

Student Pages

Research Question: ______________________________

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Source: ______________________________

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Findings: ______________________________

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Source: ______________________________

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Findings: ______________________________

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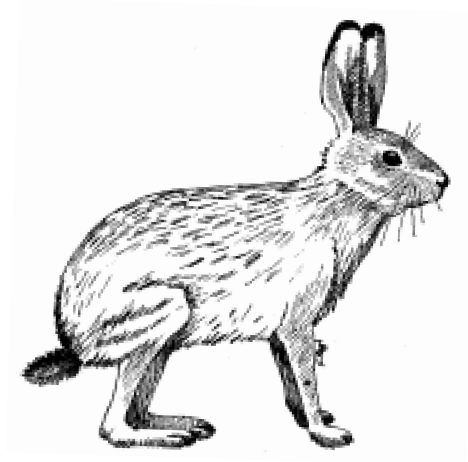
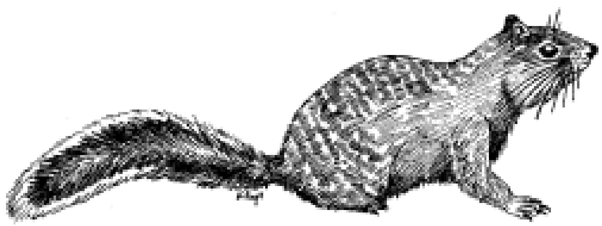
Animals of San Francisco Bay

Mammals

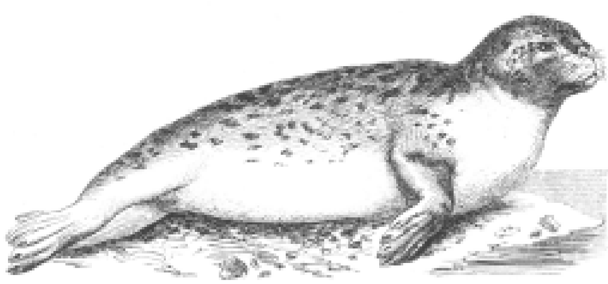
Black-tailed Jackrabbit *(Lepus californicus)*
Found throughout the San Francisco Bay area in salt marshes, open fields, and mountains. Diet consists of grasses, nuts, and seeds. Eaten by owls, hawks, and foxes. Its long ears help to cool it in hot weather.





California Ground Squirrel *(Spermophilus beecheyi)*
Lives in upland burrows that it digs itself, found in dry grasses in the marsh or on levees. Feeds on nuts, seeds, fruit, grasses, some insects, and carrion. Eaten by owls, hawks, and foxes.

California Sea Lion *(Zalophus Californianus)*
California sea lions inhabit rocky and sandy beaches of coastal islands and mainland shorelines. They eat fish, squid, and octopi. Sea lions are adapted for movement on land as well as in the water. Their loud roars explain why they are named after lions that live on land.



Harbor Seal *(Phoca vitulina)*
Graceful swimmer but clumsy on land. Spends part of each day on land, coming ashore at places called haul-outs. Eats one large meal a day, consisting of fish, shellfish, and squid. Eaten by large sharks and killer whales. Habitat includes mudflats, shallow water, bay waters, and sandy beaches.

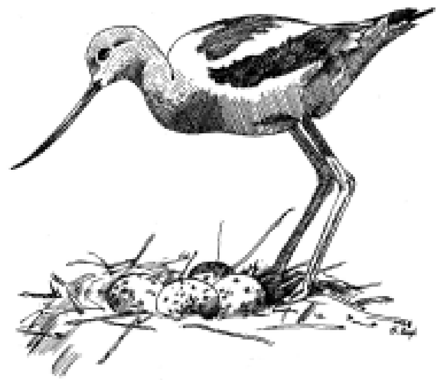
Muskrat (*Ondatra zibethica)*
Semiaquatic rodent found in North America. Its body, about 30 cm (about 12 in) long, is covered with brown to blackish outer hairs and a dense underfur. The tail, almost as long as the body and nearly hairless, is scaly and flattened laterally; it is used as a rudder in swimming. Its diet is mostly water plants, but it also eats freshwater mussels, other invertebrates, and fish.

Salt Marsh Harvest Mouse

(Reithrodontomys raviventris)

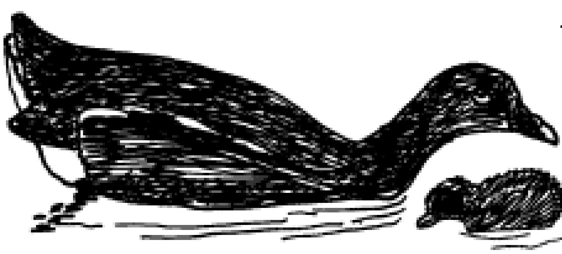
Endangered species found only in the salt marshes of the Bay. Feeds exclusively on pickleweed. Brown with a rusty belly. A tiny mouse, it is only 2 1/2 to 3 1/2 inches long. Eaten by birds of prey such as owls, northern harriers, and red-tailed hawks, as well as herons, egrets, and clapper rails.

Birds



American Avocet *(Recurvirostra americana)*

Head and neck rusty in breeding plumage, gray in winter, black and white wings with white stripe, gray body. Long legs and upturned bill, which is swept side to side through shallow water when feeding on invertebrates. Commonly found in open wetlands, most common in shallow waters. Nests on levees and islands in and around the salt ponds.

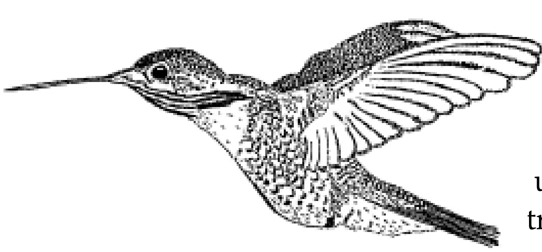


American Coot *(Fulica americana)*

Dark grey and black duck-like bird with a white bill. Feeds on the shore and on the surface of the water or under it, diving with an upward jump before submerging. Found in freshwater ponds and in sloughs. Large flocks occur on the mudflats. Often called mud hen.

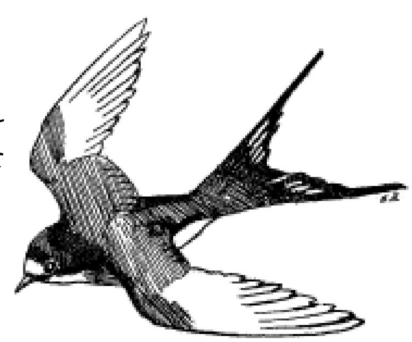
American White Pelican *(Pelecanus erythrorhynchos)*

Large bird with black lining of the wings. Breeding adult has pale yellow crest, bill is brighter orange. Does not dive for food, but dips its bill into the water while swimming. Breeding birds may fly 150 miles from the nest to feed. Alternates flapping and gliding while flying.



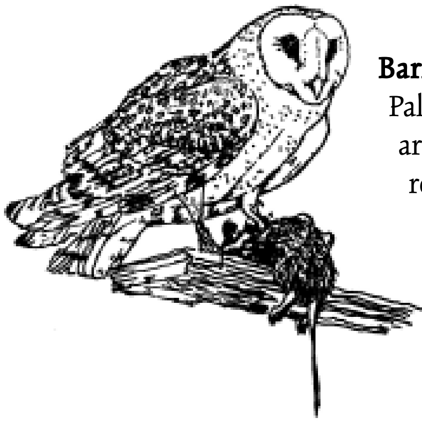
Anna's Hummingbird *(Calypte anna)*

Male's head and throat are a deep rose red. Female's throat has reddish flecks. Both have grayish underparts, washed with green. Feeds on nectar, water, spiders, and tree sap, and is found in open woodland, chaparral, and gardens.



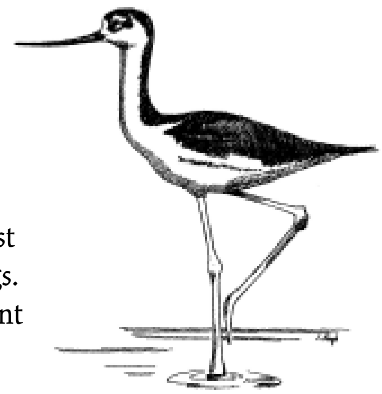
Barn Swallow *(Hirundo rustica)*

Iridescent blue back, with a cinnamon colored belly and throat. Most distinctive is a long, deeply forked tail. Nests under bridges, inside culverts or on building walls. Open cup-shaped nest. If it cannot find any mud to create the nest, the barn swallow makes its own by walking in water and then soil. Eats insects while flying.



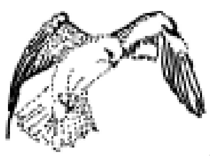
Barn Owl *(Tyto alba)*

Pale face with dark eyes in a heart-shaped outline on the face. Upper parts are rusty brown and underparts vary from white to cinnamon. Nests and roosts in dark cavities in city and farm buildings, cliffs, and trees.



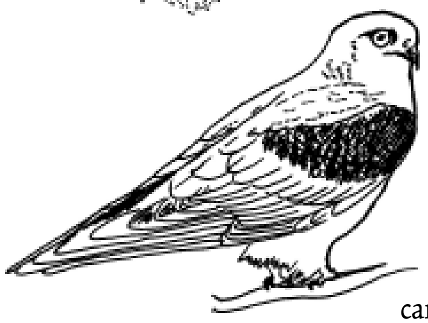
Black-necked Stilt *(Himantopus mexicanus)*

The black-necked stilt's glossy black back, bill and back of neck contrast sharply with white underparts (the “tuxedo bird”). Long red or pink legs. Found in the salt ponds, the black-necked stilt is mostly a summer resident throughout California but winters in the San Francisco Bay as well.



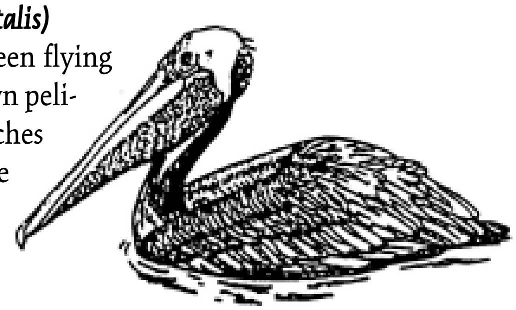
White-tailed Kite *(Elanus leucurus)*

Long, pointed grey wings, straight, long, mostly white tail and belly, grey back. Black shoulders show in flight. Often hovers (like a kite), flapping wings rapidly while hunting, then dive-bombs its prey. Eats mainly rodents and insects. Seen above marshes and resting on dead trees. Formerly called White-tailed Kite.



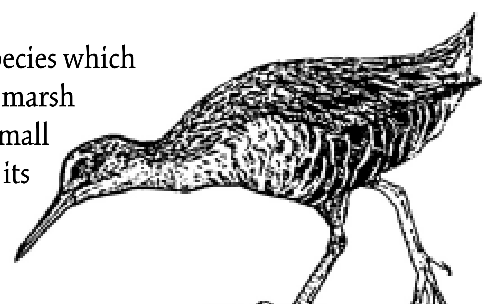
Brown Pelican *(Pelicanus occidentalis)*

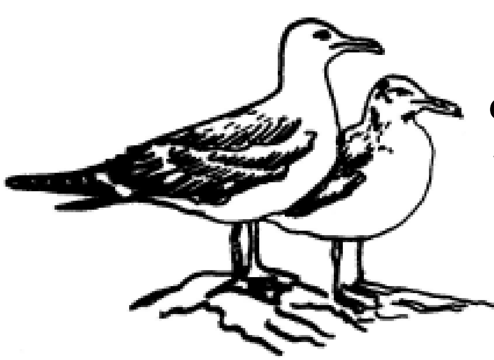
This large, greyish bird is often seen flying above the ocean or bay. The brown pelican has an 8 foot wing span and catches fish by diving bill first into the water. An endangered species, the Brown Pelican's population declined due to DDT and DDE, pesticides whose use is now banned in the United States.



California Clapper Rail *(Rallus longirostris obsoletus)*

Gray-brown marsh bird with cinnamon underside. An endangered species which lives only around the San Francisco Bay. Lives in dense patches of salt marsh cordgrass and pickleweed. Feeds on crustaceans, insects, spiders, mice, small fish, and cordgrass. Clapper rails are eaten by birds of prey and foxes; its eggs are eaten by rats.

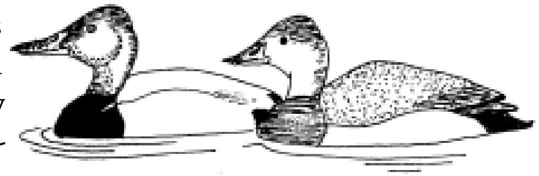




California Gull *(Larus californicus)*

Adult has dark grey wings and back, white head, dark eye, and a yellow bill with black and red spots. Greenish yellow legs. These gulls, seen often around the salt ponds, mature in four years and acquire different plumage in each of the first four winters.

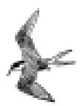
Canvasback *(Aythya valisineria)*



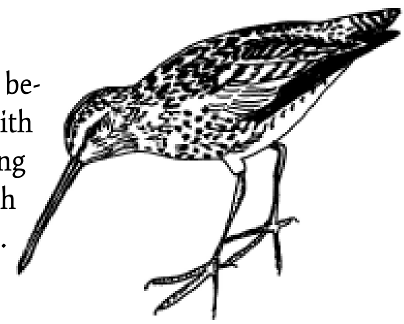
Diving duck, with legs set far back on body for ease in diving; makes walking difficult. Male has chestnut red head and neck, white back and sides, dark breast. Female has pale brown head and neck and pale grey back and sides. The canvasback can be found on the open bay, especially in San Pablo Bay.

Double-crested Cormorant *(Phalacrocorax auritus)*

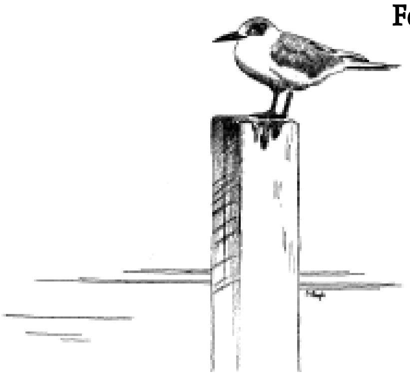
Large, rounded throat pouch is orange year-round. Double crests are seldom visible. Kinked neck is distinctive in flight, flies with rapid wing beat. A resident along coast, lakes and estuaries. Body is black throughout.



Dowitcher *(Limnodromus scolopaceus)*



This shorebird's nickname is the sewing machine bird because of its feeding technique, probing in the mudflats with its long, straight bill. Winter plumage, grayish; breeding adult is entirely reddish below, spotted brown above, with a whitish rump patch. Found in sloughs and mudflats.

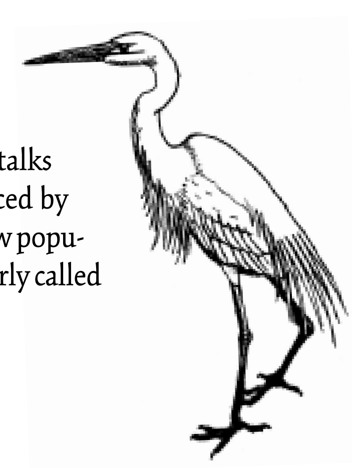


Forster's Tern *(Sterna forsteri)*

Pale grey above, black crown and nape (back of neck) in summer, red bill with black tip in spring. Orange legs and feet, slow wing beat. Long, deeply forked grey tail has white outer edges. A widespread migrant on seashore bays, inland lakes and marshes. Tends to be quarrelsome with birds of other species, sometimes attacking them viciously to protect its nest. Can be seen hovering and diving for fish in the salt ponds and sloughs.

Great Blue Heron *(Ardea herodias)*

One of the largest wading birds in California, standing to 4 feet tall. Slate blue with white head, black stripe extends above eye, white fore neck streaked with black. Graceful and majestic, the great blue heron eats frogs, mice, and fish (spears fish and flips them upwards, catching them in midair). Resident of fresh and salt water marshes and tidal areas.

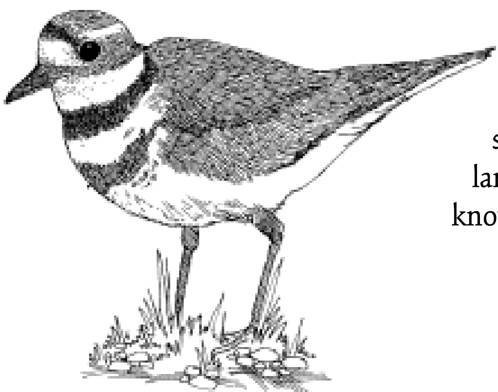


Great Egret *(Ardea alba)*

Large white heron with yellow bill, blackish legs and feet. Stalks prey slowly and methodically. Population was greatly reduced by feather plume hunters (for hats) at the turn of the century. Now population is recovering. Common in marshes and mudflats. Formerly called Common Egret and American Egret.

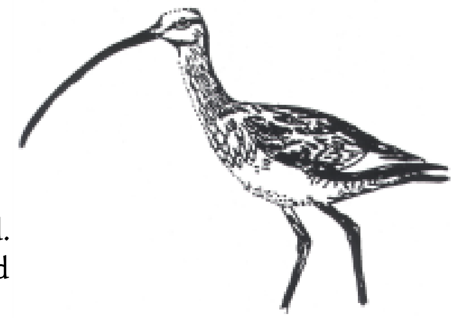
American Kestrel *(Falco sparverius)*

Bird of prey about the size of a robin. Rust colored feathers, bright yellow talons, and a hooked beak. Kestrels have binocular vision, which means their sight range is similar to humans. They live in prairies, meadows, and fields. Kestrels are carnivores. Their main diet is insects, but they also eat small animals such as rats, mice, and lizards.



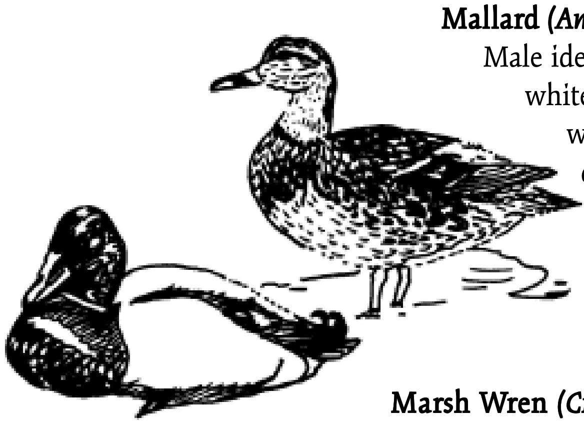
Killdeer *(Charadrius vociferus)*

Two distinctive black or brown breast-bands, bright orange tail and eye ring, black bill. Loud, shrill call that sounds like "kill-dee". Lives in grasslands and estuaries. Can live close to people and has been known to nest on the flat roofs of houses.



Long-billed Curlew *(Numenius americanus)*

Large shorebird (23 inches long) with a cinnamon brown back and lighter breast. The bill is very long and downcurved. into mudflats with bill, feeding on small mud



Mallard *(Anas platyrhynchos)*

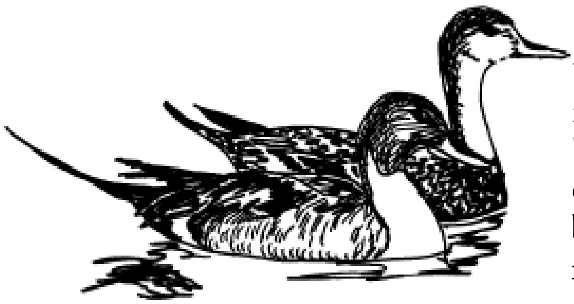
Male identified by metallic green head and neck, yellow bill, narrow white collar and chestnut breast. Black tail feathers curl up. Female with molted plumage. Chiefly winters in salt marshes. A “puddle duck” that feeds with its tail in the air and head underwater.

Marsh Wren *(Cistothorus palustris)*

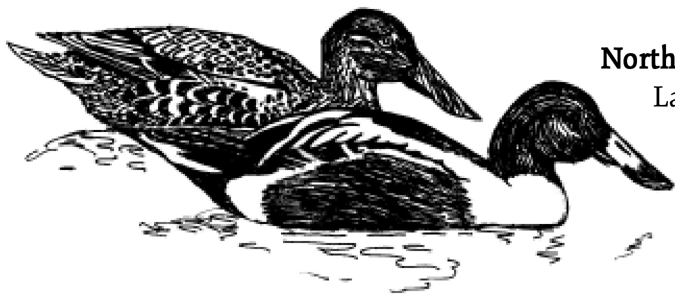
Brown crown, bold white eye line, black triangle on upper back, streaked with white, underparts mostly white. Call sounds like a lawn sprinkler (whish, whish). Found in reedy marshes, either fresh or brackish water.

Northern Harrier
(Circus cyaneus)

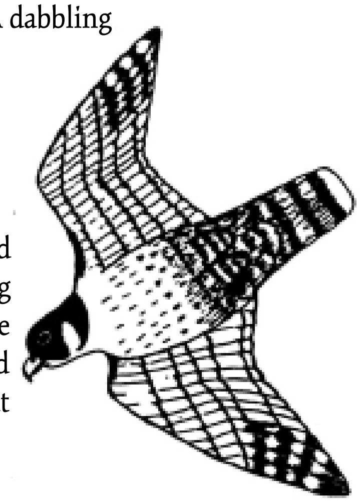
Distinct white area between the lower back and tail. Wings are long and narrow, with a 4 foot span. Flies close to the ground searching for mice, rats, frogs, rabbits, small birds and other small prey. Commonly found in wetlands and open fields. Formerly called the Marsh Hawk.



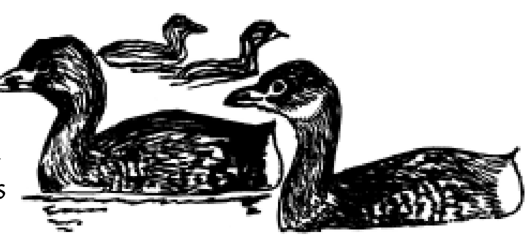
Northern Pintail ***(Anas acuta)***
When feeding, this dabbling duck "tips over" for its meal (plant matter) showing off its long tail feathers. The male has a chocolate brown head and white neck with a dark stripe down the back. Black central tail feathers extend to form a "pintail". Female is mottled brown, paler on head and neck. Found around sloughs and salt marshes.



Northern Shoveler ***(Anas clypeata)***
Large, spatula-like bill, longer than head. Male has a green head, white breast and brown sides. Female's grayish bill is tinged with orange. A dabbling duck found in marshes.



Peregrine Falcon ***(Falco peregrinus)***
A powerful raptor with a black "helmet" and long, pointed wings. The fastest bird in the world, the peregrine can reach speeds of up to 200 miles per hour, diving from above to kill its prey, usually small to medium-sized birds. The peregrine falcon was recently delisted as an endangered species. Its population has recovered due to federal protection and a national ban on the use of DDT, a pesticide that accumulates in the food chain and weakens eggshells.

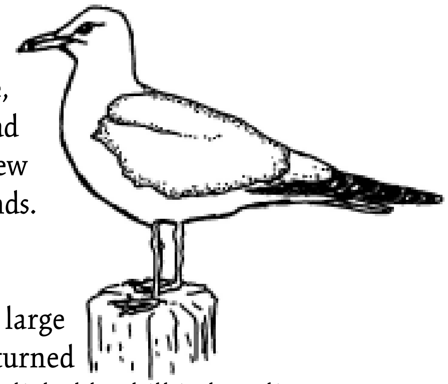


Pied-billed Grebe ***(Podilymbus podiceps)***
Small, stocky brown bird with a black ring around its stout whitish bill, black chin and throat, pale belly. Nests around marshy ponds and sloughs; tends to hide from intruders by sinking like a submarine. Grebes spit up pellets of undigested materials, such as bones, like owls do.

Red-tailed Hawk ***(Buteo jamaicensis)***
A skilled glider, the red-tailed hawk has broad and fairly rounded wings; plumage extremely variable. All adult red-tailed hawks have a dark bar on the leading edge of the underwing, contrasting with paler wing linings. Reddish upper tail, paler red undertail. Preys on rodents.

Red-winged Blackbird
(Agelaius phoeniceus)
Glossy black male has red shoulder patches. In perched birds, yellowish border shows. Female is dark brown above, with a streaked belly. May be found singly or in large flocks, usually nesting in thick vegetation of freshwater marshes, sloughs and fields.

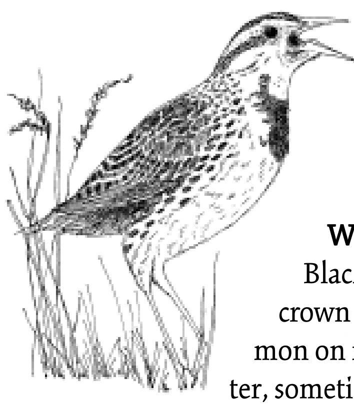
Ring-billed Gull ***(Larus delawarensis)***
Adult has black ring around yellow bill. Greenish-yellow legs, pale-grey mantle, white head and underparts, black primary feathers tipped with white spots. Head streaked with brown in winter. These gulls mature in three years and acquire new and different plumage in each of the first three winters. Found around salt ponds.



Ruddy Duck ***(Oxyura jamaicensis)***
A chunky, thick-necked duck with large white cheek areas and a stiff upturned tail. Male has rusty sides and a light blue bill in breeding season (April to August). Female is mottled brown. Nests in dense vegetation of freshwater marshes, lakes and ponds. Can be found on salt ponds during winter.

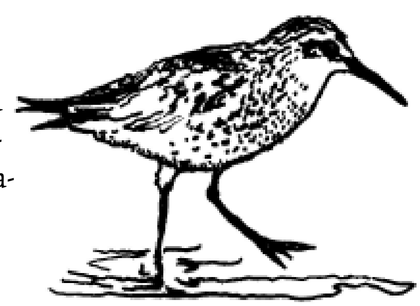
Snowy Egret ***(Egretta thula)***
White feathers, black bill, black legs with bright yellow feet (these "golden slippers" are used as lures to attract fish). In the breeding season, fluffy plumes curve upward from the back of the head and neck.

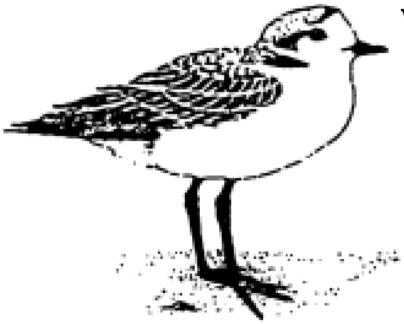
Turkey Vulture ***(Cathartes aura)***
Seen from below, two-tones wings (flight feathers dark silver-grey, linings black). In flight, wings are often held in an upward, shallow "V" seldom flapping, usually rocking from side to side. Turkey Vultures feed on carrion (dead animals) and refuse. Common in dry open country.



Western Meadowlark ***(Sturnella neglecta)***
Black V-shaped band on bright yellow breast. Wing upper parts are dark, with lighter edges. Song is a variable series of bubbling, flutelike notes, accelerating toward the end (beautiful)! Common in open country and grasslands, often heard before it is seen.

Western Sandpiper ***(Calidris mauri)***
Black legs, drooped bill at tip. In summer, back and crown are rusty, in fall the plumage is gray above. Common on mudflats, where it probes at the edge of the water, sometimes submerging its head.



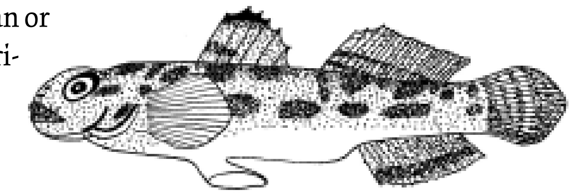


Western Snowy Plover
(Charadrius alexandrinus nivosus)
A threatened shorebird. Pale above and white below, with a thin dark bill, dark legs, and a dark breast band and ear patch. Nests on sandy beaches, dried salt ponds, and salt pond levees. Recognizable by behavior: these small, compact birds dart a short distance, quickly stop, and then run again. Eggs and chicks blend in with sand or levee material, making it difficult for predators to see them.

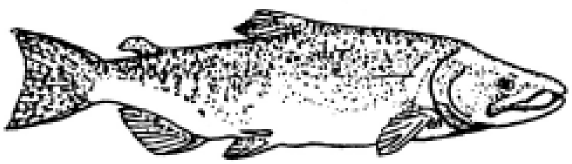
Willet ***(Catoptrophorus semipalmatus)***
Large and plump when standing, grayish above, belly white. In flight, striking black and white wing stripes are visible. Nests in wetlands, winters in salt marshes and on coastal beaches. Often seen in small flocks.

Fish

Bay Goby ***(Lepidogobius lepidus)***
A bottom-dwelling fish with a "suction cup" under its chin. Tan or pale olive, grows to 4 inches long. Feeds on plankton and detritus, eaten by birds, such as egrets, herons, and terns.

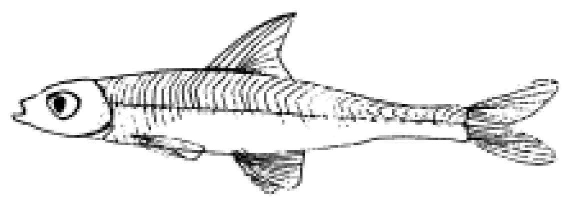


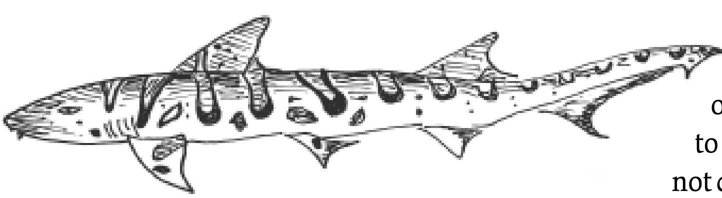
Chinook Salmon ***(Oncorhynchus tshawytscha)***



The largest of the salmons, the chinook can be almost 6 feet long and weigh up to 135 pounds. Chinook have black spots on their back and dorsal fin. Salmon are "anadromous", which means they are born in fresh water rivers or streams, they swim to estuaries or the ocean to grow up, and then return to fresh water to spawn.

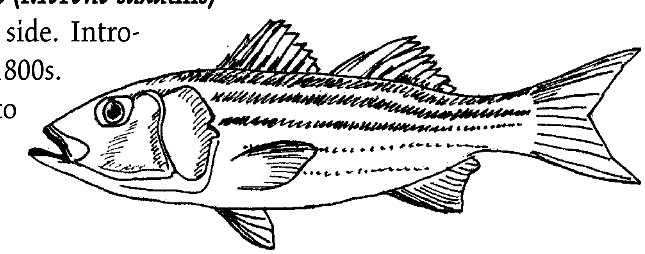
Delta Smelt ***(Hypomesus transpacificus)***
Silvery fish with a faint, speckled side stripe and a small mouth. Grows to about four and a half inches long. Habitat is brackish and fresh water.

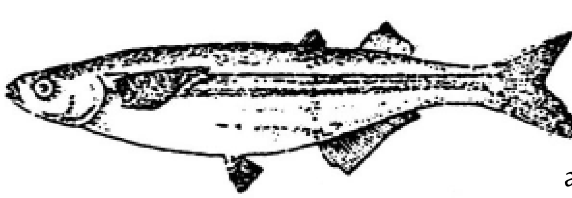




Leopard Shark ***(Triakis semifasciata)***
This shark is gray above with black spots and crossbars on back and sides, white below. The leopard shark grows to 7 feet and eats a variety of fishes and invertebrates. It is not considered dangerous to humans.

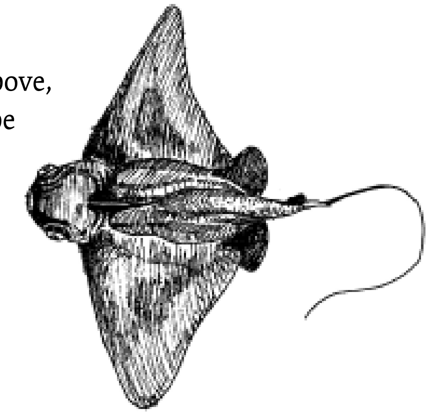
Striped Bass ***(Morone saxatilis)***
Greenish above, silvery below, with black stripes on the side. Introduced to the Pacific Coast of North America in the late 1800s. A migratory fish which moves along the coast and into rivers in the spring to spawn.



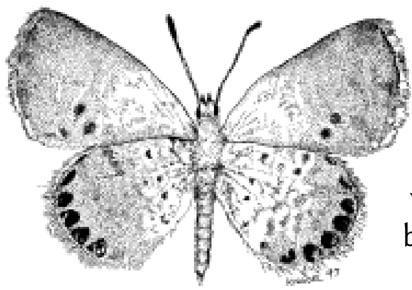


Topsmelt ***(Atherinops affinis)***
Green fish with a bright silver side stripe; silvery below. Can be up to fourteen inches long. Habitat is bay waters, rocky areas, and kelp beds.

Bat Ray *(Myliobatis californica)*
Square head is elevated above wings; color is dark brown to olive or black above, white below; tail is long and whiplike. Grows up to four feet long. Can be seen swimming in sloughs.

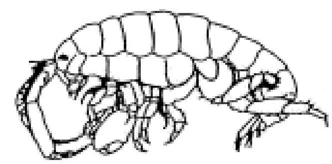


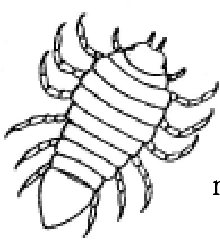
Invertebrates



Western Pygmy Blue Butterfly *(Brephidium exilis)*
The smallest butterfly in North America, the pygmy blue has brown wings with a white fringe and blue near its body. Often seen around Australian salt bush. Butterflies peak in late summer and fall.

Amphipods *(Amphipoda)*
A crustacean about the size of a pinhead, it is flattened from side to side and has long legs at both ends. Scavenger who feeds on detritus (decomposed plants and animals).



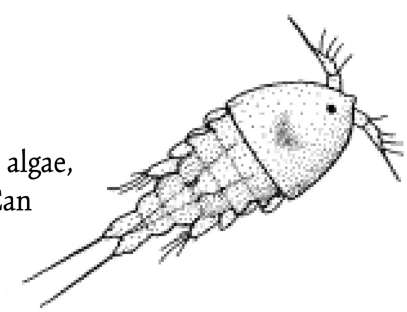


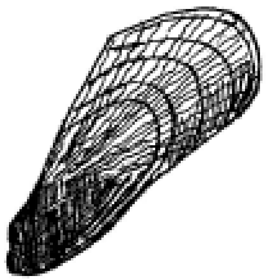
Isopods *(Isopoda)*
A tiny crustacean flattened from top to bottom, it has 2 pairs of antennae and four sets of jaws. There are over 10,000 species of isopods living on land, in fresh water, and in salt water. The isopods found in San Francisco Bay are realated to the sowbugs and pill bugs you might find in your garden.

Crabs *(Brachyura)*
Has claws and four other pairs of legs. Sheds its shell as it grows (molts). Burrows in the mud and feeds upon detritus and plankton. Can move quickly.

Clams *(Lamellibranchia)*
A bivalve of varying size. Uses its muscular foot to burrow in mud. Has two openings in its shell to filter water in order to obtain food.

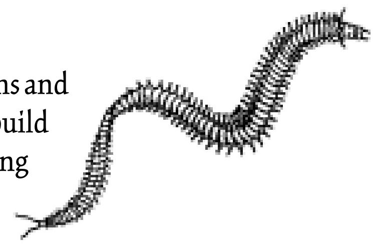
Copepod *(Copepoda)*
Crustacean (like the crab and lobster) which is about 2 mm. long. Feeds on algae, bacteria, and detritus (decomposed plants and animals). Eaten by small fish. Can be found in shallow waters and mudflats of sloughs.





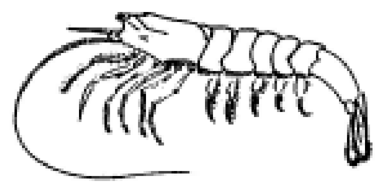
Mussels *(Filibranchia)*
A bivalve that lives on shores attached to rocks by strong threads excreted by a special gland. Lacks head and tentacles. Eats detritus and plankton. Eaten by humans and shorebirds.

Polychaetes *(Polychaeta)*
One of the numerous species of worms living in the mud along the sides of sloughs and on the muddy bay bottom. Some species crawl on the mud or swim, but most build tubes for their home. Eats mud and sand, digesting the organic material and passing the mineral sediments in long, coiled earthworm-like castings.



Snails *(Gastropod)*
Crawls slowly in shallow water, feeding on diatoms scraped off the mud by its tongue. Also eats algae, plant material and clams. Has a single coiled shell and a distinct head and tentacles. Habitat is mudflat in the slough.

Ghost Shrimp *(Callianassa stimpsoni)*
Small creature which burrows in the mudflats. A crustacean, but covered with a flexible cuticle rather than a hard shell. To feed, it sifts through sand to find bacteria, diatoms, and detritus.

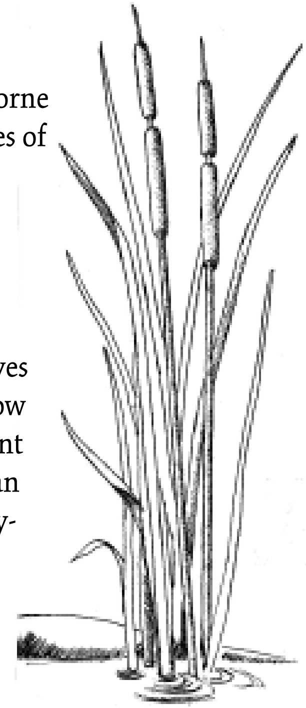


Wetland Plants of the San Francisco Bay Area

Alkali-heath *(Frankenia salina)*
This low, sprawling shrub is commonly found in the drier parts of salt marshes, along levees, and other areas with very alkaline soil. The small green leaves are opposite each other and the small pink flowers grow in the leaf axil (the area where the upper side of the leaf meets the stem).

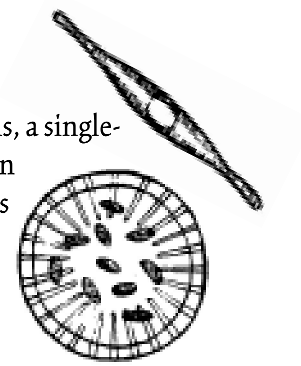
Australian Saltbush *(Atriplex semibaccata)*
The stem of this greenish-gray plant lies along the ground in dense mounds. The flowers are small and inconspicuous and the red, fleshy fruits are edible. This is an important food for the larvae of the Pygmy Blue Butterfly.

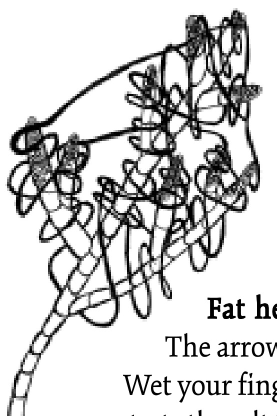
Cattail *(Typha spp.)*
Tall upright plants with a 6 to 12 inch cigar-shaped seed head that scatters downy airborne seeds in the fall. Cattails grow in freshwater marshes and provide important sources of food and cover for wildlife.



Cordgrass *(Spartina foliosa)*
This plant looks somewhat like a corn plant and lives between the mudflat and pickleweed zones. It can grow up to 4 feet tall and 1 acre produces more usable plant material (biomass) than 1 acre of wheat. Since it can be submerged for up to 22 hours, cordgrass moves oxygen from its leaves to its roots to survive.

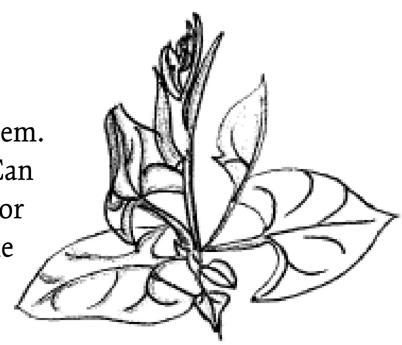
Diatoms
A microscopic type of phytoplankton with "pillbox" shaped cases made of silicon. Diatoms, a single-celled algae, account for most of the amazing productivity of salt marshes. The thick golden sheen sometimes seen on the surface of the mud flat is actually a mat of millions and millions of diatoms.





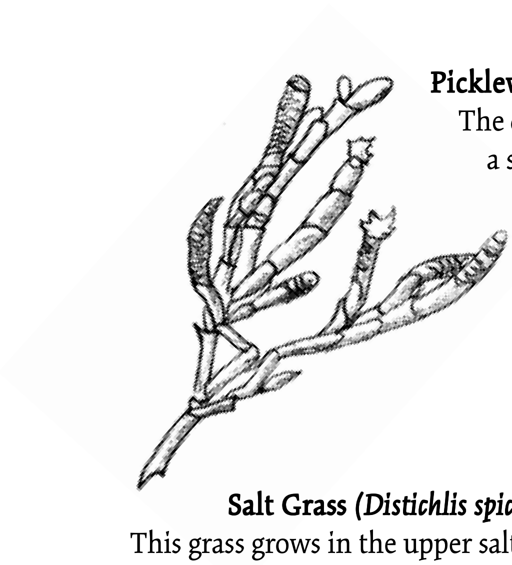
Dodder *(Cuscuta salina)*
This orange, stringy, parasitic plant is found on pickleweed. Small white flowers bloom from June through August. Its leaves are reduced to minute scales. Its common name is Devil's Sewing Thread.

Fat hen *(Atriplex patula)*
The arrow-shaped leaves of this plant have white crystals on them. Wet your finger, rub one of the leaves and then taste your finger. Can you taste the salt from the leaves? The leaves can be used as a substitute for spinach. Ground squirrels and mice eat the leaves and ducks are very fond of the tasty seeds.



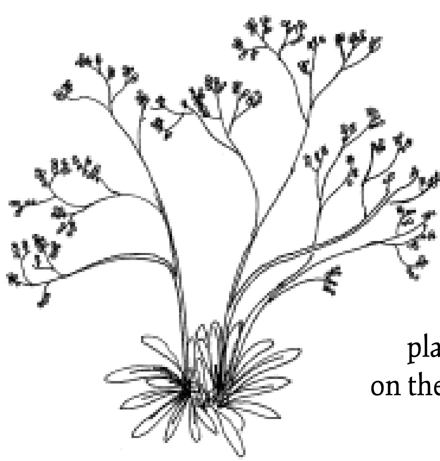
Gum Plant *(Grindelia stricta)*
This low-growing plant is a member of the sunflower family. If you look closely at what appears to be the center of the 1-2 inch yellow gum flower, you will find that it is really many tiny flowers. The plant takes its name from the sticky substance it secretes, especially around the flower heads.

Ice Plant *(Mesembryantheum nodiflorum)*
This low-growing plant is covered with tiny glistening beads that are swollen with water. In the fall, the seeds turn red and sparkle like rubies. This small succulent plant was introduced from Africa in the late 1800s



Pickleweed *(Salicornia virginica)*
The compressed leaves of this low-growing marsh plant look like a series of gray-green pickles attached end to end. Pickleweed takes salt water up through the roots and stores the excess salt in the top "pickles". In the fall, this part turns red and falls off, ridding the plant of the extra salt. Taste a tiny bit of this edible plant, but be sure to leave lots for the salt marsh harvest mouse to eat!

Salt Grass *(Distichlis spicata)*
This grass grows in the upper salt marsh. It has stiff, wiry leaves and often grows low along the ground. Look for salt crystals that have been "sweated" out onto the leaves.



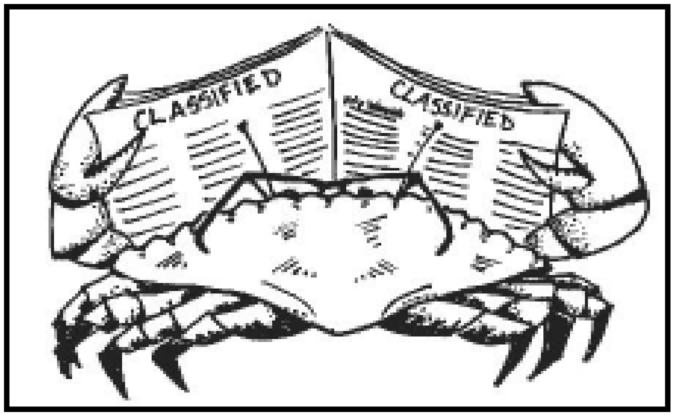
Sea Lavender *(Limonium californicum)*
Also known as Western Marsh Rosemary, this native marsh plant has wide, oval leaves at the base of tall stems. Small, lavender flowers in bunches at the tops of the stems. Cultivated plants are used in flower displays. Salt can often be found on the leaves.

Tule *(Scirpus acutus)*
Long, slender, reed-like plants that are found in brackish and freshwater marshes. Tule are found in dense stands at the edges of sloughs, ponds, and ditches.

Help Wanted!

Understanding niche

Overview
Help Wanted is a simple activity designed to help students understand the term niche. Students write a newspaper-style want-ad looking for an organism to fill a certain niche.



Sharón Friedner

Estimated Time
2-3 class periods, depending on how readily available your resources are.

Objectives
Students will be able to:
- Explain the term niche
- Describe the niche of an organism that lives in the Bay
- Use what they know about an organism's niche to write a newspaper style want ad

Materials
- Books and resources containing information on animals that live in San Francisco Bay

Vocabulary
- Niche, adaptation, habitat

Background
Studying ecology can be frustrating for many students because of all the vocabulary words and phrases. Definitions for terms like *ecosystem, habitat, community, population,* and *niche* all seem to blur and lose specific meaning for students. Students will better retain vocabulary words if they use them in an enjoyable activity.

One term that students often have trouble with is *niche*: the specific role or "job" of an organism within its habitat. Everything an organism does is part of its niche – how it obtains food, how it protects itself, where it lives, and when it is active. A well-adapted organism fills its niche very well. An interesting way to help students understand the niche concept is by writing a niche want ad. By completing the niche want ads, students will not only better understand the concept of ecological niche, but they will also learn more about a particular organism and how it interacts with its environment.

California Science Content Standards
Grade 6
Standard Set 5.c: populations of organisms can be categorized by the functions they serve in an ecosystem.
Standard Set 5.d: different kinds of organisms may play similar ecological roles in similar biomes. Ecology (Life Science)

English and Language Arts Standards
Grades 6-8: Writing Strategies
...writing exhibits students' awareness of the audience and purpose. Essays contain formal introductions, supporting evidence, and conclusions. Students progress through the stages of the writing process as needed.

Teacher Procedure
Students choose an organism that lives in San Francisco Bay. After researching the organism, they write a 30-50 word ad in the style of the want ads in the newspaper. The ads should describe the role of the organism in its habitat, including activities and relationships. The description should contain how the organism finds food, how it protects itself, where it lives, its position in the food chain, and any other unique features of its activities or its relationships with other organisms. The completed ads can be used in a variety of ways. Students can read them to each other and try to name the designated organisms, or the ads could be used as part of an "econewspaper" about San Francisco Bay or your school grounds.

Example

Help Wanted

(black-necked stilt)
Elegant individual needed to probe into mudflats and feed on small mud creatures. Must enjoy the outdoors and be able to withstand long hours standing in salt water. Webbed feet, long legs, and long bill a plus. Formal dress (tuxedo, white shirt) required.
1-800-664-BIRD

(bay goby)
Excellent swimmer needed to live and work on the bottom of San Francisco Bay. Main responsibility will be eating plankton and detritus. Experience with camouflage required, prefer tan and olive colors. Must be able to recognize and avoid egrets, herons, and terns.

Acknowledgement
Adapted from "Finding Your Niche in the Want Ads," written by Michael E. Baldwin, Brownsville Independent School District, Brownsville Texas. Published in Science Scope, January 1994.

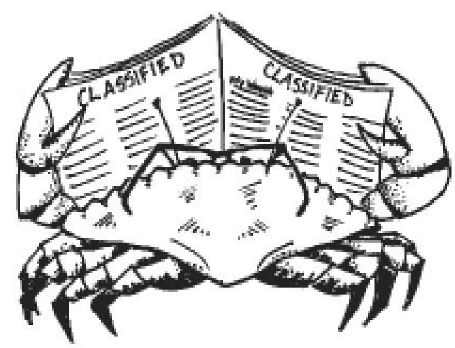
Help Wanted!

Understanding niche

Student Pages

INTRODUCTION

A *niche* is the specific role or "job" of an organism within its habitat. Everything an organism does is part of its niche – how it obtains food, how it protects itself, where it lives, and when it is active. A well-adapted organism fills its niche very well.



Sharón Friedner

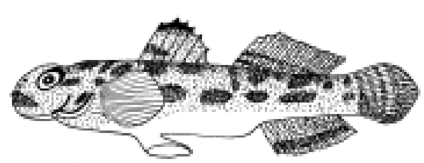
In this activity you will research an organism that lives in the San Francisco Bay. Find out as much as you can about the organism's niche, including how the organism obtains food, how it protects itself, where it lives, its position in the food chain, and any other unique features of its activities or its relationships with other organisms. Then, write a newspaper-style help wanted ad describing the perfect job for your organism.

CLASSIFIED

Help Wanted

Elegant individual needed to probe into mudflats and feed on small mud creatures. Must enjoy the outdoors and be able to withstand long hours standing in salt water. Webbed feet, long legs, and long bill a plus. Formal dress (tuxedo, white shirt) required.
1-800-555-BIRD

Excellent swimmer needed to live and work on the bottom of San Francisco Bay. Main responsibility will be eating plankton and detritus. Experience with camoflauge required, prefer tan and olive colors. Must be able to recognize and avoid egrets, herons, and terns.
510-555-FISH



Your Name: ______________________

Student Pages

Help Wanted

Name of Organism: ______________________

Adapted for Survival?

Designing a Bird Adapted to Its Habitat

TEACHER'S PAGES

Overview

"Adapted for Survival" is designed to allow students to think about specific adaptations and how they pertain to the survival of the individual, and ultimately, the species. Students design a habitat and then design a bird with specific adaptations that would be best suited for their bird's survival in its habitat. After drawing the bird and its habitat, students exchange habitats with another group and must decide and then explain if their bird could survive in the new environment.

Estimated Time

One class period

Objectives

Students will be able to:

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

Materials

- 1 large piece of paper (poster size) and one small piece of paper (8 ½ X 11) for each group of 3 or 4 students
- markers/colored pencils, scissors, tape
- Copies of student worksheets

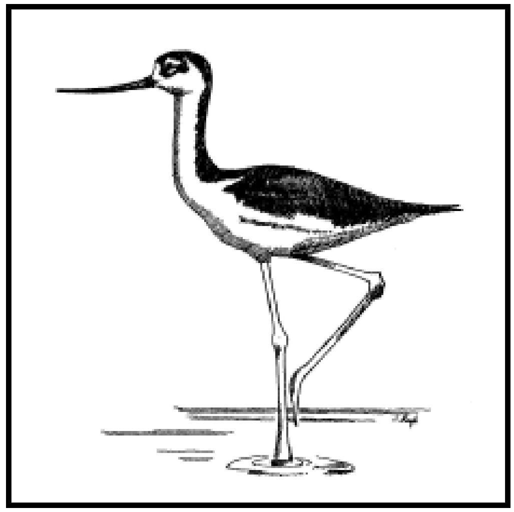
Vocabulary

adaptation, evolution, species, natural selection, habitat, extinction

Science Content Standards

Grade 7

Standard Set 3.a: eoth genetic variation and environmental factors are causes of evolution and diversity of organisms.



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

Grades 9-12

Biology/Life Sciences Standard Set 6.a: biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.

Biology/Life Sciences Standard Set 8.a: how natural selection determines the differential survival of groups of organisms.

Biology/Life Sciences Standard Set 8.b: a great diversity of species increases the chance that at least some organisms survive large changes in the environment.

Acknowledgment

This activity is based on "Fashion-A-Fish" which is found in Aquatic Project Wild and published by the Western Regional Environmental Education Council.

Additional Resources/Activities

Fish Heads: http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/fishhead.html

Bird Beak Buffet: http://pubs.usgs.gov/of/of98-805/lessons/chpt2/act5.htm

Background

Biological evolution accounts for the diversity of species developed through gradual processes over many generations. For instance, birds are the products of countless adaptations over long periods of time. These adaptations, for the most part, are features that increase birds' likelihood of surviving in their habitat.

When a habitat changes, either slowly or catastrophically, the species with adaptations that allow them many options are the ones most likely to survive. Some species have adapted to such a narrow range of habitat conditions that they are extremely vulnerable to change. They are over-specialized and are usually more susceptible than other species to death or extinction.

"California is one of the most biologically diverse areas in the world. Within its 160,000 square miles, California harbors more unique plants and animals than any other state. The diversity of climates and landscapes, and all the barriers to migrations such as rivers, mountains, and deserts, have led over thousands of years to the evolution of a large number of isolated species and varieties of animals, many of which are found only here. For example, there are about 30,000 species of insects recorded in California, 63 freshwater fishes, 46 amphibians, 96 reptiles, 563 birds, 190 mammals, and about 8,000 plants.

"Yet it is also true that today, California's extraordinary diversity is being lost in many important habitats throughout the state… Why does California have more endangered species than any other state? Biologists believe that the basic cause is an ever-increasing human population that is degrading the environment at an ever-accelerating rate. Many of California's unique species live in restricted habitats, under special conditions to which they have been adapting for hundreds or thousands of years. As people change these habitats, their native inhabitants die or fail to reproduce."

By Robert I. Bowman, *Evolution and Biodiversity in California*, p. 3 in California's Wild Heritage: Threatened and Endangered Animals in the Golden State, by Peter Steinhart, California Dept. of Fish and Game, 1990.

Teacher Procedure

1. Students should be divided into groups of three or four.
2. Each group will need two sheets of drawing paper - a smaller piece may be used for the bird, a larger piece for the habitat.
3. Each group is assigned a habitat to draw on the large sheet of butcher paper. The descriptions of each habitat (salt marsh, redwood forest, freshwater pond, grasslands, mountain, desert, riparian or river habitat, and beach) should be photocopied and distributed to the students.
4. After drawing the habitat, each group must choose one of each of four adaptations for body shape, coloration, beak, feet, and nesting strategy. It may be helpful to enlarge the adaptation sheet, photocopy on cardstock and then laminate and cut out the individual cards from which students may select. These may then be reused in the future.
5. Allow students to design and draw the bird. Students draw, color and cut out their bird separately from the habitat so that they can exchange habitats later. When all groups are finished, have each group share with the class their bird, explaining adaptations and why the bird is well-suited to the habitat.
6. After sharing this information, have the groups randomly exchange habitats with each other. Each group must then discuss among themselves and answer questions pertaining to the fate of their bird in its new habitat. Could it survive and why?
7. As an in-class assignment or for homework, each student should read the California clapper rail description and answer questions about its adaptations and habitat.

Adapted for Survival?

Student Pages

INTRODUCTION

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

PROCEDURE

1. Read the description of the habitat your group has been assigned and draw the habitat on the large piece of paper, showing details such as plants, animals, water, soil, etc.
2. Design a bird to live in this habitat.
    a. Choose one of each type of adaptation for beak, feet, body, and nest, using the adaptations page, before designing your bird.
    b. List and describe your bird's specific adaptations below.
        1. What does it eat and how does it get its food?
        2. How does it build its nest, reproduce, and raise its young?
        3. How does it protect itself from predators?
    c. Explain why your bird is adapted to survive in its specific habitat.
3. Using the smaller piece of paper and pencils provided, design, color, and cut out one bird showing all of the adaptations you have chosen and described. Use your imagination to add details!
4. Assign your bird a scientific name and a common name. Write both in the space below and on the back of your bird.

    Scientific name:____

    Common name:____

5. Place your bird in its habitat and secure gently with tape if necessary.
6. When everyone is done designing their bird, explain to the class how your bird is adapted for this particular environment. Describe the habitat your bird lives in and the adaptations that are most important to your bird's survival in this habitat.
7. Trade habitats with another group, keeping the bird you designed.
8. Place your bird in the new habitat and reevaluate the probability of success for your bird.

Analysis Questions

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

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

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

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

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

6. The California clapper rail, *Rallus longirostrus obsoletus*, is a bird that lives only in the salt marshes surrounding San Francisco Bay. Read the one-page description about the California clapper rail.

   a. How is the California clapper rail adapted to the salt marsh? Be specific.

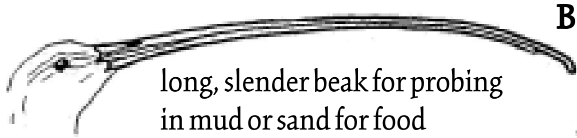
   b. What issues have affected the California clapper rail in the past and what issues are currently affecting it?

   c. Is it important to protect the remaining salt marsh? Explain why or why not.

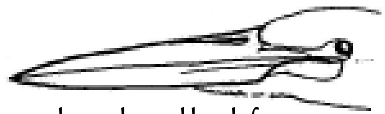
Adapted for Survival?

Choose one adaptation from each category (a beak, a pair of feet, a nest, and a body).
Use these adaptations to design a bird for your habitat.

Beaks

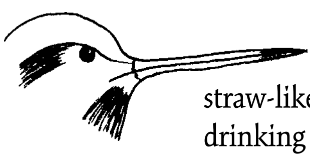

long, slender beak for probing in mud or sand for food


sharp, hooked beak for tearing apart small animals


long, broad beak for spearing fish, crabs, or rodents

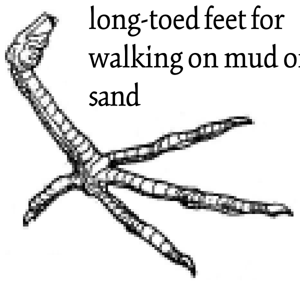

slim, sharp beak for catching insects

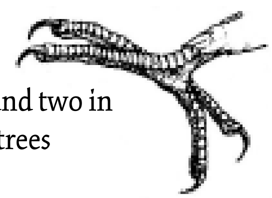

broad, flat beak for straining plankton from water

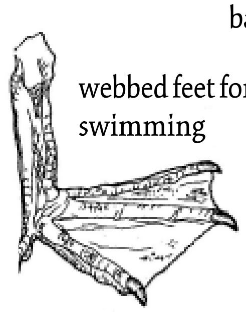

straw-like beak for drinking nectar

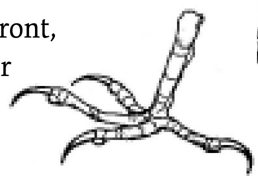

long, hooked beak for catching fish

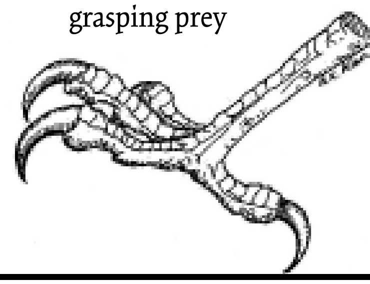
Feet


long-toed feet for walking on mud or sand

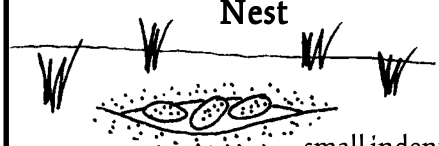

two toes in front and two in back for climbing trees

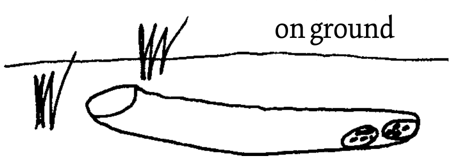

webbed feet for swimming

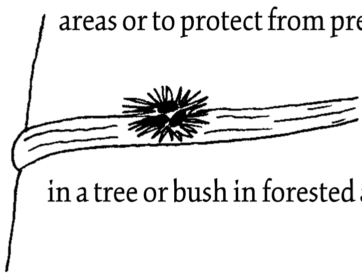

three toes in front, one in back for perching on branches


sharp-clawed feet for grasping prey

Nest

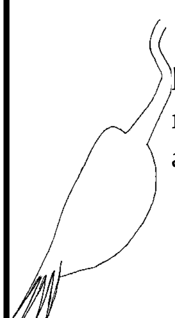

small indentation on ground

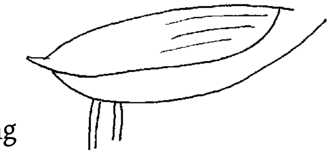

burrow in ground or plant for hot areas or to protect from predators

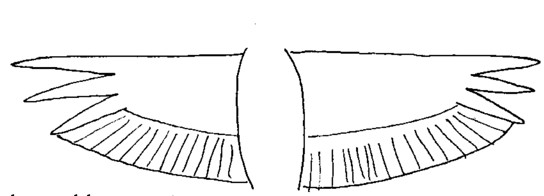

in a tree or bush in forested areas

Body


small body and rapid wingbeats for flying and perching in trees


large body and long neck to spear crabs and fish


legs set back on body for swimming


large body and large wings to soar overhead looking for prey

Adapted for Survival?

Habitats

Photocopy this page and cut apart the descriptions; assign one habitat to each group of students and give them the description with their worksheet.

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

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

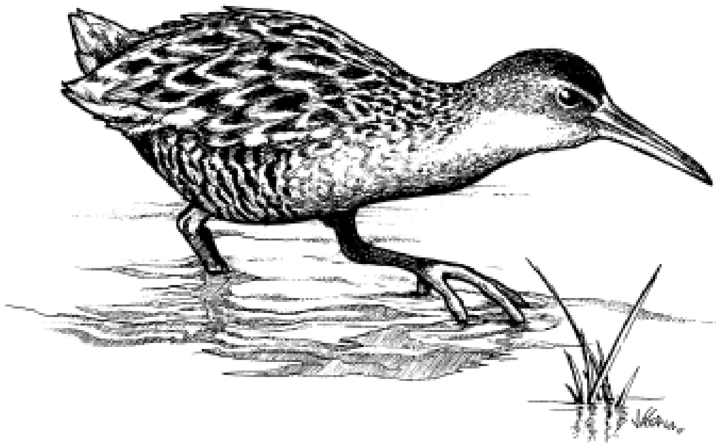
3. Grasslands
In the Central Valley, low-lying flat areas are covered with grasses. Lizards and snakes bake on exposed rocks. Kit foxes and kangaroo rats roam during the night. Summers are hot and winters are cold.

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

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

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

7. Beach / Shoreline
The sandy shore exists where the ocean meets the land. In the sand, invertebrates live. Dead bits of kelp, seaweed, and animals are washed up with the tides each day and left behind. Dunes of sand are formed at the highest points on the beach, and beach grasses grow.



CALIFORNIA CLAPPER RAIL

Rallus longirostris obsoletus

THE CALIFORNIA clapper rail, one of three subspecies of clapper rail found in California, formerly nested in tidal marshes from Humboldt County to San Luis Obispo County. A short, compact bird with a tawny brown breast, flanks striped with white, a dappled back, and a patch of white under the tail, it slips quietly through the cordgrass and pickleweed marshes of San Francisco Bay, searching in the mud for a meal of clams, mussels, and crabs. These elusive birds are most often observed during flood tides when they are forced out of their marshland cover. At other times they may be detected by their distinctive "clapper" or "clatter" call from which the species derives its common name.

This bird requires dense stands of vegetation in the lower marsh, where it nests and hides from predators, as well as upper marsh areas which it uses as retreats during high tides. Over 85 percent of the tidal marsh that once provided habitat for clapper rails has been destroyed. It has been diked and filled and turned into marinas, airports, garbage dumps, housing tracts, industrial parks, and salt ponds. During the winter months nearly the entire population of California clapper rails is found in only eight marshes around San Francisco Bay. Almost everywhere, levees now separate the remaining tidal marsh from the rail's historic high marsh retreat areas, which now underlie shoreline development. With no easy access to cover during high tides, the normally elusive clapper rails become vulnerable to predators such as northern harriers.

Clapper rails have been hunted by European settlers since the 1700s. They were so abundant at the turn of the century that hunters boasted of shooting two hundred in a day, and San Francisco restaurants hung strings of rails in their windows. But by 1987 California clapper rails were confined to San Francisco Bay — more than 90 percent of them in the south bay — and the entire population was estimated at only seven hundred birds. In 1989 the total population was estimated to be fewer than five hundred birds.

An indicator of environmental quality, the clapper rail is responding to the continued degradation of San Francisco Bay. Introduced predators have decimated rail numbers in some key marshes, sewage effluent has converted salt marsh habitat into brackish marsh, and pollutants from urban runoff and sewage discharge are finding their way into the rails' food. With less than five hundred individuals remaining, there is little certainty that this bird will survive for another twenty years.

If the California clapper rail is to be saved, exotic predators must be controlled, bay water quality must be improved, and historic tidal marshes must be restored.

In 1988 legislation was passed in the U.S. Congress that authorized the U.S. Fish and Wildlife Service to acquire up to twenty thousand acres to expand the San Francisco Bay National Wildlife Refuge. Purchase of abandoned salt ponds will enable the Service to restore additional tidal marshes which may give the clapper rail a chance at survival.

California's Wild Heritage: Threatened and Endangered Animals in the Golden State, by Peter Steinhart, California Dept. of Fish and Game, 1990.

Survival or Extinction?

The Evolution of Bay Animals and their Limiting Factors

Overview
The success of a population is dependent on the limiting factors impacting its environment. This activity is designed to help students understand how limiting factors may have directed evolutionary pathways, and applies this understanding to current environmental problems. Students work in groups to evolve into a present day species by playing a board game as a class. They then have to find solutions to present day problems facing their species in order to survive.

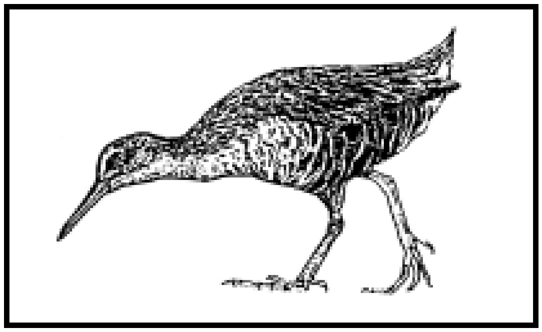
Estimated Time
one class period and homework assignment

Objectives
Students will be able to:
- Explain the relationship between limiting factors and evolution
- Hypothesize possible evolutionary pathways for modern day organisms
- Apply what they have learned to current environmental problems
- Construct a phylogenic tree
- Identify limiting factors affecting species that use the San Francisco Bay.

Materials
- Transparency copy of Evolution Game Board,
- Dry erase markers in 6 different colors,
- Scenario Cards (Photocopy cards, cut up, and put into a bag labeled Round 1).
- Role Cards (Photocopy and cut up)

Vocabulary
limiting factor, evolution, phylogenic tree, common descent, divergent, convergent

California's Science Content Standards
Grade 7
Standard Set 3.a: both genetic variation and environmental factors are causes of evolution and diversity of organisms.



Standard Set 3.b: the reasoning used by Darwin in making his conclusion that natural selection is the mechanism of evolution.
Standard Set 3.d: how to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics, and expand the diagram to include fossil organisms.
Standard Set 3.e: extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

Grades 9-12
Biology/Life Sciences Standard Set 8.a: how natural selection determines the differential survival of groups of organisms.
Biology/Life Sciences Standard Set 8.b: a great diversity of species increases the chance that at least some organisms survive large changes in the environment.
Biology/Life Sciences Standard Set 8.d: reproductive or geographic isolation affects speciation.

Additional Resources/Activities
Evolution Activity: http://www.nap.edu/readingroom/books/evolution98/evol6-c.html

Limiting Factors-Migration: http://www.expeditionnorthamerica.com/Education/migration_act_01.htm

Teacher Procedure

1. Divide the students into 6 groups. Explain that all groups will start out at the beginning of the phylogenic tree, and can choose their own paths as they evolve. All paths have the same number of steps; the cards they draw will determine how quickly they move on the board. (Two groups cannot evolve into the same species, so there are limits to the routes each group can take on the phylogenic tree.)

2. The scenario cards describe historical events that have changed the earth's environment. Evolution is the result of genetic changes that occur in constantly changing environments. Natural selection determines the differential survival of groups of organisms. Organisms that were adapted to a particular change survived, while others died or failed to reproduce. Make sure the students realize that these scenario cards are not in correct historical order, as they are drawing them from the bag randomly. Also, not all of the scenario cards truly affected the species they are evolving into, but they demonstrate the limiting factors that have occurred over the history of life on Earth. Emphasize that this is a simulation.

3. Now is your chance to evolve! Have each group take turns drawing scenario cards from the bag (roll dice to see who goes first). Their group needs to choose together which forks to take on the phylogenic tree. As they evolve, mark their spaces on the overhead with six differently colored dry-erase markers. Used cards go back in the bag.
4. The game ends once each group reaches the end of the board. At this point, hand out the cards describing the species that they have evolved into: Human, Winter Run Chinook Salmon, California Clapper Rail, Brown Pelican, Salt Marsh Harvest Mouse, Harbor Seal

5. Everyone has now evolved to become a present -day species that depends upon the San Francisco Bay to survive. Hundreds of thousands of years have been spent adapting to the environmental conditions that exist on Earth and thousands of years have been spent adapting specifically to the San Francisco Bay. Over the last 150 years, beginning with the Gold Rush, new limiting factors have appeared, primarily caused by a human population explosion around the Bay. Is survival or extinction next for these species? It's in the cards. In order for your species not to go extinct, you have to come up with a reasonable solution to one of your limiting factors. Hand each group the description of their limiting factor and allow them time to discuss solutions as a group. Each groups should then present their solutions to the rest of the class, and either you or the class should vote – Survival or Extinction. (Choose the fairest voting method for your class).

6. After the solutions are discussed, hold a group discussion about evolution and limiting factors. Some of the following questions could be used:
   - Is evolution happening today?
   - Are the extinctions of large numbers of species occurring presently "natural"?
   - How does a high diversity of species help an ecosystem?
   - Why would we want to save species from extinction?

Adapted from Limiting Factors/Evolution Game by Amy Quillen and Gail Corey, as part of the Woodrow Wilson Leadership Program in Biology

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

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

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

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

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

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

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

A decrease in temperatures has caused freezing of the polar ice caps. Land mass has increased. Evolve 3 spaces.

The Ice Age ends and the San Francisco Bay is formed as water levels rise. This provides you with habitat. Evolve two spaces.

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

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

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

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

You are a winner in the Darwin gene pool. Evolve 3 spaces.

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

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

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

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

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

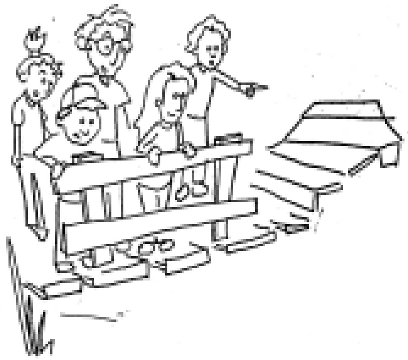
Your ability to filter feed on krill using your baleen allows you to eat lower on the food chain (a helpful adaptation). Evolve 3 spaces.

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

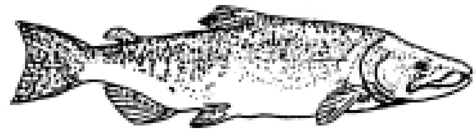
Sedimentation from rivers flow into the San Francisco Bay, increasing your wetland habitat. Evolve 2 spaces.

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

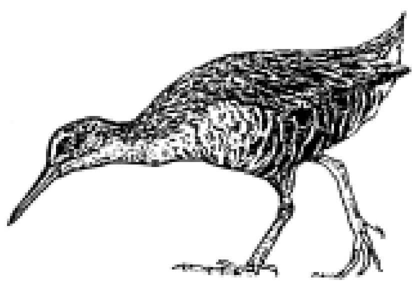
Humans
Emissions from cars are causing greenhouse gasses to build up. Global warming may threaten your ability to grow food.



Winter Run Chinook Salmon
Limiting Factor: Dams have been built on nearly every California river, and you are unable to return to your breeding grounds in order to reproduce.

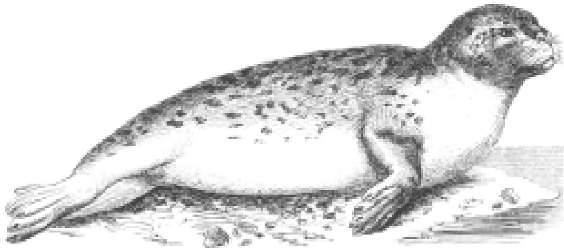


California Clapper Rail
Limiting Factor: Red foxes have been accidentally introduced by humans to California and are eating you and your young. Only 700 California clapper rails remain and the future is grim.

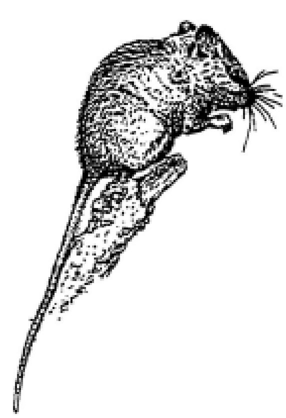


Brown Pelican
Limiting Factor: DDT, a pesticide, weakens your egg shells, causing them to crack. You are unable to successfully reproduce.

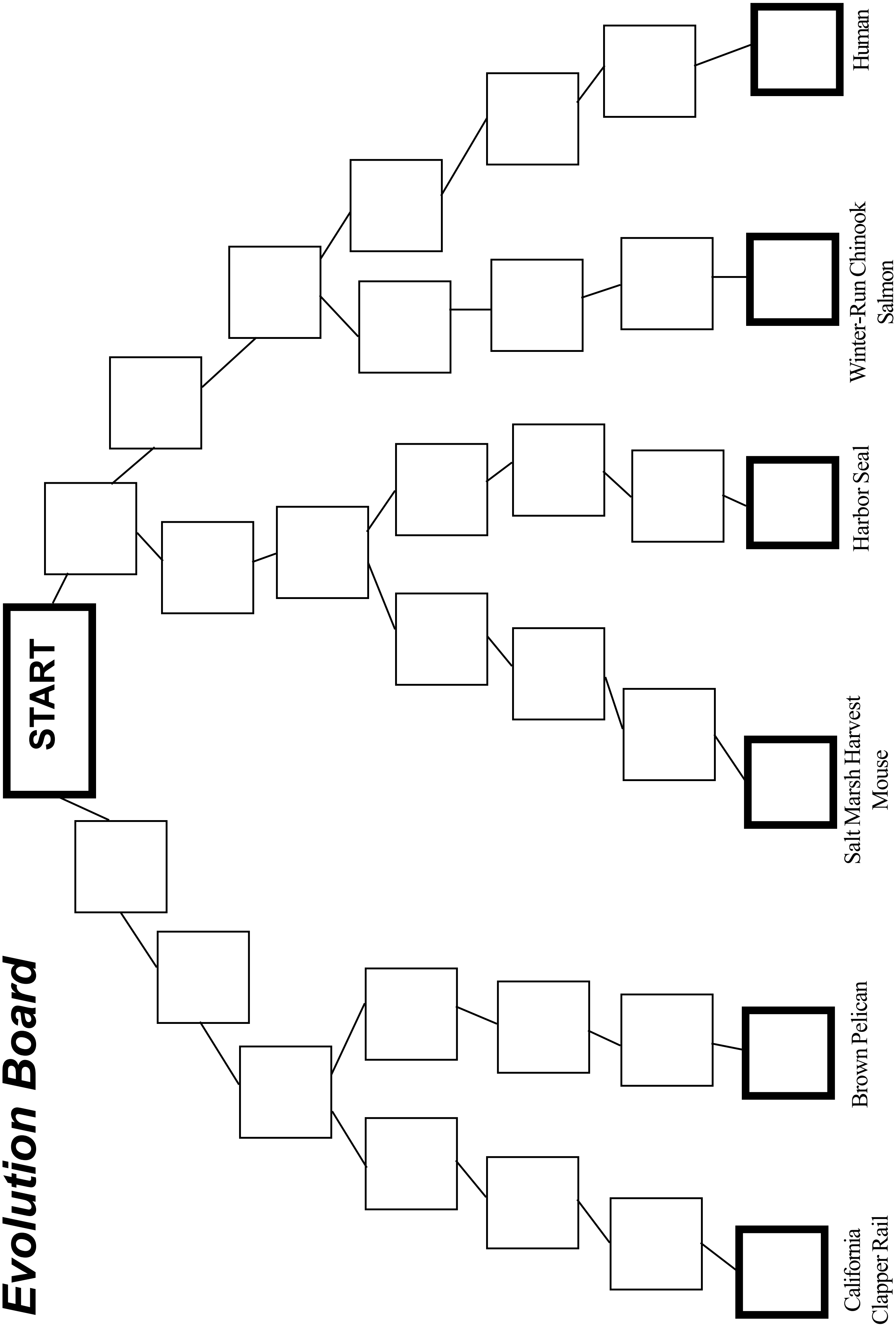
Harbor Seals:
Limiting Factor: Pollution from streets, yards, farms, and industries flows into the Bay each day. Polluted plankton are eaten by fish and you eat the fish. Ultimately, pollution builds up in you, and you are unable to to reproduce.



Salt Marsh Harvest Mouse
Limiting Factor: Your salt marsh habitat is disappearing. Only 10% is left and it's threatened by development.



Evolution Board



Earth Day Birthday Party

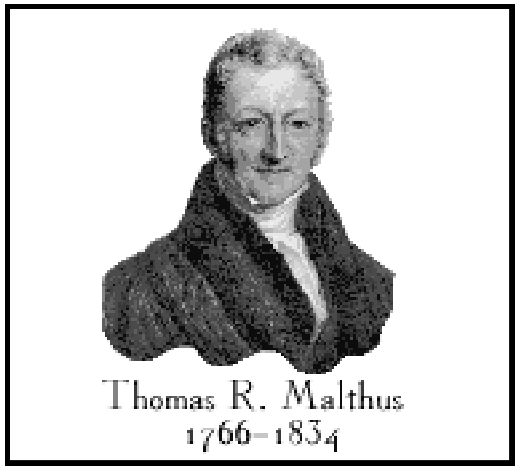
Analyzing Population Growth

Overview
This activity connects population growth and biological evolution. Students take part in a fun and edible simulation of Thomas Malthus' theory and graph world population growth. After reading articles with various viewpoints on population growth and Earth's resources, students are forced to make tough decisions about population growth and write persuasive essays supporting their viewpoints.

Estimated Time
Parts I, II, and III can be done in one or two periods, with Part IV as a homework assignment.

Objectives
Students will be able to:
- Explain Thomas Malthus' theory
- Graph world population growth
- Describe at least two viewpoints on world population growth
- Defend their own viewpoint on population growth with a persuasive essay

Materials
Part I: Popcorn Game
- Two brown paper grocery bags decorated with the Earth, the USA, and an X on your location. Label it "Earth's Resources."
- 2 plastic trash bags (one for reserve popcorn and one for recycled popcorn).
- Popcorn - a few days ahead, tell students they will receive bonus points for bringing a full, unopened bag of popped popcorn on the morning of the Earth Day Birthday Party (otherwise they will eat it before it gets to your classroom).



- Hot air popcorn popper and a bag of popcorn in case donations do not arrive!
- Fill the grocery bags with popcorn and hide the extra popcorn in the plastic bag.
- Paper towels
- Paper or index cards numbered for generations (#1-16 for a class of 32).
- Small (50ml) and larger (400 ml) beakers to scoop popcorn.

Part II: Thomas Malthus
- Photocopies of student worksheet.

Part III: Forced Choice
- Forced Choice questions written on board or flip chart with a piece of paper with masking tape or magnets at the top covering the questions.

Part IV: Articles and Persuasive Essay
- Photocopies of newspaper articles and student worksheet.

Activity adapted from Access Excellence, http://www.accessexcellence.org, *written by Catherine Ross. The Popcorn game was originally developed at a 1979 Energy and Transportation Workshop (The Detroit Connection) at Wayne State University through the Physics Department.*

California Science Content Standards

Grade 7

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

Grades 9-12

Biology/Life Sciences Standard Set 6.c: how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
Biology/Life Sciences Standard Set 8.a: how natural selection determines the differential survival of groups of organisms.
Investigation and Experimentation g: recognize the use and limitations of models and theories as scientific representations of reality.

English/Language Arts Standards

Grades 6 - 8

Reading Comprehension: Students read and understand grade-level-appropriate material.
Writing Applications: Students write persuasive texts of at least 500 to 700 words.

Grades 9 - 12

Reading Comprehension: Students read and understand grade-level-appropriate material.
Writing Applications: Students combine the rhetorical strategies of narration, exposition, persuasion, and description to produce texts of at least 1,500 words each.

Teacher Procedure

Part I: Popcorn Game

Discussion Questions

- What is our Planet's greatest problem? (hunger, drugs, pollution, homelessness, diseases, crime, war, global warming, ignorance…)
- Is overpopulation the underlying cause of all these problems?
- Has overpopulation affected the Bay Area? How? (Lack of housing, traffic, smog, pollution, filling in of Bay, etc.)

Introduce yourself as Mother or Father Earth and show the students the two paper bags filled with popcorn, representing all the resources of our planet (food, fuel, water, shelter, space…)

Hand out the generation numbers on index cards to pairs of students and pass out paper towel placemats. In a class of 32, you would have 16 generations.

Go to generation "1" and scoop out 2 50ml beakers of popcorn and put it on their placemat. This represents all the Earth's resources that their generation used. Then go to generation "2" and congratulate them on the birth of their beautiful children. Ask them how much of the Earth's resources they need, if there are now twice as many people on the Planet. They will say "4 beakers". After giving them their popcorn, ask the third generation to identify themselves and ask them how much they need to survive (they need 8). As you start to go scoop-crazy, you might want to use a larger beaker (400ml) for distribution.

Each generation will need twice as much as the preceeding generation (2, 4, 8, 16, 32, 64, 128, 256…). Usually around the 6th generation, the supply cannot meet the demand, and humans go extinct. Hand the last generation what is left or give them the entire bag. When the complaints begin, Mother/Father Earth just comment that "you aren't even born, so what's your problem??"

After the anxiety level is high and to avoid mutiny, ask the early generations if they are willing to be better caretakers of the planet and share the resources with later generations. You can redistribute the popcorn so everyone gets some.

Part II: Thomas Malthus

Distribute the worksheet to the students for an in-class or homework assignment.

Part III: Forced Choice

Have these questions, or others you come up with, written on the board or a flip chart. Cover them with a piece of paper attached with magnets or masking tape, so that you can reveal one question at a time. As you reveal the questions, ask the students who think “no” to stand on the left side of the room and the students who think “yes” to stand on the right side of the room. They are being forced to make a choice.

- Will the human population be supported by Earth over the next 100 years?
- Should we make changes in our lifestyles to make sure there are enough resources for the population?
- Should we reduce population growth?
- Should everyone try to eat lower on the food chain (beans, grains, vegetables)?
- Should meat and dairy be illegal?
- Should each couple only be allowed to have one child?
- Should people who have more than one child be punished?
- Should we look for cures for diseases?
- Should the terminally ill not receive life-extending measures?
- Should people try to ride bikes, use public transit, and carpool?
- Should cars be outlawed?

Part IV: Articles and Persuasive Essays
Distribute the articles and worksheet for an in-class or homework assignment

Additional Resources/Activities

M&M Population Simulation: http://www.pbs.org/teachersource/mathline/concepts/earthday/activity3.shtm

World Population Clock: http://www.census.gov/cgi-bin/ipc/popclockw

US Population Clock: http://www.census.gov/cgi-bin/popclock

Population Quiz: http://www.dayof6billion.org/cgi-local/quiz.cgi?num=1

Six Billion and Beyond: http://www.pbs.org/sixbillion/

Thomas Malthus

Thomas Malthus had a strong interest in the social conditions of his time in 18^{th} century England. Thomas Malthus' Hypothesis in 1798 included the idea that the size of the human population is regulated by certain external forces. His two assumptions were: food is necessary for existence and that humans will continue to reproduce. In his own words, he hypothesized:

"I say, that the power of population is indefinitely greater than the power in the earth to produce subsistence [food] for man. Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will shew the immensity of the first power in comparison of the second."

Population, when unregulated, increases in an exponential manner. Thus, it accelerates faster each year. An exponential series of numbers would be; 2, 4, 8, 16, 32, 64, 128… Each subsequent number is obtained by multiplying a constant, in this case 2. What would the next number in this exponential series be? ______

Food or subsistence increases in an arithmetic manner. Arithmetic growth is much slower than exponential growth. An arithmetic series of numbers would be: 2, 4, 6, 8, 10, 12, 14, 16, 18… Each subsequent number is obtained by adding a constant, in this case 2. What would the next number in this arithmetic series be? _______

Under this theory, ultimately there will not be enough food to support the human population. Malthus proposed that wars, famines, plagues, and natural disasters would control the population. Malthus' essay influenced the young Charles Darwin. He saw that overreproduction would lead to natural selection of those individuals best able to obtain the available resources and thus reproduce their own kind.

What do you think? But, before you decide, using the most recent population data, construct a line graph of human population growth on the back of this paper, with the years on the x-axis (horizontal) and the population on on the y-axis (vertical).

Year	World Population
1 A.D.	150 million
1350	300 million
1700	600 million
1800	900 million
1900	1.6 billion
1950	2.4 billion
1985	5 billion
2000	6 billion

Want to see what the population is right now? Check out these web sites:
World Population Clock: http://www.census.gov/cgi-bin/ipc/popclockw
US Population Clock: http://www.census.gov/cgi-bin/popclock

Population Growth
Articles and Persuasive Essay

Student Pages

Read the three attached articles and answer the following questions:

1. *Now we are 6 billion,* by Michael Binyon, Diplomatic Editor, The Times, U.K., October 13, 1999.

- According to Clare Short, what is the best solution for slowing population growth?
- According to Zhang Weiqing, what policy has slowed China's population growth?
- At a UN conference in 1994, what type of program was adopted by 179 countries?
- What do experts believe will happen with world population in the future?

2. *Populations outrunning water supply as world hits 6 billion*, by Lester R. Brown and Brian Halweil, Worldwatch, September 23, 1999.

- Give three examples that Brown and Halweil cite to support their theory that the world's water supply is decreasing as population increases.
- According to the last paragraph in the article, what is the main thesis of the article?

3. *Growing Gains,* by Jacob Sullum, Reason Online, January 5, 2000.

- What blunders does Sullum state have disproved Malthus' theory?
- What does Sullum believe will enable us to support population growth and what example in the field of agriculture does he cite to prove his idea?

Do you still have the same opinions after reading the articles or have some of your opinions changed? Formulate your own opinion on population growth. Is there a problem? Was Malthus' idea correct? Does something need to be done to curb population growth or to reduce our use of resources or will we be able to use technology to solve population growth issues?

Write a persuasive essay, including a well-defined thesis, and providing evidence and examples. Differentiate between fact and opinion and anticipate the reader's counterarguments.

NOW WE ARE SIX BILLION

BY MICHAEL BINYON, DIPLOMATIC EDITOR
The Times, United Kingdom

THE world's six billionth inhabitant was welcomed by Kofi Annan, the United Nations Secretary General, at a maternity clinic in Sarajevo yesterday.

Marking the day when UN experts estimate that the global population reached the figure, he congratulated Helac Fatima, a Bosnian Muslim woman, and her newborn son at the Kosovo hospital as experts and politicians around the world called for better education and healthcare to let families plan for their future.

Clare Short, the International Development Secretary, at a rally in Trafalgar Square, called for better education of girls and a chance for the poor to have smaller, healthier families.
She said that the world's population had doubled since 1960, but growth was slowing because more girls were being educated and more people had access to contraception.
"Experience has shown us that tough population control policies, based on demographic targets, violate human rights and often have little success in stabilising population," she said.

"The good news is that population growth has actually been in steady decline, because women today have more choices, more access to family planning, access to education and greater freedom of choice."

China said yesterday that the world's population would have reach six billion earlier had it not imposed a policy of one child per family 20 years ago. "Without taking effective measures to slow down the rapid growth of its population, China would have 300 million people more than the current figure of 1,248 billion," Zhang Weiqing, a senior family planning official, said.

China's National Bureau of Statistics said that the population was expected to peak at 1.5 billion in 40 years' time, when it achieves zero population growth. By the end of last year the growth rate had fallen to less than 1 per cent, but, even so, the huge population base means that China will add ten million to its total every year for decades.

The UN said that the global population had quadrupled this century, faster than at any time in history. At the beginning of the century it was 1.5 billion. In 1927 it reached 2 billion; in 1960, 3 billion; in 1974, 4 billion; and in 1987, 5 billion. The total population is set to increase by about 78 million each year, with three babies born every second.

About 90 per cent of the 356,000 babies born each day will be raised in developing countries. Of the 4.8 billion in the Third World, nearly three-fifths lack basic sanitation. About a third have no access to clean water. A quarter do not have adequate housing and a fifth have no access to modern health services.
Family size in developing countries has fallen swiftly. In 1969 it was six children per woman, whereas now it is three.

At the UN conference on population and development in Cairo in 1994, 179 countries adopted a programme to tackle population growth by focusing on human needs rather than numbers. A 20-year programme called for greater access to education, especially for girls, and for reproductive health rights, a commitment that was bitterly opposed by the Vatican.

The governments agreed in Cairo that $17 billion a year would be needed in 2000 for this programme, with two-thirds paid by the developing countries and a third from donor countries.

Population projections for 2050 range between 7.7 billion and 10.6 billion, with a mean estimate of 9.4 billion. Experts believe that the world population may reach it highest level in the middle of the next century and start to fall after that.

POPULATIONS OUTRUNNING WATER SUPPLY AS WORLD HITS 6 BILLION

Lester R. Brown and Brian Halweil

As world population approaches 6 billion on October 12, water tables are falling on every continent, major rivers are drained dry before they reach the sea and millions of people lack enough water to satisfy basic needs.

Water tables are now falling in China, India, and the United States, which together produce half the world's food. Historically, irrigated farming has been plagued with waterlogging, salting, and silting, but now, with the advent of powerful diesel and electrically powered pumps, it is also threatened by aquifer depletion.

In China, water tables are falling almost everywhere that the land is flat. Under the North China Plain, the country's breadbasket, water tables are falling by 1.5 meters, or roughly 5 feet, per year. Where wells have gone dry, farmers have been forced either to drill deeper, if they can afford it, or to abandon irrigated agriculture, converting back to lower-yield rainfed farming.

In India, a country whose population hit 1 billion on August 15, the pumping of underground water is now estimated to be double the rate of aquifer recharge from rainfall. The International Water Management Institute, the world's premier water research group, estimates that India's grain harvest could be reduced by up to one fourth as a result of aquifer depletion. In a country adding 18 million people per year, this is not good news.

In the southern Great Plains of the United States, depletion of the Ogallala aquifer has already led to irrigation cutbacks. Texas, Oklahoma, Kansas, and Colorado have been losing irrigated land over the last two decades. Texas, for example, has lost irrigated land at roughly one percent per year since 1980.

Rivers running dry provide an even more visible manifestation of water shortages as growing populations take more water. The Yellow River, the cradle of Chinese civilization, first ran dry in 1972. Since 1985, it has run dry for part of each year. In 1997, it failed to reach the sea during 226 days, or roughly 7 months of the year.

During the dry season, the Ganges River has little water left when it reaches the Bay of Bengal. India, with more than a billion people taking the lion's share of the water, is leaving too little for the farmers of Bangladesh during the dry season.

In central Asia, the Amu Darya, one of two rivers that once fed the Aral Sea, is now drained dry by farmers in Turkmenistan and Uzbekistan. As the Sea has shrunk to scarcely half its original size, the rising salt concentration has destroyed all fish, eliminating a rich fishery that once landed 100 million pounds of fish per year.

Similarly, the Colorado, the major river in the southwestern United States, rarely ever makes it to the Gulf of California. The fishery at its mouth that once supported several thousand Cocopa Indians has now disappeared. Today the Nile, like many other major rivers, has little water left when it reaches the sea. Even though virtually all the water in the river is now claimed, the population of the three principal basin countries-Egypt, the Sudan, and Ethiopia, where most of the water originates-is projected to increase from 153 million today to 343 million in 2050, generating intense competition for water.

Hydrologists estimate that when the amount of fresh water per person in a country drops below 1,700 cubic meters per year the country is facing water stress. In her new book, Pillar of Sand: Can the Irrigation Miracle Last, Worldwatch senior fellow Sandra Postel reports that the number of people living in countries experiencing water stress will increase from 467 million in 1995 to over 3 billion by 2025 as population continues to grow. In effect, these people will not have enough water to produce food and satisfy residential and other needs.

Postel estimates the current world water deficit (the excess of water pumping over recharge from rainfall) at 160 billion tons per year. Since it takes 1,000 tons of water to produce 1 ton of grain, this water deficit is equal to 160 million tons of grain, a quantity only slightly less than annual world grain exports of 200 million tons.

Ironically, the excessive grain supplies that have depressed world grain prices in 1999 are partly the result of overpumping. If falling water tables were stabilized by a cutback in pumping, the resulting decline in grain production would likely drive prices off the top of the chart.

As water becomes scarce, the competition for water between cities and countryside intensifies. In this competition, farmers almost always lose. In North Africa and the Middle East, the region ranging from Morocco in the west to Iran in the east, virtually every country is experiencing water shortages. As cities grow, countries take water from agriculture to satisfy expanding urban water needs. The countries then import grain to offset the water losses.

Given that importing one ton of grain is equal to importing 1,000 tons of water, this is the most efficient way for water-short countries to import water. Last year the water required to produce the grain and other farm products imported into this region was roughly equal to the annual flow of the Nile River. With more and more countries looking to the world market for food, spreading water scarcity may soon translate into world food scarcity.

It is often said that the competition for water among countries may take the form of military conflict. But it now seems more likely that the competition for water will take place in world grain markets. It is the countries that are financially strongest, not those that are militarily the strongest, that are likely to win in this competition.

If the world could move from the U.N. medium population projection of nearly 9 billion in 2050 to the low projection of less than 7 billion, water stresses would be greatly alleviated, making the water problem much more manageable. If the world stays on the current population trajectory, a growing share of humanity may simply lack the water needed for a decent life.

LESTER R. BROWN is president and BRIAN HALWEIL is staff researcher at Worldwatch Institute, a Washington, D.C.-based research organization.

GROWING GAINS

By Jacob Sullum
January 5, 2000

Now that the world has survived the Y2K bug, doomsayers will be casting about for another looming catastrophe to scare us with. Many will settle on an old classic: We are outstripping the earth's ability to support us.

This idea, which has been around for 200 years or so, has survived despite the many wrong predictions it has generated. Unlike the Y2K panic, it seems impervious to facts.

"The power of population is indefinitely greater than the power in the earth to produce subsistence for man," the British economist Thomas Robert Malthus wrote in 1798. "Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio."

Without deliberate population control, Malthus argued, there would never be enough food for everyone. A certain portion of the human race would always be condemned to a life of bare subsistence, with the population kept in check by starvation.

Since then, assorted critics of capitalism have embellished Malthus's bleak scenario. Chicken Littles such as Stanford University entomologist Paul Ehrlich and the Worldwatch Institute's Lester Brown have warned that we are running out of just about everything that humans use, including water, fuel, wood, metals, and arable land.

In his 1968 book *The Population Bomb*, Ehrlich declared: "The battle to feed humanity is over. In the 1970s, the world will undergo famines—hundreds of millions of people are going to starve to death in spite of any crash programs embarked on now."

You don't remember the famines? Then you probably also missed the "Great Die-Off" of the 1980s, when billions of people, including 65 million Americans, starved to death. Or so Ehrlich predicted in 1970.

In a less dramatic but equally decisive refutation of the anti-growth faith, the economist Julian Simon bet Ehrlich in 1980 that the inflation-adjusted price of "any standard mineral or other extractive product you name" would be lower a decade later. Ehrlich picked five metals, and in 1990 he had to pay up.

If the neo-Malthusians are embarrassed by such blunders, they're not letting on. In *Culture Jam*, his recent critique of "our mediated, consumption-driven culture," *Adbusters* magazine publisher Kalle Lasn pushes "ecological economics," which holds that "the world is already 'full' and further expansion will lead us into an ecological nightmare, a prolonged and possibly permanent 'age of despair.' "

The Competitive Enterprise Institute offers a cogent response to that position in *Earth Report 2000* (McGraw-Hill), a collection of illuminating essays edited by Ronald Bailey, *Reason* magazine's science correspondent. As Bailey notes in the first chapter, the Malthusian view has been thoroughly discredited by experience.

For one thing, production has more than kept up with population growth. "Between 1820 and 1992," writes Bailey, "world population quintupled even as the world's economies grew 40-fold."

Malthus was also wrong to think that "population...invariably increase[s] where there are means of subsistence." In fact, notes Bailey, "we find that the countries that are the wealthiest and have the greatest access to food—the United States, Germany, Italy, Spain, Japan, France—are precisely those countries that have the lowest birth rates, all of them below replacement levels."

Likewise, the neo-Malthusians are wrong to think that economic growth inevitably leads to environmental degradation. In fact, as Bailey's book shows with data on air pollution and other indicators, "greater affluence means an improving natural environment, not a worsening one."

It's true enough, as opponents of growth constantly remind us, that the earth's resources are finite. But what Malthus missed, and what his ideological heirs fail to appreciate, is the human ingenuity that enables us to arrange those resources in an infinite variety of combinations.

The improvements in agriculture that we have seen in the last century, on a scale beyond anything that Malthus imagined, are just one example of that ingenuity. "The United States uses less than half of the land for farming in the 1990s than it used in the 1920s," Bailey notes, "but it produces far more food now than it did then."

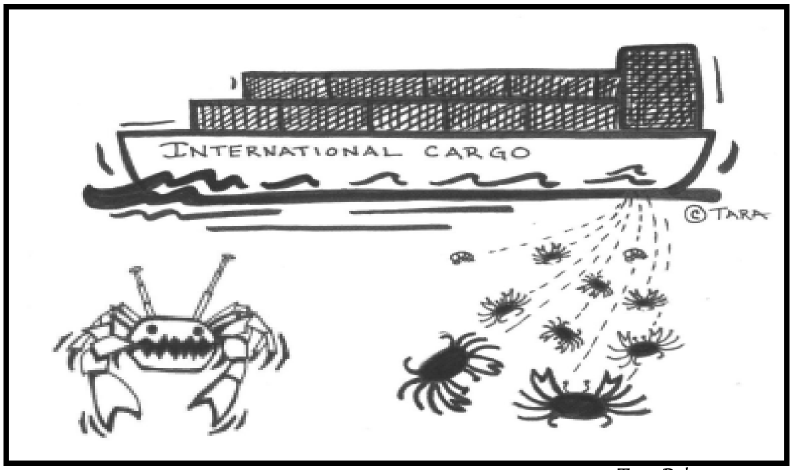
Market incentives constantly drive people to find ways of doing more with less, to devise better "recipes" for the things they need and want. "Two centuries after Malthus," Bailey concludes, "we now know that the exponential growth of knowledge, not of our numbers, is the real key to understanding the promising future that lies ahead for humanity and for the earth."

Creature Double Feature...

Native vs. Non-Native Species in San Francisco Bay

TEACHER'S PAGES

Overview
In this activity, students will learn about two non-native species and the effects they are having on San Francisco Bay ecosystems. Students will read articles and answer questions that bring to light some of the problems and ethical dilemmas surrounding non-native species.



Tara Reinertson

Estimated time
1.5 hours

Objectives
Students will be able to:

- Define native and non-native species
- Understand the ecological problems caused by non-native species
- Study specific cases where non-native species have become a problem in the Bay
- Discuss possible solutions to the problem of non-native species

Materials
For each student: Photocopies of Student Pages and Articles

Vocabulary
non-native, alien, invasive, introduced, exotic, native, indigenous

California Science Content Standards
Grade 6
Standard Set 5.c: populations of organisms can be categorized by the functions they serve in an ecosystem.
Standard Set 5.e: the number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

Grades 9-12
Biology/Life Sciences Standard Set 6.a: biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.
Biology/Life Sciences Standard Set 6.b: how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

English/Language Arts Standards
Grades 6-12
Reading Comprehension
(please refer to standards for details)
Listening/Speaking Strategies
(please refer to standards for details)

Additional Resources
USDA Invasive Species: http://www.invasivespecies.gov/

Weedbuster Game: http://www.invasivespecies.gov/education/weedbustergame.pdf

Exotic Species Quiz: http://massbay.mit.edu/exoticSpecies/student/quiz.html

Background

From the Marine Science Institute website:
http://www.sfbaymsi.org

Within the last 150 years, increased numbers of humans and increased avenues open to international shipping have greatly contributed to the decline of Bay resources. One way in which these resources have been compromised is the replacement of native flora and fauna with exotic species. Species introductions can be intentional or non-intentional. Most of the species that have been introduced into our Bay during the last 150 years were non-intentionally introduced. One of the most common mechanisms of non-intentional introductions is the release of ballast water carried on ships from foreign ports, a practice still occuring in our Bay today. Although new species are probably introduced into the Bay all of the time, it is the species that are introduced and become established that we need to worry about.

Over the last 140 years, over 200 species of non-native aquatic invertebrates have become established as a part of the San Francisco Bay fauna. Most of the fish that presently occur in the Bay are non-native species. One introduced species, the striped bass, is even used as an indicator species to give us information about the health of our Bay!

Andy Cohen, a marine biologist specializing in aquatic species introductions, estimates that one new aquatic species has been introduced into the Bay every 24 weeks since 1970.

Nichols and Patmatmat (1988) stated that accidentally introduced species may have thrived in San Francisco Bay because of the relatively young age of our Bay and the predominance of a single habitat type, soft mud, throughout the Bay. The young age of the Bay may not have allowed a diverse fauna to evolve prior to the introduction of exotic species. A single habitat type limited the number of niches available in the Bay for species to invade and diversify.

Some of the notable introduced species into San Francisco Bay are the Striped Bass, Asian Clam, European Green Crab, Chinese Mitten Crab, and the marsh grass *Spartina alterniflora*.

References: Nichols, F. H. and M. M. Patmatmat. 1988. The ecology of the soft-bottom benthos of San Francisco Bay: a community profile. U. S. Fish and Wildlife Service Biological Report 85 (7-23) 73 pp.
Cohen, A. 1997. personal communication. University of California - Berkeley.
Monroe, M. W. and J. Kelly. 1992. State of the Estuary. San Francisco Estuary Project. U.S. Environmental Protection Agency and the Association of Bay Area Governments. Oakland, CA.

Teacher Procedure

1. Have students read Alien Invasion, Unwelcome Predator, Chinese Mitten Crab's Life and History, and Crab Invasion.

2. Students answer questions in a written format (worksheets provided).

3. Once the students are familiar with the issues, lead a class discussion using the "discussion" questions as a starting point. Try to draw out and highlight different points of view. Note: you may want to lead separate discussions for the red fox issue and the mitten crab issue, then tie them together at the end.

Unwelcome Predator – Worksheet answers

1. Why is the non-native red fox such a formidable predator?
   Adapts easily to its surroundings, lives for eight years, has many pups

2. Name five native species that are eaten by the red fox.
   Snowy plovers, light-footed clapper rails, terns, western gulls, egrets, herons, California clapper rails

3. What method does the U.S. Fish and wildlife service use to control red fox populations?
   They trap and euthanize them.

4. According to the article, which methods of red fox population control have proven to be unsuccessful? Why were they unsuccessful?
   Relocating foxes transfers the non-native predation problem elsewhere, Fences are ineffective in containing foxes

Discussion

1. Why do you think animal rights activists might oppose the method that is currently being used to control red fox populations?
2. How do people make the decision to preserve one species over another?
3. Do you believe that humans should be trying to control the red fox population? Why or why not?

Crab Invasion – Worksheet Answers

1. How might mitten crabs have been introduced into the bay?
   They may have been purposely introduced for fishing, or they may have been released accidentally in ballast water
2. What do mitten crabs eat?
   Plants and invertebrates (they are omnivorous)
3. What are some of the mitten crab's predators in the Bay?
   White sturgeon, striped bass, bullfrogs, loons, egrets
4. Why do Mitten Crabs migrate from salt to fresh water?
   Adult crabs breed in salt water. After hatching, the young mitten crabs migrate to fresh water to rear.

Discussion

1. How is the invasion of the red fox similar to the invasion of the Chinese mitten crab in the San Francisco Bay? How is it different?
2. Do you think it is important to control non-native species in order to protect native species? Why or why not?

3. While quite a bit is known about the possible economic impact of the Chinese mitten crab, scientists are still not sure what the ecological impacts might be. Use what you have read about the mitten crab's life cycle, feeding habits, and migration to predict the effect the mitten crab might have on other forms of life in the bay. Does your prediction show a positive or negative effect?

4. In the article <u>Crab Invasion</u>, the author states that neither Dealy nor Tsukimura would like to allow commercial fishing for mitten crabs. Why do they feel that way? Do you agree with their opinion? Why or why not?

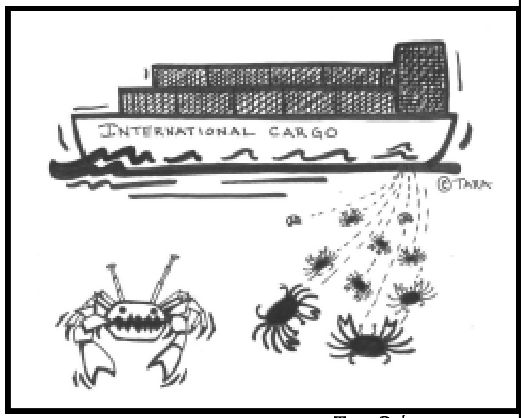
   Dealy and Tsukimura believe that commercial fishing would lead to the further spread of mitten crabs, and that it would be hard to dissuade people from fishing for the crabs once they become accustomed to doing so.

5. How do you think people should deal with the mitten crab "invasion?" Describe one possible solution. Make sure your solution addresses the various economic and ecological concerns about the mitten crab.

Creature Double Feature...

Native vs. Non-native species in San Francisco Bay

Student Pages



Tara Reinertson

INTRODUCTION

You may have read or heard about problems facing San Francisco Bay - problems such as pollution, urban development, and habitat loss. But did you know that right now, at this very moment, San Francisco Bay is being invaded by aliens? It's true!

These aliens did not arrive in a UFO. They do not come from Mars or any far-away universe. In fact, these aliens are from right here on Earth. In ecological terms, "aliens" or "non-native" species are animals or plants that do not occur naturally in an area. They are plants and animals that have either been brought to an area by humans, or have hitchhiked on boats and larger animals.

The opposite of a non-native species is a native species. A native species is a plant or animal that *does* occur naturally in an area. Ecologists use historical reports, museum records, natural history surveys, and archeological studies to determine which species are native and which are not.

Non-native species are generally harmful to any ecosystem. Ecosystems have a delicate balance between soil, water, plants, and animals. The organisms in an ecosystem are interrelated by complicated food webs involving predator and prey. Native predators and prey evolve together, each developing specific traits to aid in survival. When a non-native species is introduced into the mix, the delicate balance is thrown off.

When a non-native plant or animal is introduced into an already stressed ecosystem, it often has an advantage over native species. The ecosystem of the San Francisco Bay has been severely impacted by loss of habitat due to the building of roads, businesses, homes, and other developments that drive California's economy. Because native species are already struggling to survive, they cannot effectively compete with or defend themselves against the non-native species that are invading the Bay.

Researchers have documented more than 200 non-native species that live and reproduce in the Bay, and it is likely that there are many more that we do not know about. Many of the Bay's native species are now endangered or threatened, due, in part, to the invasion of non-native species. Non-native species present some challenging questions for people who are trying to preserve the natural ecosystem of the Bay. How do we prevent non-native species from entering the Bay? How do we control their population? Is it ethically right to eliminate an introduced species in order to save a native species from extinction? These are complex questions that have no clear-cut answers.

Creature Double Feature...

Native vs. Non-native species in San Francisco Bay

Student Pages

Using what you've read about non-native invasion, answer the following questions:

1. What is a non-native or "alien" species?

2. What is a native species?

3. How do non-native species enter an area?

4. How are non-native species harmful to ecosystems?

5. Why are non-native species particularly harmful to native species in the San Francisco Bay?

Unwelcome Predator

Read the article "Unwelcome Predator" by Tracy L. Palazzo, then answer the following questions.

1. Why is the non-native red fox such a formidable predator?

2. Name five native species that are eaten by the red fox.

3. What method does the U.S. Fish and wildlife service use to control red fox populations? Why do you think animal rights activists might oppose the method that is currently being used to control red fox populations?

4. According to the article, which methods of red fox population control have proven to be unsuccessful? Why were they unsuccessful?

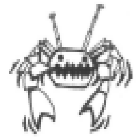
Discussion

1. Why do you think animal rights activists might oppose the method that is currently being used to control red fox populations?

2. How do people make the decision to preserve one species over another?

3. Do you believe that humans should be trying to control the red fox population? Why or why not?

Crab Invasion



Read the articles "Chinese Mitten Crabs Life and History" by the California Department of Fish and Game and "Crab Invasion" by Dennis Pollock and answer the following questions:

1. How might Chinese Mitten Crabs have gotten into the Bay?

2. What do mitten crabs eat?

3. What are some of the mitten crab's predators in the Bay?

4. Why do Mitten Crabs migrate from salt to fresh water?

5. What are three negative impacts the Chinese Mitten crab could have on the economy of the Bay area?

Discussion

1. How is the invasion of the red fox similar to the invasion of the Chinese mitten crab in the San Francisco Bay? How is it different?

2. Do you think it is important to control non-native species in order to protect native species? Why or why not?

Crab Invasion *(continued)*

Student Pages

3. While quite a bit is known about the possible economic impact of the Chinese mitten crab, scientists are still not sure what the ecological impacts might be. Use what you have read about the mitten crab's life cycle, feeding habits, and migration to predict the effect the mitten crab might have on other forms of life in the bay. Does your prediction show a positive or negative effect?

4. In the article Crab Invasion, the author states that neither Dealy nor Tsukimura would like to allow commercial fishing for mitten crabs. Why do they feel that way? Do you agree with their opinion? Why or why not?

5. How do you think people should deal with the mitten crab "invasion?" Describe one possible solution. Make sure your solution addresses the various economic and ecological concerns about the mitten crab.

Unwelcome Predator

By Tracy L. Palazzo

The red fox (*Vulpes vulpes*) is an attractive, furry mammal, but it is also an out-of-state interloper with an appetite for California endangered species, among others. Ranchers brought red foxes to the state in the 1800s and raised them for their pelts. Now, with their numbers growing rapidly, these predators are devastating populations of snowy plovers, California clapper rails, light-footed clapper rails, and San Joaquin kit foxes (see species descriptions). From San Francisco to Orange County, red foxes have extirpated colonies of nesting terns, western gulls, egrets, herons, and stilts. The pale red or straw-colored predators can wade estuary channels and destroy entire egret and heron colonies in just a few days.

Part of what makes the fox such a formidable predator is its ability to adapt easily to its surroundings. Whether backyard creek embankment, neighborhood park, or wilderness area, the nonnative red fox claims it as its own. Suburbia provides an unending supply of garbage as a dietary supplement, and people generously fortify red fox diets with handouts. With a life expectancy of up to eight years and an annual litter of four to seven pups beginning in the female's first year, red fox populations soar. And where there is an escalating red fox population, rapid range expansion always follows.

Traveling across roads and through flood-control channels and culverts, red foxes can quickly broaden their territorial range. As their local population grows, young foxes depart to establish new territories miles away from where they were born. Red foxes currently range into the Sierra foothills, up to an elevation of about 3,000 feet. At 4,000 feet and above lives the native Sierra Nevada red fox (*Vulpes vulpes necator*), listed as threatened under the state Endangered Species Act (ESA). Biologists fear that further expansion of the nonnative red fox's range may lead to interbreeding with the Sierra Nevada red fox population.

From Life on the Edge, A Guide to California's Endangered Natural Resources, Biosystems Books, Santa Cruz, CA and Heyday Books, Berkeley, CA, 1994, p. 183.

In the past decade, red fox predation and range expansion have prompted intensive control efforts. The U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) have conducted the largest control programs to date. Unfortunately, red foxes are trapped and killed because few realistic alternatives exist. Some animal rights activists oppose the lethal control efforts, but the USFWS and the CDFG say that nonlethal methods aren't effective: relocating the foxes to save species immediately threatened only transfers the nonnative predation problem elsewhere, and doesn't stop the red fox population increase.

The state has classified the red fox as a "prohibited species." All red fox importation or release into California without a CDFG-approved permit is currently illegal. Although scientists do not know exactly how many red foxes there are in California, they are sure that there are too many. Studies indicate that the statewide population numbers in the thousands. And even while agencies such as the USFWS continue to forge ahead with red fox control programs, red fox numbers can be expected to increase statewide.

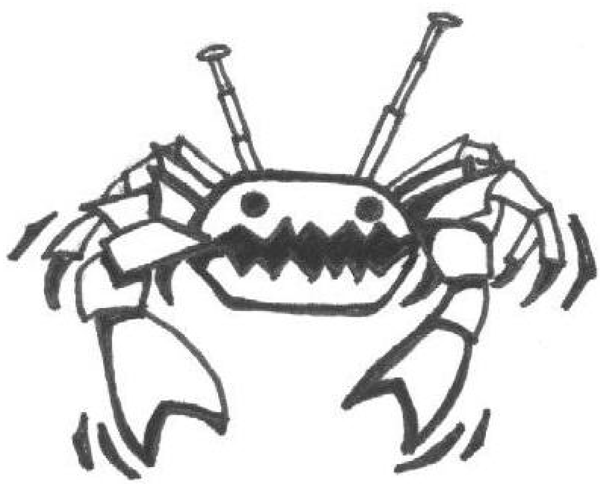
THE FRESNO BEE

June 1, 1999

CRAB INVASION

Two Fresnans help study Chinese mitten crabs, which number in the millions in the state.

BY DENNIS POLLOCK
THE FRESNO BEE



Two Fresnans have starrin roles in what is shaping up to b like something from a B movi that might be called "Attack c the Chinese Mitten Crabs."

Such a movie would *not* be comedy. It's taking the form of curious drama with serious ecc nomic implications for the state' environment and its huge agr cultural industry.

The crabs, about the size of hockey puck when full growr ıumber in the millions in th Sacramento-San Joaquin Delt ınd its tributaries. They are nc ret being accorded the kind c ɔuzz in Valley farming circle :hat killer bees and fire ants re ɔeive.

But questions are rising alon with the crabs' burgeoning num bers: Will they eat crops? Wi they clog drains and cut off vita water? What threats do they pose for other aquatic life? How can their numbers be reduced?

Simple answers to those questions are not yet available. That's why the two Fresnans, along with others in the state, are at work gathering facts.

Carl Dealy, natural resource specialist with the Fresno-based South Central California Area Office of the Federal Bureau of Reclamation, is chairman for a statewide panel that is looking at the agricultural impacts of the crab invasion.

Dealy terms the critter "a non-native nuisance species that has pretty much invaded our waterways." He is trying to corral information on farm impacts of the crab at the same time that Brian Tsukimura, an assistant biology professor at California State University, Fresno, is trying to learn more about its life cycles and the biological cues that make it do what it does.

"Once we know more about them, we can perhaps do something about the cues they might be responding to, whether it's light, water temperature or something else," he said.

Tsukimura is a member of a panel that will look into such things as the number of reproductive events, how their diet shifts with age, predators and population control.

Tsukimura and Dealy are part of an interagency ecological program that deals with management of one of the most invaded ecosystems in North America, where more than 200 life forms are immigrants.

Both say there is much more to learn about the creature before major alarms are sounded. Little is known in this country about the crab that was first detected in the San Francisco Bay in 1992, Tsukimura said, but his years-long research with such crustaceans indicates to him "they'll eat anything in their way; they are encounter feeders."

Dealy said there has been no documentation of the creatures consuming crops in California, though the crabs have reportedly damaged rice crops in China and Korea. He says he doesn't want to sound "like Chicken Little" as he talks about the crab. But he readily acknowledges that when workers at state water pumps near Tracy found 20,000 crabs in fish screens in a single day — up from 20 a day the year before.

"We said, 'We've got a problem here.'"

Last year, nearly 50 tons of the crabs were hauled away from those Tracy pumps, he said.

There's concern the crabs will get sucked from the Delta and into the canals that crisscross California and thus will be spread all the way to Southern California.

Please see **Crabs,** Page C3

Crabs: Fresnans study invading species

Continued from Page C1

It's unknown how the crabs arrived. It's suspected they may have been purposely imported, or they may have been stowaways in the ballasts of ships arriving from the Far East.

The population of the 3-inch-wide, hairy-clawed crabs has exploded into the low millions since that first discovery seven years ago. They have spread through Central Valley streams from Colusa to Merced. A crab was also found in the Coalinga Canal, said Liz Hudson, a Westland Water District spokeswoman.

Dealy said one difficulty in pinpointing where the crabs are now is "people haven't been looking until now." He's asking farmers to call his office at 487-5139 with any information his panel could use as it assesses agricultural impacts.

Clearly, the crabs are a menace to fish — including endangered species — because their numbers are so great that they injure fish as they become packed together at the screening equipment aimed at keeping fish out of the canal system.

Dealy said crowds of crabs could clog "on-farm pumps." He said it is unlikely their numbers would become so great that they would result in shutdown of major pumping stations.

Because the crabs are burrowing creatures, they weaken levees. Failed levees have caused major flooding of farmland in recent years, and such flooding could carry the crabs to new sites.

Because so many of the critters are taken from the Tracy water-pumping station, Dealy said he would like to see them used in some beneficial way: "Maybe they could be processed into compost, used in some beneficial matter."

What neither Dealy nor Tsukimura would like to see happen is commercial fishing for the critters. Last month, the Fish and Game Commission voted against granting special permits to allow fishermen to catch the crabs when they begin congregating to spawn in the Sacramento-San Joaquin Delta.

Both say that such commercial use of the animal could lead to its further spread and to established fishing interests that would be hard to alter later.

The crab is native to the coastal rivers and estuaries of China's Yellow Sea. It is a delicacy in its native China.

Tsukimura said part of the challenge in learning about the crab is that most of the literature concerning it is written in Chinese. And because it is commercially consumed in China, much remains unknown.

For example, he said, it is not known how often the animal breeds: "Once it gets to a certain size, it's dinner."

What is known includes some jarring facts:

■ The animals can travel on land.

In Germany, large numbers of mitten crabs were reported to leave the water at night and occasionally wander the streets and enter houses.

In Stockton, two adult mitten crabs climbed over a levee and into a swimming pool when they encountered a small dam blocking their downstream migration.

■ The crabs mate in salt water and mature in fresh water. In California, that has meant they have moved up freshwater streams for miles, then returned to the salt water to spawn.

Tsukimura said they can move at 4½-5 mph upstream and at 10-12 mph downstream.

■ The crabs like warm water. Tsukimura said that could make water in irrigation ditches a favored spot. From there, he fears, they might forage on row crops.

■ The crabs can survive out of the water at least 24 hours, perhaps even three days, he said.

"They've been found in water traps in Napa and Petaluma golf courses," Tsukimura said.

■ "They're cryptic — hard to find," Tsukimura said. They burrow nearly 2 feet deep.

■ A single female can carry 250,000 to 1 million eggs. After hatching, small juvenile crabs settle in salt or brackish water and migrate to fresh water.

■ The crab may carry a parasite known as the Oriental lung fluke. If consumed by humans in a crab not fully cooked, it causes tuberculosislike symptoms.

■ More details on the crab can be found on the Internet at www2.delta.dfg.ca.gov/mittencrab/front.html.

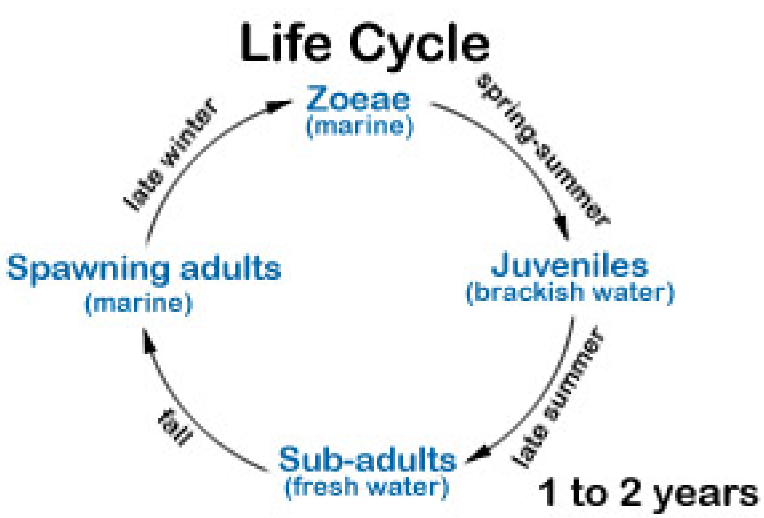
Chinese Mitten Crabs

Life and History

Life History and Background Information on the Chinese Mitten Crab
August 5, 1998
from the California Department of Fish and Game
http://www2.delta.dfg.ca.gov/mittencrab/life_hist.html

The Chinese mitten crab *(Eriocheir sinensis)*, so named for the dense patches of hairs on the claws of larger juveniles and adults, is native to the coastal rivers and estuaries of the Yellow Sea. It was accidentally introduced to Germany in the early 1900s and spread to many northern European rivers and estuaries. In San Francisco Estuary, the mitten crab was first collected in 1992 by commercial shrimp trawlers in South San Francisco Bay and has spread rapidly throughout the estuary. Mitten crabs were first collected in San Pablo Bay in fall 1994, Suisun Marsh in February 1996, and the Delta in September 1996. As of August 1998, the known distribution of the Chinese mitten crab extends north of Colusa to Hunter's Creek (near Delevan National Wildlife Refuge) in the Sacramento River drainage, east to Roseville (Cirby Creek) and eastern San Joaquin County near Calaveras County (Mormon Slough and Littlejohns Creek) and south in the San Joaquin River to Hiway 165, near San Luis National Wildlife Refuge. The most probable mechanism of introduction to the estuary was either deliberate release to establish a fishery or accidental release via ballast water. In Asia, the mitten crab is a delicacy and crabs have been imported live to markets in Los Angeles and San Francisco.

The mitten crab is catadromous - adults reproduce in salt water and the offspring migrate to fresh water to rear. In the San Francisco Estuary, the mitten crab probably matures in 2 to 3 years, although it reportedly matures from 1 to 5 years elsewhere, depending on water temperature. Males and females grow to a maximum carapace width of approximately 80 mm (3 inches) in the estuary. Mating and fertilization occurs in late fall and winter, generally at salinities >20‰. The females carry their eggs until hatching and both sexes die soon after reproduction. A single female can carry 250,000 to 1 million eggs. After hatching, larvae are planktonic for approximately 1 to 2 months. The small juvenile crabs settle in salt or brackish water in late spring and migrate to freshwater to rear.



Young juvenile mitten crabs are found in tidal freshwater areas, and usually burrow in banks and levees between the high and low tide marks. Mitten crabs apparently do not burrow as extensively in non-tidal areas, probably because they are not subject to desiccation during low tides. Older juveniles are found further upstream than younger juveniles, and in China and Europe they have been reported several hundred miles from the sea. We do not understand what cues this upstream migration, although high densities were reportedly a factor in Germany and the upstream migration may be tied to the monsoon season in southern China. Maturing crabs move from shallow areas to the channels in late summer and early fall and migrate to salt water in late fall and early winter to complete the life cycle.

Mitten crabs are adept walkers on land, and, in their upstream migration, they readily move across banks or levees to bypass obstructions, such as dams or weirs. In Germany, large numbers of mitten crabs were reported to leave the water at night when they encountered an obstruction and occasionally wandered the streets and entered houses. In Stockton, 2 adult mitten crabs climbed over a levee and into a swimming pool when they encountered a small dam blocking their downstream migration.

Mitten crabs are omnivores, with juveniles eating mostly vegetation, but preying upon animals, especially small invertebrates, as they grow. In the Delta, adult crabs have been incidentally caught by anglers using a variety of baits, ranging from ghost shrimp to shad. Relatively little is known about the predators of the mitten crab, although white sturgeon, striped bass, bullfrogs, loons, and egrets have been reported to prey upon them in the estuary. We assume that other predatory fishes, including largemouth bass and larger sunfishes, river otters, racoons, and other wading birds will consume mitten crabs.

Based on the impacts of mitten crabs in their native range and Europe, they pose several possible threats. The mitten crab is the secondary intermediate host for the Oriental lung fluke, with mammals, including humans, as the final host. Humans become infested by eating raw or poorly cooked mitten crabs. However, neither the lung fluke nor any of the freshwater snails that serve as the primary intermediate host for the fluke in Asia have been found in the Estuary. It has been noted that several species of freshwater snails which could possibly serve as an intermediate host are present in the watershed.

The burrowing activity of mitten crabs may accelerate the erosion of banks and levees. In Germany, burrows were reported to be up to 50 cm (20 inches) deep and some damage to levees and structures has occurred. Mitten crab burrow densities as high as 30/m2 (2.7/ft2) have been reported from South Bay creeks, with most burrows no more than 20-30 cm (8-12 inches) deep. The highest density of juvenile crabs was approximately 6/m2 (0.8/ft2) in Suisun Marsh and 1/m2 (0.1/ft2) in the Delta in summer 1997. In the Delta large numbers of juvenile mitten crabs were also reported in water hyacinth, which is not found in Suisun Marsh, San Francisco Bay, or it's tributaries.

In China and Korea, juvenile mitten crabs have been reported to damage rice crops by consuming the young rice shoots and burrowing in the rice field levees. Rice fields in tidally influenced areas apparently are most subject to damage.

The most widely reported economic impact of mitten crabs in Europe has been damage to commercial fishing nets and the catch when the crabs are caught in high numbers. The mitten crab has become a nuisance for commercial Bay shrimp trawlers in South Bay, as it is time consuming to remove the crabs from the nets (one trawler has reported catching over

200 crabs in a single tow several times). Shrimp trawlers have also reported that a large catch of mitten crabs damages and even kills the shrimp, making them unsuitable for the bait market. Shrimp trawlers have been able to move to areas with fewer crabs, but, as the mitten crab population grows, this option diminishes.

The mitten crab overlaps in dietary and habitat preferences with the introduced red swamp crayfish (Procambarus clarkii) in South San Francisco Bay creeks and negative interactions between the two species have been observed in the field. In the Delta, the mitten crab may reduce abundance and growth rates of the introduced signal crayfish (Pacifastacus leniusculus), which supports a commercial fishery.

The ecological impact of a large mitten crab population is the least understood of all the potential impacts. Although juveniles primarily consume vegetation, they do prey upon animals, especially invertebrates, as they grow. A large population of mitten crabs could reduce populations of native invertebrates through predation and change the structure of the Estuary's fresh and brackish water benthic invertebrate communities.

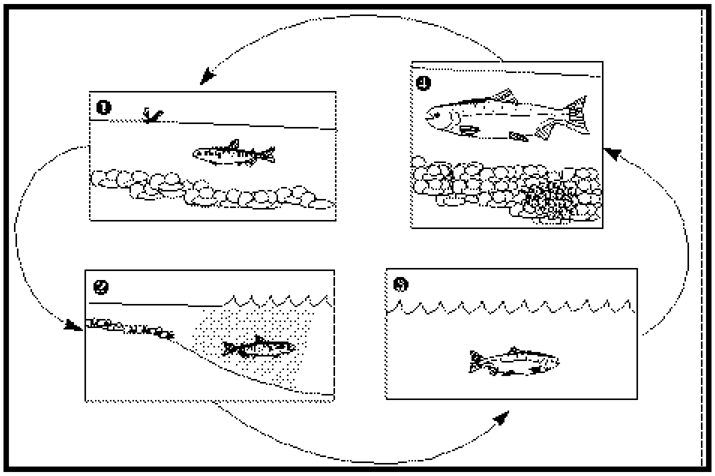
In Germany, extensive efforts were undertaken by the government in the 1920s and 1930s to control mitten crab populations in some rivers. Control measures often took advantage of the mitten crab's migratory behavior; traps were placed on the upstream side of dams to capture juvenile crabs as they migrated upstream. At one site, as many as 113,960 crabs were trapped in a single day. It was hypothesized that this population explosion may have coincided with a reduction of predators, especially fishes, in the rivers. In recent years, European mitten crab populations have apparently been stable, although there are occasional reports of "invasions". In 1981, the mitten crab population in the Netherlands increased substantially, resulting in serious damage to fishing nets.

Information on the impacts of the mitten crab in China and Korea has been more difficult to obtain. Although the mitten crab damages rice crops, no control measure have been reported. In some rice fields, they are cultured with fish. Apparently, mitten crabs are stocked at a rate that does not damage the rice crop.

Note: It is illegal to import, transport, or possess live Chinese mitten crabs (Title 14 of the California Code of Regulations). Accidental release or escape will spread these crabs to uninfested waters. If you keep a mitten crab, it must be dead. Although there are no bag or size limits, methods of take for marine and inland waters differ.

Salmon Challenge

Salmon evolution and obstacles to survival



Overview

Students become salmon and, in two different activities, experience many of the obstacles that salmon face while swimming upstream to spawn. Students then work as scientists to place different evolutionarily significant population units of two species of salmonids (chinook salmon and steelhead trout) on a grid map of the West Coast of the United States according to data of where and when fish were collected.

Estimated Time

Three 50-minute periods

Objectives

Students will be able to:

- Describe the obstacles that salmon currently face in their attempt to swim upstream and spawn.
- Describe the patterns of salmon distribution and their likely evolutionary relationships, and probable sequence of formation from the original form, noting a compelling example of reproductive isolation resulting in evolutionarily important differences.
- Explain what issues in certain watersheds on the west coast have endangered particular evolutionarily significant populations of chinook salmon and steelhead trout.

Materials

Part I: Salmon Challenge

Very long jump rope (at least 4 people need to be able to run through it at a time)

Part II: Obstacles to Survival

10 pairs of dice
red and green marking pens
ten obstacle signs (photocopy enclosed sheet)
50 3" x 5" challenge cards (10 each of 5 colors is ideal)
awards for survivors (optional), such as ribbons or buttons.

Part III: Salmon Evolution

Colored pencils
Copies of student pages (one copy for each student)
Enlarged copies of grid map of the west coast (two copies for each team of 2-4 students)
Overhead transparency of grid map to illustrate the procedure in your class introduction.
For color drawings of the salmon, use a color printer and visit the web site: http://www.nwr.noaa.gov/1salmon/salmesa/mapswitc.htm. Laminate these color copies for future use. This web site also has detailed maps of each species of salmon and the evolutionarily significant population units. For future research projects, it is an excellent resource.

Vocabulary

anadromous, iteroparous, spawn, migrate, evolution, populations, genetics, streamflow, niche

California Science Content Standards
Grade 7

Standard Set 3.a: both genetic variation and environmental factors are causes of evolution and diversity of organisms.

Standard Set 3.c: how independent lines of evidence from geology, fossils, and comparative anatomy provide a basis for the theory of evolution.

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

Grades 9 - 12

Biology/Life Sciences Standard Set 6.a: biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.

Biology/Life Sciences Standard Set 6.a: how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

Biology/Life Sciences Standard Set 8.d: reproductive or geographic isolation affects speciation.

Investigation and Experimentation i: analyze the locations, sequences, or time intervals of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).

Part I: Salmon Challenge
Teacher Procedure

1. You can begin the activity with a physical group challenge, if appropriate for your students. You will need to find a large grassy area outside, and take the long jump rope with you. Choose one other person (a student or adult) to help you, and begin the challenge with a few questions, such as:
   - What do you know about salmon? (Take many answers to determine what is already known about salmon.)
   - What is an anadromous fish? (A fish that is born in a river, migrates out to the ocean where it lives most of its life, and migrates upstream to spawn.)
   - What might be an obstacle to salmon swimming upstream? (Anglers, grizzly bears, pollution, etc. Make sure that someone mentions dams.)
2. Begin turning the jump rope with your partner. Explain to the students that they have all become salmon who want to travel upstream to spawn. The jump rope represents a turbine on a dam. Turbines produce electricity as water passes through. The students all need to get through the turbine to get to the stream where they were born. The rules are: they all have to make it through the turbine in X turns of the rope (make the X equal to about one-third or one-half of the number of students, depending on how much of a challenge you want to create); they have to go through the turbine (not around); if one salmon is hit by the turbine, all of the salmon have to start over; and once the first salmon runs through the turbine, the countdown begins.

3. Before the students begin, you may want to review the principles of teamwork. Ask the students what they think are important teamwork skills, making sure they mention communication, encouragement, listening, and respect.

4. Let the students figure out how to tackle the challenge on their own, only stopping and talking to the group if communication breaks down or if feelings are being hurt.

5. At the end of the activity, gather the students for a wrap up, about teamwork skills and working together, as well as about the lives of salmon and the difficulties they currently encounter.

Part II: Obstacles to Survival
A more complex activity demonstrating many of the obstacles faced by salmon can take place in the classroom after the warm-up activity.

Preparation

Make ten obstacle signs using photocopies of the obstacles. Make 50 challenge cards using 3" x 5" cards and the red and green markers. These challenge cards will be used at 5 of the obstacles. Create challenge cards as follows:

Ocean Fishing	5 cards with a red dot 5 cards with a green dot
Gill Net Fishing	3 cards with a red dot 7 cards with a green dot
Stream Fishing	5 cards with a red dot 5 cards with a green dot
Poachers	4 cards with a red dot 6 cards with a green dot
Predators	3 cards with a red dot 7 cards with a green dot

Procedure

1. Choose ten students to play the obstacles. The obstacles should sit at a long table or at desks lined up in a row. They each receive an obstacle sign and should place it in front of them. The obstacles should be in the order indicated by the numbers at the top left corner of the card. Five of the obstacles (ocean fishing, gill net fishing, stream fishing, poachers, and predators) should receive challenge cards in the proportions explained above (they need to shuffle these cards without looking at the colors). The other obstacles (culverts, dams, sedimentation, water diversions, and pollution) do not have challenge cards, but <u>all of the obstacles</u> should receive a pair of dice (ten pairs total).

2. Explain the game to the students: The obstacle signs explain what is necessary to beat this obstacle. Show them an example of an obstacle card, as you explain. A "?" in the lower left corner of the obstacle card indicates that there are challenge cards associated with the obstacle. The lower right figure, for example "5+" indicates the survival number.

3. Play proceeds as follows. All of you, except for the obstacles, will become salmon and will stand in a line, ready to swim upstream from the ocean. The first salmon will step up to the first obstacle, the ocean fisherman. Because there is a "?" in the bottom right corner, you will draw a challenge card. If the card has a green dot, then the salmon has passed the challenge and moves on to the next obstacle. If a red dot is drawn, then the salmon rolls one die and the obstacle rolls the other die. If the sum of the two dice is the same or higher than the survival number, the salmon has survived and moves on to the next obstacle. If the total is less than the survival number, then the salmon has died and goes back to the end of the salmon line to try again.

4. Five of the obstacles have no challenge cards. At these obstacles the salmon must role the dice with the obstacle. If the sum of the two dice is the same or higher than the survival number, the salmon has survived and moves on to the next obstacle. If the total is less than the survival number, then the salmon has died and goes back to the end of the salmon line to try again.

5. As soon as the first salmon is done at the first obstacle, the next salmon starts, so there is a continuous run of salmon through the course.

6. Discuss expected outcomes with the students. All of these obstacles are very common on the northern California coast. How many salmon will actually make it to the spawning grounds and how many will die along the way? Note: the game typically allows for a 5% survival rate, which is approximately 5 times higher than in real life.

7. Have the students play the game. End the game with enough time for discussion before class ends.

Discussion questions:

- Did the game turn out as expected?
- Will salmon survive if they are unable to spawn?
- How could we make it easier for salmon to survive in the real world?

Part III: Salmon Evolution

Background

While natural selection explains evolutionary modifications within lineages, speciation explains evolutionary branching and diversification. Speciation involves genetic differentiation, ecological differentiation (niche separation) and reproductive isolation. Isolation of members of a species in different environments may result in the formation of a number of subspecies (in the case of salmon, these are not subspecies, but evolutionary significant populations).

This lesson is probably best presented near the end of a unit on genetics, especially if you have covered population genetics. It helps at this time to see some visible features of real populations and how they are distributed as different populations in a particular region. Discussion of the pattern of distribution, in terms of how they may have come to be this way, brings you nicely full circle to the process of evolution again, showing how a broad concept (evolution) can help make sense out of an interesting pattern of distribution, and also how this pattern provides a strong bit of evidence, and compelling experience, that evolution has occurred.

Teacher Procedure

1. Set up your teams (probably best to work in pairs at first, coloring in the appropriate squares on their grids). Teams can combine to answer the discussion questions. (say into groups of 4).

2. Demonstrate (using overhead) how they should color in the squares on the grid map. The students will be mapping the evolutionarily significant units (ESUs) of steelhead trout and of chinook salmon. You could demonstrate the mapping with the Washington Coast ESU of the Steelhead Trout. Color in squares 9E, 9F, and 10G with one color, using either horizontal, vertical, or diagonal lines, and in the Key, draw this pattern in the box next to Washington Coast ESU. They should use one map for Steelhead Trout and one map for Chinook Salmon. Ask them to take turns coloring in the grid for each evolutionarily significant unit. Some of the ESUs overlap, which is why the students should use a variety of lines, versus filling in the entire square with a solid color.

3. Hand out the student pages. Students read and proceed as directed in handouts.

4. For class discussion, you can simply go over their discussion questions, calling on representatives from each team randomly or in succession. Be sure to use the overheads or a wall map of the United States and be sure you have thoroughly familiarized yourself with the questions before doing this lesson.

Adapted from Speciation, Evolution and the Nature of Science Institutes (ENSI) presentations by: Cheryl (George) Garcia, Steve Harness, Judy Loundagin, and Carol-Anne Piehl; Reviewed / Edited by: Martin Nickels, Craig Nelson, Jean Beard: 12/15/97, Edited / Revised for website, http://www.indiana.edu/~ensiweb/home.html, by L. Flammer 5/99.

Original Source: Biological Science - An Ecological Approach (BSCS Green Version), 1987, Kendall/Hunt Publishing Co., pages 296-299. Also,1992 edition, pp. 230-233.

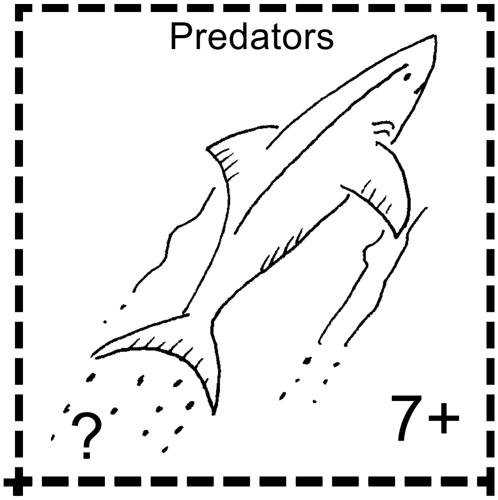
Additional Resources/Activities

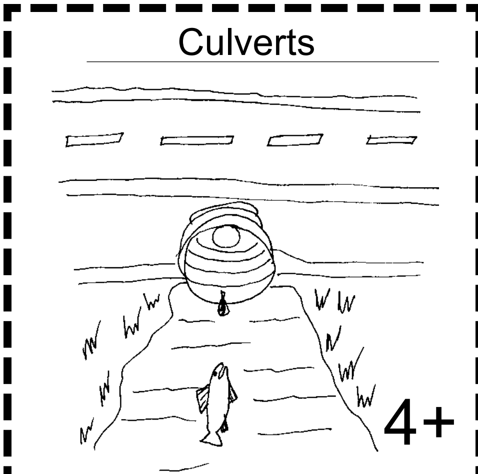
WILD Salmon Trunk Activities: http://wdfw.wa.gov/outreach/education/trunksum.htm

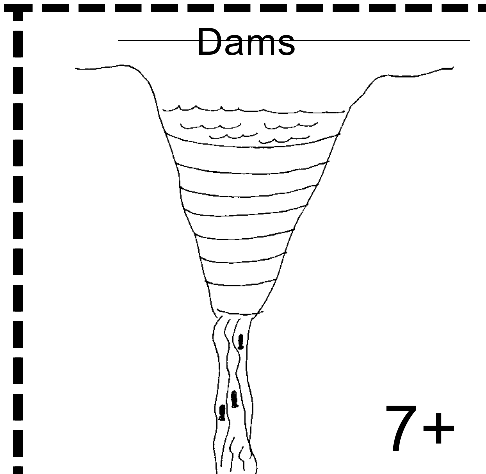
Salmon Activities for the Classroom: http://www.wavcc.org/wvc/cadre/WaterQuality/salmonactivities.htm

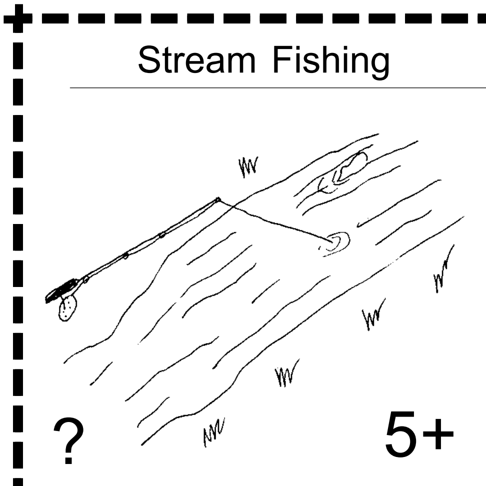
Salmon Challenge

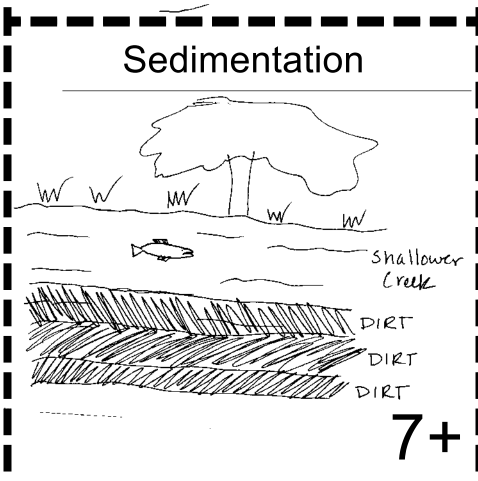
Part II
Obstacle Cards
Photocopy these 10 cards and cut them apart. The ten students who are playing the role of obstacles each receive a card, which they should set in front of themselves on teh desk or table.

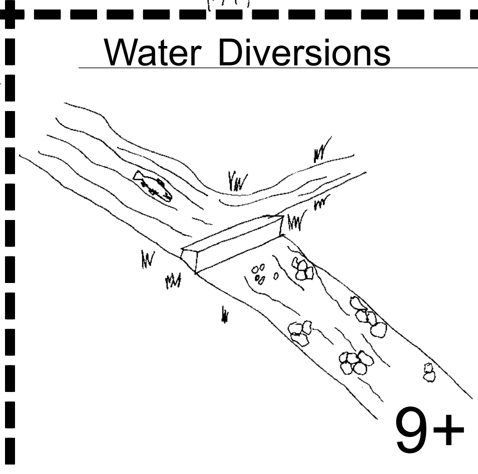


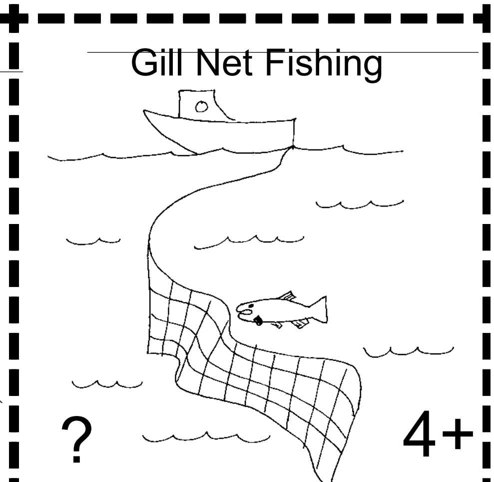


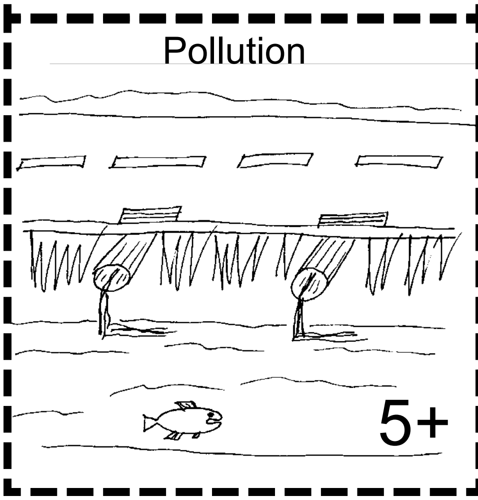


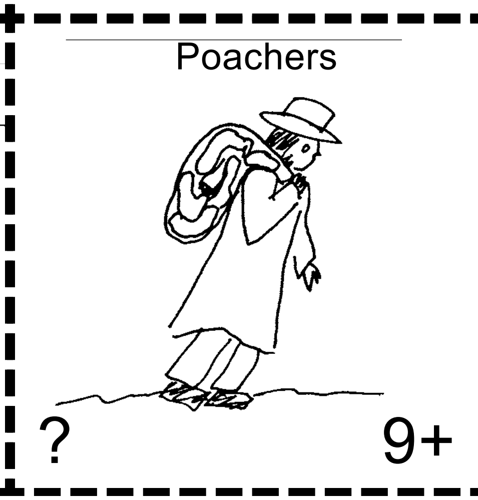


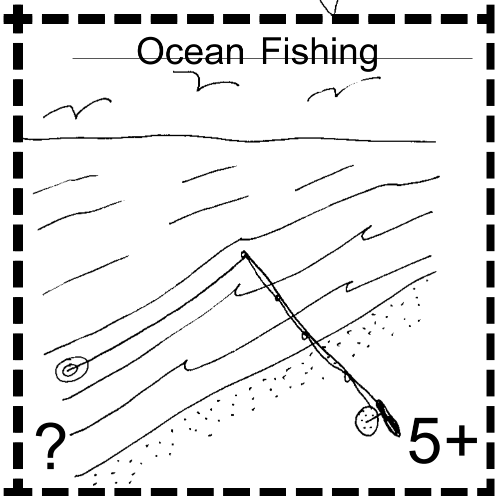












Salmon Challenge

Salmon evolution and obstacles to survival

Student Pages

INTRODUCTION

There are many species of salmonids on the west coast of North America, including Coho Salmon, Pink Salmon, Chinook Salmon, Chum Salmon, Sockeye Salmon, and Steelhead Trout. Most of these breed in streams and rivers from Alaska south to the Pacific Northwest. The San Francisco Bay Watershed is home to Chinook Salmon and Steelhead Trout.

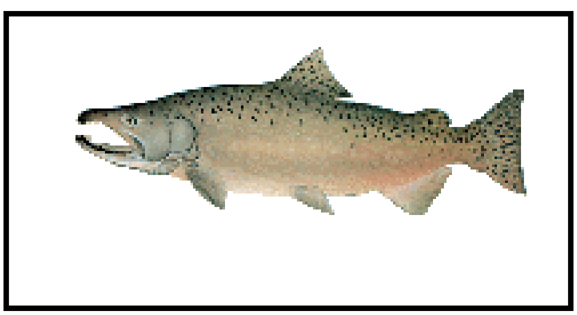
Like all species of Pacific salmon, chinook salmon are anadromous. They hatch in fresh water, spend part of their life in the ocean, and then spawn in fresh water. All chinooks die after spawning. Chinook salmon may become sexually mature from their second through seventh year. Steelhead trout are also anadromous, and typically migrate to ocean waters after spending two years in fresh water. They then reside in the ocean for typically two to three years prior to returning to their natal stream to spawn as four or five years old. Unlike salmon, steelhead are iteroparous, meaning that they are capable of spawning more than once before they die.

The essential environmental conditions which enable continued survival and reproductive success among salmonids include: access to spawning sites, adequate streamflows (freshwater), acceptable water temperature and water quality, appropriate substrate (stream bottom) composition, and abundant food.

Historically, Steelhead and Chinook occurred in most coastal streams in Washington, Oregon, and California, as well as many inland streams in these states and in Idaho. However, during this century, many populations of steelhead and chinook have disappeared and many more are in decline. The National Marine Fisheries Service is responsible for administering the Endangered Species Act for fish and marine mammals. They have listed many "evolutionarily significant units" of steelhead trout, chinook salmon, and other salmon as endangered or threatened species.

Salmonids have been divided into evolutionarily significant units (ESUs) by scientists. Much of the work of determining the ESUs was conducted using genetic data. A salmonid population must satisfy two criteria to be considered an ESU:

1) It must be reproductively isolated from other population units.
2) It must represent an important component in the evolutionary legacy of the biological species.



PROCEDURE

Imagine you are a fisheries biologist with the National Marine Fisheries Service. You have received coordinates of the locations where specific Evolutionarily Significant Units of salmon have been found on the West Coast of the United States (Washington, Oregon, California, and Idaho). You need to map the ESUs of Chinook Salmon and Steelhead Trout on two separate maps and answer a series of questions about salmonids, their evolution, and the issues affecting them today.

Choose a color and pattern (horizontal lines, vertical lines, diagonal lines, dots, etc.) for each of the ESUs listed on the two maps and first fill in the squares on the key with the colors and patterns you choose. Next, fill in the squares on the two grid map of the western United States according to the coordinates that are listed on the sheet entitle "ESU Coordinates". For example, the square in the top left corner is A1. Note: don't use solid colors, as some of the ESUs overlap.

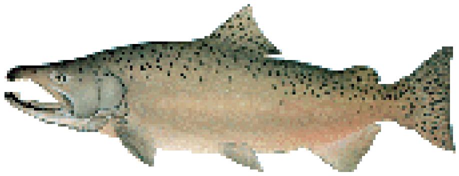
QUESTIONS

1. Is the species uniformly distributed throughout the West Coast of the United States? Use your knowledge of salmonids' ecological requirements (see Introduction) to offer an explanation of their distribution.

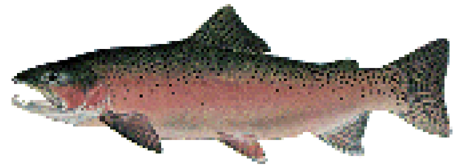
2. Consider the geography of the West Coast of the United States. What patterns do you notice in the distribution of the salmonids?

3. From the introduction, what are the two criteria that scientists use to determine the evolutionarily significant units (ESUs) of salmonids? Explain in your own words what is meant by the second criteria.

4. The following ESUs are endangered. Using your key, identify the units on the map, using a highlighter or a symbol to mark the ESUs on the map.



Chinook Salmon
Sacramento River Winter-run
Snake River Fall-run
Snake River Spring/Summer-run
Puget Sound
Lower Columbia River
Upper Willamette River
Upper Columbia River Spring-run
Central Valley Spring-run
California Coastal



Steelhead Trout
Southern California
South-Central California Coast
Central California Coast
Upper Columbia River
Snake River Basin
Lower Columbia River
California Central Valley
Upper Willamette
Middle Columbia River
Northern California

5. What environmental factors could lead to the decline of salmonids?

6. What pattern do you notice on the maps in regards to endangered ESUs of salmonids? Where are most of the endangered ESUs located?

7. What characteristics do you think the regions where salmonid ESUs are endangered might have in common? What characteristics do you think the regions where salmonid ESUs are not endangered have in common?

Steelhead Trout Map

Central California Coast: E25, E26, E27, E28, F27, F28

Central Valley: F22, F23, F24, F25, F26, G22, G23, G24, G25, G26, G27, G28, H22, H26, H27, H28, I27, I28

Klamath Mountains Province: C18, C19, C20, D18, D19, D20, D21, E18, E19, E20, E21, F18, F19, F20, F21, G18, G19

Lower Columbia River: F11, F12, G11, G12

Middle Columbia River: H9, H10, H11, H12, H13, H14, I9, I10, I11, I12, I13, I14, J11, J12, J13, J14, K11, K12, K13, K14, L11, L12, L14

Northern California: C21, C22, D22, D23, D24, D25, E23, E24

Olympic Peninsula: D5, D6, D7

Oregon Coast: C17, D11, D12, D13, D14, D15, D16, D17, E11, E12, E13, E14, E15, E16, E17, F17, G17

Puget Sound: E5, E6, E7, F5, F6, F7, F8, G5, G6, G7, G8

Snake River Basin: L9, L10, L13, M9, M10, M11, M12, M13, N9, N10, N11, N12, N13, O9, O10, O11, O12, O13, P9, P10, P11, P12, P13, Q10, Q11, Q12, Q13, R12, R13, R14, R15, S13, S14, S15

South-Central California Coast: F29, F30, G29, G30, G31, G32, H30, H31, H32, I32

Southern California: H33, H34, I33, I34, J33, J34, J35, K33, K34, K35

Upper Columbia River: H7, H8, I6, I7, I8, J6, J7, J8, J9, J10, K9, K10

Upper Willamette River: F13, F14, F15, G13, G14, G15

Washington Coast: D8, D9, D10, E8, E9, E10, F9, F10

Chinook Salmon Map

California Coastal: C21, C22, D22, D23, D23, D24, D25, D26, E23, E24, E25, E26

Central Valley Fall: F22, F23, F24, F25, G22, G23, G24, G25, G26, G27, G28, H26, H27, H28, H29, I28

Central Valley Spring: F22, F23, F24, F25, G22, G23, G24, G25, G26, G27

Upper Klamath-Trinity Rivers: E20, E21, F19, F20, F21, G19, G20

Lower Columbia River: E11, E12, F11, F12, F13, G12

Mid-Columbia River Spring: H9, H10, H11, H12, I9, I10, I11, I12, I13, I14, I15, J9, J10, J11, J12, J13, J14, K10, K11, K12, K13, K14, K15, L10, L11, L12, L14, L15

Oregon Coast: C16, C17, D13, D14, D15, D16, D17, E13, E14, E15, E16, E17, F17, F18

Puget Sound: E5, E6, E7, F5, F6, F7, F8, G5, G6, G7, G8

Southern Oregon and Northern California Coastal: C18, C19, C20, D18, D19, D20, D21, E18, F18, G18

Sacramento Winter: F22, F23, F24, F25, G22, G23, G24, G25, G26, G27

Snake River Fall: M9, M10, M11, M12, N10, N11, N12, O10, O11, O12, P9, P10, P11, P12, Q11, Q12, Q13, R12

Deschutes River Summer/Fall: I13, I14, I15

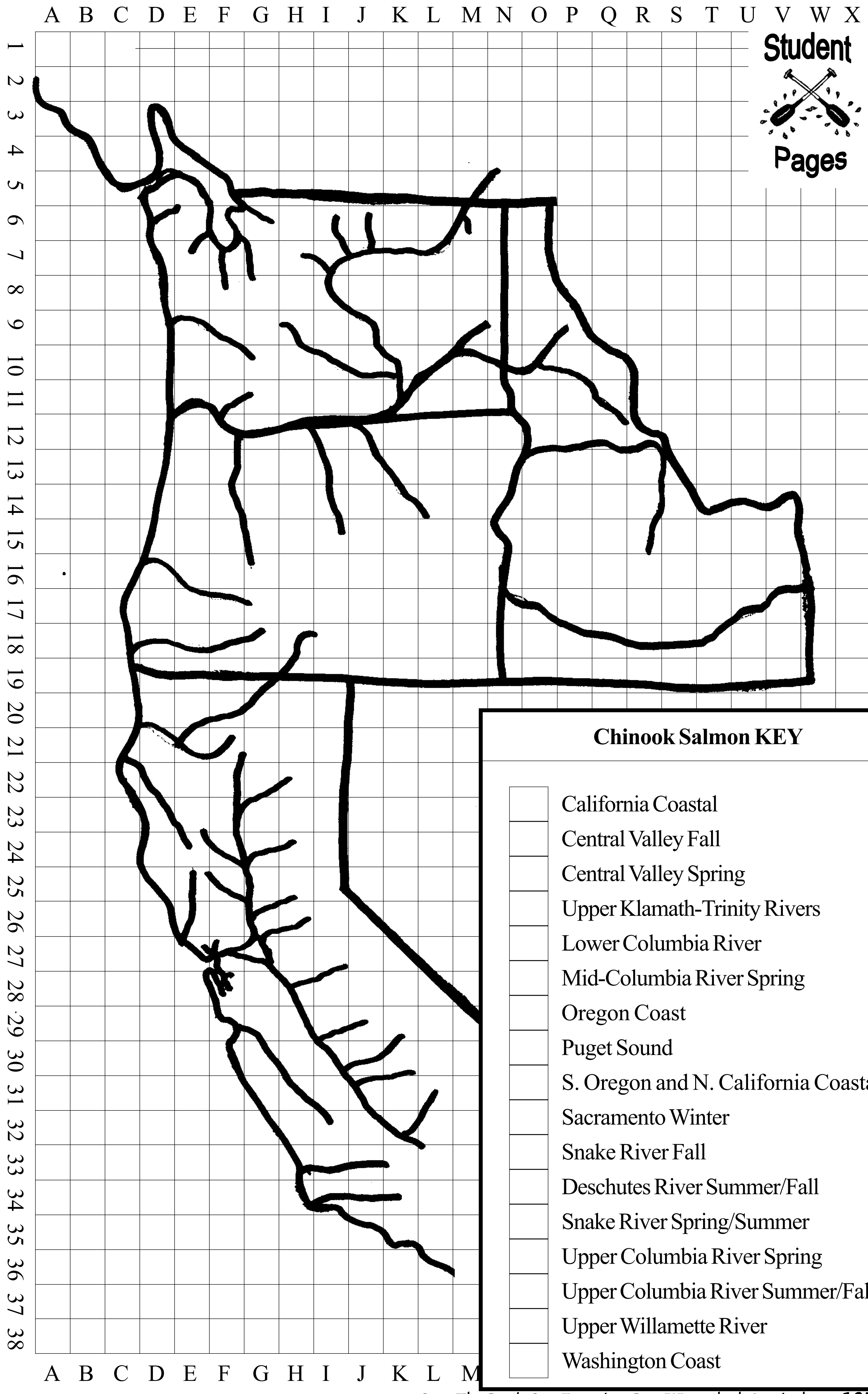
Snake River Spring/Summer: M9, M10, M11, M12, N10, N11, N12, O11, O12, O13, P13, Q13, R13, R14, R15, S13, S14, S15

Upper Columbia River Spring: H7, H8, I6, I7, I8, J6, J7

Upper Columbia River Summer/Fall: H7, H8, H9, H10, I6, I7, I8, I10, J6, J7, J9, J10, K10

Upper Willamette River: F14, F15, F16, G13, G14, G15, G16

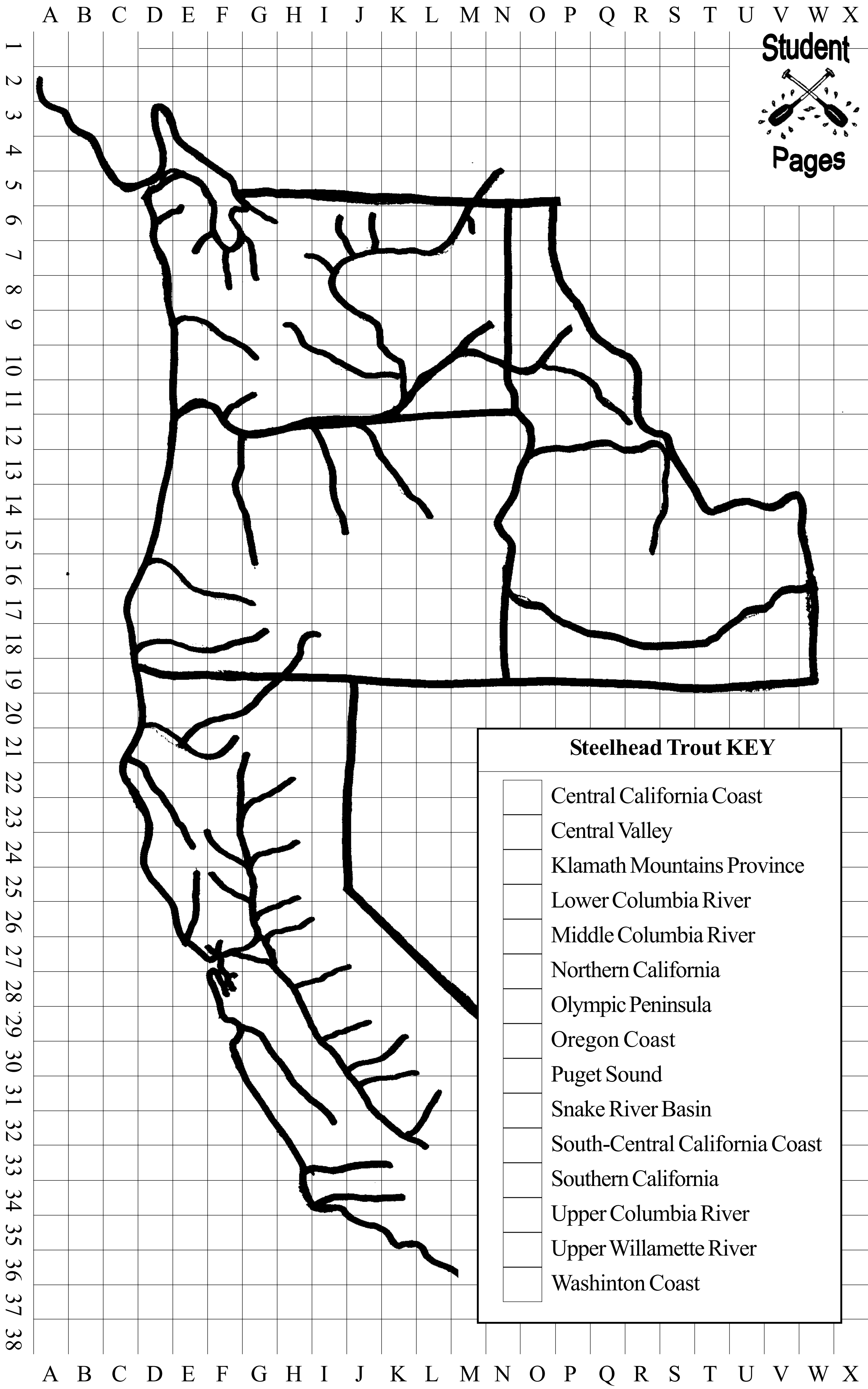
Washington Coast: D5, D6, D7, D8, D9, D10, E8, E9, E10, F9, F10, G10



Student Pages

Chinook Salmon KEY

- California Coastal
- Central Valley Fall
- Central Valley Spring
- Upper Klamath-Trinity Rivers
- Lower Columbia River
- Mid-Columbia River Spring
- Oregon Coast
- Puget Sound
- S. Oregon and N. California Coastal
- Sacramento Winter
- Snake River Fall
- Deschutes River Summer/Fall
- Snake River Spring/Summer
- Upper Columbia River Spring
- Upper Columbia River Summer/Fall
- Upper Willamette River
- Washington Coast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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38
Steelhead Trout KEY
Central California Coast
Central Valley
Klamath Mountains Province
Lower Columbia River
Middle Columbia River
Northern California
Olympic Peninsula
Oregon Coast
Puget Sound
Snake River Basin
South-Central California Coast
Southern California
Upper Columbia River
Upper Willamette River
Washinton Coast

Saving the Bay

"Never doubt that a small group of thoughtful committed people can change the world, indeed it's the only thing that ever has."
Margaret Mead

Overview
The current protections afforded to San Francisco Bay are a result of concerted public pressure, governmental regulation, and organized action. Through this activity students will understand the role of the citizen in a democracy, by investigating historical figures who affected change, primarily the three women who founded Save The Bay. San Francisco Bay historically was seen as a garbage dump, an empty space to be filled, and unrealized real estate. In the early 1960s there were plans being considered that would have dramatically altered the size and health of the Bay. Students will read several articles to distinguish the various points of view and the issues that were at stake in the late 1960s. Students will also explore a successful citizen action that brought significant change to the Bay Area.

Estimated Time
Approximately one hour in class and a one-hour homework assignment.

Objectives
Students will be able to:
- describe how civil society makes it possible for individuals or groups to bring influence to bear on government.
- explain the political history of San Francisco Bay in the 1960s and how democracies rely upon active individuals.

Materials
For each student: photocopies of student pages, articles, and calls to action

California Science Content Standards Grades 9-12

Earth Sciences Standard Set 9.c: the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

Investigation and Experimentation m: investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples include . . . land and water use decisions in California.

California History/Social Science Content Standards
Grades 9-12
Historical and Social Sciences Analysis Skills
Chronological and Spatial Thinking
1. Students compare the present with the past, evaluating the consequences of past events and decisions and determining the lessons that were learned.

Historical Interpretation
3. Students interpret past events and issues within the context in which an event unfolded rather than solely in terms of present-day norms and values.
4. Students understand the meaning, implication, and impact of historical events and recognize that events could have taken other directions.
5. Students analyze human modifications of landscapes and examine the resulting

environmental policy issues.

Grade 11

Standard 11.11.5: Trace the impact of, need for, and controversies associated with environmental conservation, expansion of the national park system, and the development of environmental protection laws, with particular attention to the interaction between environmental protection and property rights.

Grade 12

Standard 12.3.2: how civil society makes it possible for people, individually or in association with others, to bring their influence to bear on government in ways other than voting and elections

Standard 12.7.5: how public policy is formed, including the setting of the public agenda and how it is carried out through regulations and executive orders

Standard 12.7.6: the process of lawmaking at each of the three levels of government, including the role of lobbying and the media

Standard 12.8.1: the meaning and importance of a free and responsible press

English/Language Arts Content Standards Grades 9-12

Reading Comprehension

2.0 Students read and understand grade-level appropriate material.

Writing Strategies

1.0 Students write coherent and focused essays that convey a well-defined perspective and tightly reasoned argument.

Listening and Speaking Strategies

1.0 Students deliver focused and coherent presentations of their own that convey clear and distinct perspectives and solid reasoning.

Teacher Procedure

1. Place students in groups of three or four. Each student receives a packet of articles, a copy of the student pages, and a copy of the quotes.

2. Students should read "They're Filling in San Francisco Bay" individually and work as a group to answer Part I questions. Ask each group to report on their answer to question 3 in Part I (is the author biased?).

3. Students should individually read "Diagnosis of San Francisco Bay" and work as a group to answer Part II questions. Ask each group to report on their answer to question 3 in Part II (a metaphor they would use to protect the Bay).

4. Students should individually read "Powerful 'Tea Ladies' want help saving the Bay" and the attached quotes and respond to Part III, either in class or as a homework assignment.

Extensions:

1. In a group, students identify an issue they think is important to their community. After an issue has been selected, students will work to devise a strategy to meet their goals. The strategy should have several components: community outreach, identification of political allies and mission statement.

2. Students research the political history of San Francisco Bay and how the Bay Conservation and Development Commission came into existence. Students present a research paper illustrating the issues, controversies, and resolutions surrounding Bay protection. Students also illustrate current issues affecting San Francisco Bay: fill, airport expansion, non-native species, loss of wetlands, pollutants.

Resources

"The Saving of San Francisco Bay" Rice Odell, The Conservation Foundation 1972.

"Between the Devil and the Deep Blue Bay: The Struggle to Save San Francisco Bay" Harrold Gilliam, Chronicle Books, 1969.

"Bay in Peril" by Jane Kay, A Special Reprint of the *San Francisco Examiner*, 1993.

Saving the Bay

"Never doubt that a small group of thoughtful committed people can change the world, indeed it's the only thing that ever has."
Margaret Mead

Part I

Facts are the basis of newspaper stories. Facts are also used to sway the general public to reach certain conclusion. Individually, read "They're Filling in San Francisco Bay" from the Christian Science Monitor, written in 1967. Newspaper articles often betray a bias through the facts chosen or the quotes given.

1. Find the following facts in the article:
Between the Gold Rush and 1967, how much of San Francisco Bay was lost to fill?_______________

What percentage of this remaining amount of Bay was in private ownership in 1967?___________

2. The author of the article is reporting on "a clash between the needs of a growing community and the desire to preserve an irreplaceable resource." List the supporting facts given for each position.

Bay Fill Is Needed	Bay Fill Is a Problem

3. Based on the number of facts supporting each position, does the author show a bias and if so what is it?

4. The Christian Science Monitor article was one way that individuals inspired others to get involved and take action on behalf of the Bay. In the article, find three other ways that inspired activists took action to protect the Bay.

Part II

Metaphors communicate through association taking something familiar and using that to explain the unfamiliar. A metaphor helps create reality without stating the reality literally. For instance, we talk about the "head" of organizations and everyone understands the metaphor without it needing to be explained that the person in charge directs the organization like the brain directs the body. The choice of association depends upon the intent of the metaphor. On your own, read the following article "Diagnosis of San Francisco Bay" for the use of metaphors in creating the argument that the Bay should be saved. As a group, answer the following questions:

1. What is the metaphor and do you think it is a good association for the Bay?

2. What is the purpose of the metaphor?

3. Choose another metaphor for San Francisco Bay that supports saving the Bay. Write your metaphor below and be prepared to share it with the class.

Part III

Individually, read the article "Powerful Tea Ladies Want Help Saving the Bay."

1. What inspired the founders of Save The Bay to take action?

Now read the "Calls to Action"page and on your own answer the next two questions.

1. Which of the quotes would have most inspired you to take action? Why?

2. Is there anything in your life that would inspire you to take action in the political arena? Write an essay about an issue that would inspire you to act and what you would do to protect or support the idea you have chosen.

THE CHRISTIAN SCIENCE MONITOR

They're filling in San Francisco Bay

Saturday, May 6, 1967

Californians are worried about plans for extensive land reclamation in the Bay Area. They have been told that land fill on the scale proposed would tamper with the tidal and biological mechanisms. Here is a report on a clash between the needs of a growing community and the desire to preserve an irreplaceable resource.

By Kimmis Hendrick
Staff correspondent of The Christian Science Monitor

San Francisco

WHO OWNS SAN FRANCISCO BAY?

Anybody looking out over the Bay from Nob Hill might answer, "Why, everybody!" But it isn't that simple.

Getting a precise answer now is urgent. Proposals for extensive land fill could reduce big parts of the Bay, by United States Army Engineers calculations, to the dimensions of a river (see map). One proposal would make land about the size of Manhattan Island.

Thanks to informed citizen concern, the state has started researching the problem. The 1965 Legislature established the San Francisco Bay Conservation and Development Commission and gave it clear commitments. Now the commission is studying ownership, pollution threats, and shore-development possibilities. Its charge is to provide "a comprehensive and enforceable plan."

Citizens organized

The bill proposing the commission was authored by State Sen. Eugene McAteer of San Francisco and Assemblyman (now State Senator) Nicholas C. Petris, both Democrats.

They had backing largely because Mrs. Clark Kerr, wife of the former president of the University of California, working with some of her Berkeley neighbors, had already formed the Save San Francisco Bay Association. The association now has 10,000 dues-paying members ($1 a year) from all over the Bay Area.

They backed Senator McAteer and Assemblyman Petris by writing to legislators. Some of them even sent bags of sand. They attached cards to the bags that read, "You'll wonder where the water went if you fill the Bay with sediment." So did a multitude of other citizens.

Filling has been going on, for almost 100 years, with nobody's noticing.

San Francisco's whole financial district below Montgomery Street is on land that was once under water. More recent fills have produced Hunters Point, the San Francisco International Airport, and considerable Alameda County shore land.

Ownership debated

When the '49-ers came to San Francisco during the Gold Rush, the Bay — consisting of what are known as San Francisco, San Pablo, and Suisun Bays — covered about 680 square miles.

Today this water complex, famed the world over as one of the American continent's magnificent scenic treasures, covers only some 400 square miles.

Its ownership pattern represents questions that have hardly ever been raised until the present time. Private owners say they own 25 percent, including most of the shallow areas near the shore. The state says it owns about 50 percent. The state has granted another 20 percent to the cities and counties around the edge. The remaining 5 percent apparently belongs to the federal government.

"The question in all this now," says Mrs. Kerr, "is whether the state has the right to dispose of major parts of such a body of water. It also involves questions of federal trust for fishing and navigation — as well as questions of protecting the rights and health of future generations."

Currently the ownership question is focused on a vast undertaking organized in 1963 as Pacific Air Commerce Center (PACC). It was initiated by the Crocker Land Company, the Ideal Cement Company, and David Rockefeller to join with the City of San Francisco in the development and expansion of its airport.

Warren T. Lindquist, PACC president, recently stated that since the city intends to develop the airport by itself, PACC will devote itself to developing its extensive properties. Mr. Lindquist describes these as consisting "primarily of tidelands along San Francisco Bay, extending generally south from the airport to the San Mateo-Hayward Bridge."

PACC, which has just restyled itself Westbay Community Associates, contemplates a gigantic fill program that will yield industrial sites, commercial areas, and major residential developments.

Report awaited

In the course of a recent radio discussion, ecologist George Treichel of San Francisco State College expressed regret that the Rockefeller family is involved in the Westbay proposal. The Rockefellers, Professor Treichel commented, have made great contributions to conservation.

But Mr. Lindquist responded that the Rockefellers have also been active in business. "Many of us forget that it is business which makes all the rest of this possible."

For the time being, such a project necessarily remains in the planning stage. The state's Conservation and Development Commission is to file a final report in January, 1969. Until that time, it has control over permitting fills and extractions from the Bay, and this control is keyed to the concept that further Bay development must not be haphazard.

But the PACC, or now Westbay Associates, plan has enthusiastic supporters as well as critics. It raises questions for both; and the state commission, which is concerned only with objective research in the interests of the whole area, is studying them.

"It isn't a question of good guys vs. bad guys," comments Joseph E. Bodovitz, executive director of the state commission.

"Advocates of filling in the shallow land

(CONTINUED ON BACK PAGE)

will argue that the economic welfare of the Bay Area depends on the creation of this new land. They will say it is needed for many of the same purposes for which filling has taken place in the past—wharves, airports, roadways, homes, offices, factories, and so on.

"So the question is," Mr. Bodovitz points out, "To what extent must they be provided at the expense of the Bay?"

This is a big question. For example, Dr. H. Thomas Harvey, professor of biology at San Jose State College, has prepared a study on the Bay's marshes and mud flats.

Dr. Harvey points out that the mud flats provide oxygen in the water, preventing stagnation in the big southern parts of the Bay where pollution is already a serious problem. Army Engineers reckon that if sewage had to be piped directly to the sea from this region—instead of being emptied into the Bay as it is now—the minimum cost would be $700 million.

Smog predicted

Another study made for the state commission, this one by Dr. Albert Miller, professor of meteorology at San Jose State College, raises questions about smog and weather.

If 25 percent of the existing Bay water surface is finally eliminated, his study says, the following effects could be expected:

Cooling summer breezes, coming in through the Golden Gate, would not blow as far south and east as they do now.

Temperatures would rise over the Bay Area. San Jose's summer temperature would increase at an average maximum about five degrees—to an average maximum of 86 degrees in July.

More smog would occur.

Winter fogs would become more frequent. They would be more dense.

One concerned citizen, Palo Alto attorney Paul F. McCloskey Jr., says a thorough study of the legal questions involved in Bay ownership will cement the conclusion that the people have a right to protect that great intangible—natural beauty.

Mr. McCloskey was retained some while back by people interested in a project called Redwood Shores. His researches took him to Washington. He found that areas of interest to his clients had been designated by the 1858 Geodetic Survey as "navigable sloughs."

California law, Mr. McCloskey points out, states that all navigable waters belong to the people—unconditionally.

"The basic problem," Mr. McCloskey comments, "is the perfectly proper chamber-of-commerce view that new industry—with new people—must be developed, versus the view of people who came here because the area is beautiful and they want to keep it that way.

"Many of us," he smiles, "are refugees from Los Angeles smog."

But there is another factor, as Mr. Bodovitz emphasizes. Time was when converting a mud flat into solid ground was called "reclamation," and nobody saw any harm in doing it piecemeal.

Modern thinking regards any such structure as San Francisco Bay as a system. Dr. Harvey calls it "a single physical mechanism." A fill here may harm the weather there. Turning mud flats into sites for factories in one place may smother another place with smog.

San Francisco Bay seems unique among the country's big ones because of its narrow opening. The Golden Gate acts almost like a fixed control on tidal action. Dr. Harvey and Mrs. Kerr both point to the probability that any tampering with tides inside the Bay has got to be worked out in terms of this fact.

This system approach holds as true for Chesapeake Bay on the East Coast, apparently, as for San Francisco Bay on the West.

L. Eugene Cronin, from the Chesapeake Biological Laboratory at the University of Maryland, recently referred to changes along that body of water which can be "destructive to the efficiency of the system." He was addressing the recent North American Wildlife and Natural Resources Conference.

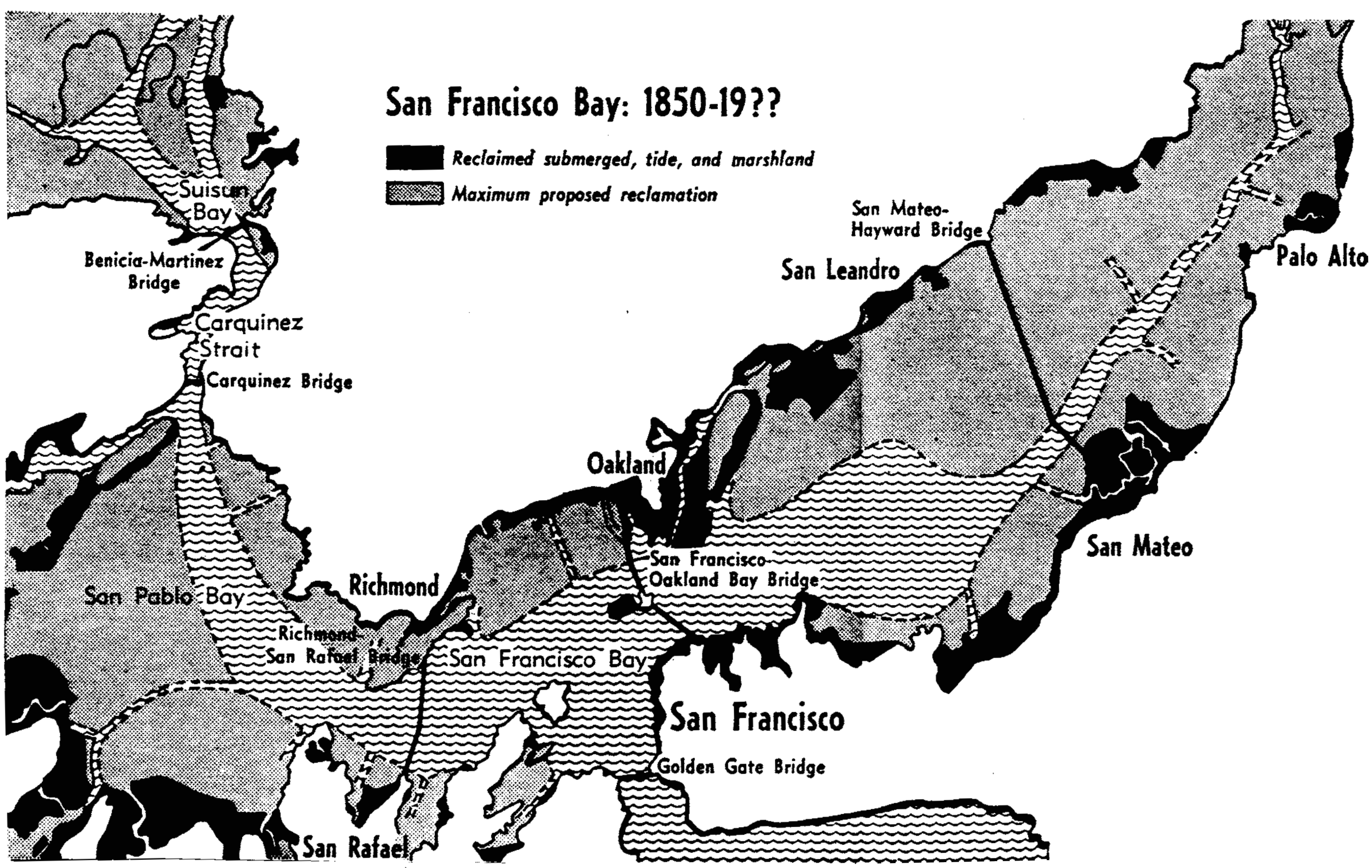
"Public concern appears to be increasing," he noted, "and this is desirable if somewhat unreliable."

Region's major asset

So far as San Francisco Bay goes, everybody agrees it is the region's major asset. Some local government officials and developers see its value in a yield of new land for industry. Other people say its scenic and natural advantages are beyond price. The Save San Francisco Bay Association argues that inland California has lots of room—and a crying need—for industry.

It is significant that California's new Governor, Ronald Reagan, has appointed the president of the Save San Francisco Bay Association as director of state parks and recreation. This is William Penn Mott Jr.

Mr. Mott points out that in his new position he must be as objective as the state commission itself. He does not hesitate to concede that a Bay-development project might be "very valid" if looked at just by itself. He is obviously deeply committed, however, to the view that San Francisco Bay presents a challenge to view such a resource in a broader context.



Diagnosis of San Francisco Bay

Freedom News, May, 1969

THE SAN FRANCISCO BAY COMMUNITY

Over five million people share the lands sloping down to the Bay's gentle wash. This community is clumped around the Bay which breathes twice a day, drawing in fresh oxygen-rich water from the sea beyond the Golden Gate. Such a dependable supply of oxygen once supported a wide variety of marine life, both in the Bay and in extensive salt marshes. But we have not understood the Bay, neither how it functions nor its role in the ecology of the Bay Region. And so we are now destroying the very thing that is responsible for our living here.

As a coal miner's lungs slowly fill up with the life-depriving particles, so we are filling up the Bay. The process begins in the farthest reaches first and gradually lowers the efficiency of the whole lung until a critical period is reached and death settles the whole issue.

Putrification within our Bay will be the result of more filling, reduced water flow and reduced quality from the delta area, and dumping more organic materials (sewage and garbage) into the Bay. But, we don't fill the Bay ourselves, we pay others to do it for us. We pay them to dilute our sewage and pump it into the Bay through a submerged pipe. We pay them to collect our trash and garbage and throw it away into the Bay's waters. Reclaimable materials and the Bay itself are both de-destroyed by this expedient, ignorant practice.

We have already filled more than one-third of the Bay. The Bay Area as a geographical entity may soon cease to exist. Would you prefer to drive over to the other side on the Bridge above the Bay's open waters or on a steel scaffold above miles of industrial development with attendant smoke, smells and ugliness?

Each sighting of the Bay and thought of it is vitally important to us in ways we do not completely understand. It is more than just an urban planner's 'open space', it has moods and movements, and we cannot possess it.

Powerful 'Tea Ladies' want help saving the Bay

The saviors of '61 turn task over to others

BY JANE KAY
EXAMINER ENVIRONMENTAL WRITER

Three East Bay women, well-connected, intelligent and stubborn, saved the Bay 30 years ago.

Cajoling, didactic and single-minded, they preached an end to filling the Bay.

They stopped golf courses, malls and high-rises proposed on new Bay fill by powerful landowners like the Santa Fe railroad. They got politicians elected and laws passed, one of which spawned the Bay Conservation and Development Commission.

Now the "Tea Ladies," Esther Gulick, 81, Kay Kerr, 81, and Sylvia McLaughlin, 76, who met as UC-Berkeley faculty wives, want others to save it again.

"The Bay is never really saved," says McLaughlin, who retired in January as president of Save San Francisco Bay Association. "Kay likes to say the Bay is always in the process of being saved."

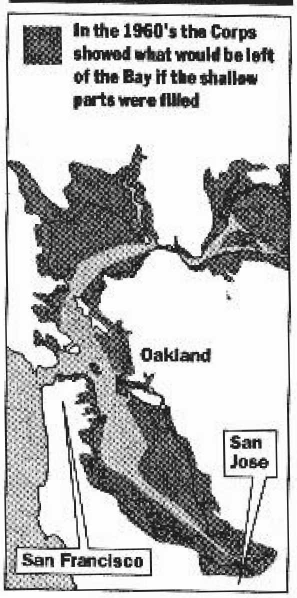
Now, McLaughlin says, "Others must fight for water quality, fresh water coming into the Bay, public access to recreation and against the continued threats of the Peripheral Canal, filling and toxics."

Gulick, Kerr and McLaughlin banded together in 1961, shocked into action by a U.S. Army Corps of Engineers map showing what the Bay would be like in 2020 — if the corps drained marshland, filled in open water and promoted construction.

The map, Gulick noted then, showed "an awful" future: one narrow river flowing from the Delta to the ocean.

"Bay or River ?" was how the trio tagged the corps map, before mailing it out to attract members for the new Save San Francisco Bay Association.

BAY OR RIVER ?



U.S. Army Corps of Engineers *map shocked women into action.*

They all loved San Francisco Bay, remembers Kay Kerr, whose husband Clark Kerr was UC president at the time.

"We all had beautiful Bay views, and we were looking out on garbage dumps. At the time, there were 41 smoking garbage dumps at the edge of the Bay. We thought of what someone had told us: When you have three people, you can accomplish miracles."

McLaughlin says, "We couldn't stand the Bay just to be filled in for garbage and future development. Berkeley had a plan to fill in more than 2,000 acres of open water. Those at the City Hall and the city manager thought it was a great idea. My colleagues and I thought open water was more important.

"Visually this is one of the most beautiful places in the world," McLaughlin says. "The price of saving the Bay will always be the eternal vigilance of concerned citizens."

Calls to Action in the United States

Silent Spring, by Rachel Carson in 1962
"For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals from the moment of conception until death. … These chemicals are now stored in the bodies of the vast majority of human beings, regardless of age. They occur in the mother's milk, and probably in the tissues of the unborn child."

"If the Bill of Rights contains no guarantee that a citizen shall be secure against lethal poisons distributed either by private individuals or by public officials, it is surely only because our forefathers, despite their considerable wisdom and foresight, could conceive of no such problem,"

Civil Disobedience, by Henry David Thoreau
"Unjust laws exist: shall we be content to obey them, or shall we endeavor to amend them, and obey them until we have succeeded, or shall we transgress them at once? Men, generally, under such a government as this, think that they ought to wait until they have persuaded the majority to alter them. They think that, if they should resist, the remedy would be worse than the evil…

"All men recognize the right of revolution; that is, the right to refuse allegiance to, and to resist, the government, when its tyranny or its inefficiency are great and unendurable. But almost all say that such is not the case now. …when a sixth of the population of a nation which has undertaken to be the refuge of liberty are slaves, and a whole country is unjustly overrun and conquered by a foreign army, and subjected to military law, I think that it is not too soon for honest men to rebel and revolutionize."

Abigail Adams, letter to her husband, John Adams, second President of the United States
"...remember the ladies, and be more generous and favorable to them than your ancestors. Do not put such unlimited power into the hands of the husbands. Remember all men would be tyrants if they could. If particular care and attention is not paid to the ladies, we are determined to foment a rebellion, and will not hold ourselves bound by any laws in which we have no voice or representation."

I Have a Dream, by Martin Luther King, Jr., Delivered on the steps at the Lincoln Memorial in Washington D.C., August 28, 1963
"We have also come to this hallowed spot to remind America of the fierce urgency of now. This is no time to engage in the luxury of cooling off or to take the tranquilizing drug of gradualism. Now is the time to rise from the dark and desolate valley of segregation to the sunlit path of racial justice. Now is the time to open the doors of opportunity to all of God's children. Now is the time to lift our nation from the quicksands of racial injustice to the solid rock of brotherhood.

"It would be fatal for the nation to overlook the urgency of the moment and to underestimate the determination of the Negro. This sweltering summer of the Negro's legitimate discontent will not pass until there is an invigorating autumn of freedom and equality. Nineteen sixty-three is not an end, but a beginning. Those who hope that the Negro needed to blow off steam and will now be content will have a rude awakening if the nation returns to business as usual. There will be neither rest nor tranquility in America until the Negro is granted his citizenship rights. The whirlwinds of revolt will continue to shake the foundations of our nation until the bright day of justice emerges."

The Hetch Hetchy Valley, by John Muir in the Sierra Club Bulletin in January, 1908
"It is impossible to overestimate the value of wild mountains and mountain temples as places for people to grow in, recreation grounds for soul and body. They are the greatest of our natural resources, God's best gifts, but none, however high and holy, is beyond reach of the spoiler. In these ravaging money-mad days monopolizing San Francisco capitalists are now doing their best to destroy the Yosemite Park, the most wonderful of all our great mountain national parks. Beginning on the Tuolumne side, they are trying with a lot of sinful ingenuity to get the Government's permission to dam and destroy the Hetch-Hetchy Valley for a reservoir, simply that comparatively private gain may be made out of universal public loss, while of course the Sierra Club is doing all it can to save the valley."

Inaugural Address, by John F. Kennedy, January 20, 1961
"In the long history of the world, only a few generations have been granted the role of defending freedom in its hour of maximum danger. I do not shrink from this responsibility—I welcome it. I do not believe that any of us would exchange places with any other people or any other generation. The energy, the faith, the devotion which we bring to this endeavor will light our country and all who serve it—and the glow from that fire can truly light the world. And so, my fellow Americans: ask not what your country can do for you—ask what you can do for your country."

Cesar Chavez
"The consumer boycott is the only open door in the dark corridor of nothingness down which farm workers have had to walk for many years. It is a gate of hope through which they expect to find the sunlight of a better life for themselves and their families."

The Great Hydraulic Mining Debate

The Sawyer Decision of 1884

TEACHER'S PAGES

Overview
During the Gold Rush, hydraulic mining was used to wash away hillsides in the pursuit of gold. Negative impacts were felt by towns, farms, and the environment. In this activity, students complete a worksheet and take part in a mock trial to learn about the impacts of hydraulic mining on towns, agriculture, and the environment, and to learn about the Sawyer Decision, which ended hydraulic mining in 1884.

Estimated Time
Two one-hour class periods, one for hydraulic mining discussion and worksheet and one for the debate (or assign the worksheet as homework beforehand).

Objectives
Students will be able to:
- Analyze the impacts of hydraulic mining
- Describe the history of California in the decades after the Gold Rush.
- Describe Judge Sawyers ruling on hydraulic mining.
- Apply Judge Sawyer's decision to other environmental problems affecting California.

Materials
- Map of California
- Copies of Hydraulic Mining Worksheets (one per student)
- Copies of role cards (a set for each of three interest group)
- Judge's robe (graduation gown) for teacher (Judge Sawyer)

California Science Content Standards
Grades 9-12
Biology/Life Sciences Standard Set 6.b: how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

Hydraulic Mining in the Sierra Foothills

Earth Sciences Standard Set 9.a: the resources of major economic importance in California and their relation to California's geology.
Earth Sciences Standard Set 9.c: the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

California History/Social Science Content Standards
Grade 8
Standard 8.8.4: the role of great rivers and the struggle over water rights.
Standard 8.12.1: patterns of agricultural and industrial development as they relate to climate, natural resource use, markets, and trade, including their location on a map.

Grades 9-12
Historical and Social Sciences Analysis Skills
Historical Interpretation
5. Students analyze human modifications of landscapes and examine the resulting environmental policy issues.

English/Language Arts Content Standards
Grades 9-12
Reading Comprehension
2.0 Students read and understand grade-level appropriate material.

Additional Resource: Photos http://www.cprr.org/Museum/Hydraulic_Mining/

Listening and Speaking Strategies

1.0 Students deliver focused and coherent presentations of their own that convey clear and distinct perspectives and solid reasoning.

Teacher Procedure

Hydraulic Mining

1. Go over the Hydraulic Mining Information with the students, focusing on the history of California in the decades after the Gold Rush. Refer to a map of California as you discuss the Central Valley, Marysville, and the Sacramento and Yuba Rivers.
2. Divide the class into small groups of 3 or 4 students. Hand out the Hydraulic Mining Worksheet to each student and ask them to work in a group to answer the questions. Answers:
   1.) 150 million
   2.) 599

The Great Debate

1. The last part of this activity is a mock court session, with you as the judge. Divide your students into three groups each representing an interest group (miners, agriculture, and townspeople).
2. Discuss the following information provided about the Great Debate.

In the United States citizens have the ability to address their concerns to the government in hope of relief. The court system of the United States allows citizens to sue each other, corporations, and the government to correct perceived wrongs. In the case of hydraulic mining, there are three clear interests: towns, farmers and miners. In the fall of 1882, Edward Woodruff filed suit against the North Bloomfield Mine of the Yuba River seeking an end to hydraulic mining on the Yuba River.

From WOODRUFF v. NORTH BLOOMFIELD GRAVEL MINING CO. and others:
"Several parties owning extensive mines at various points on the affluents of the Yuba river work them independently of each other by the hydraulic process, discharging their waste earth and other debris into the stream, whence it flows down into the main river, where the debris becomes mingled into one indistinguishable mass, passes on, and is deposited along the course of the river in the valley below, burying valuable lands and creating a public and private nuisance."

Judge Lorenzo Sawyer presided over the case and reached a verdict in 1884. The involved parties, played by the three groups in your class, will argue their case in front of Judge Sawyer (played by the teacher).

3. Provide each group with copies of the role cards and give them time to read the role cards. Run a trial in your classroom, following the guidelines, which you should review before starting the trial.

How to Run the Court

The groups are addressing Judge Lorenzo Sawyer of the California Supreme Court. The mining interests represent the North Bloomfield Mine of the Yuba River. Farming interests are represented by Edward Woodruff who filed suit against the mining operation. The Mayor of Marysville represents the interest of the townspeople.

- Each group needs to first work as a group to list the important facts that support their case, and choose representatives to present the facts of the case (everyone in the group needs to participate in some way).
- Each case is built upon the presentation of facts that support the group's opinion and a rebuttal of their opponent's facts.
- Each group will get seven minutes to conduct opening arguments, presenting their case.
- After opening arguments, each group may call witnesses. The lawyer that calls the witness asks them questions first, then the

opposing side may ask questions.

- First to present will be the lawyers for Mr. Woodruff.
- Second to present will be the lawyers for the town of Marysville
- Last to present will be the lawyers for the North Bloomfield Mine.
- After all the groups have called their witnesses, each group will get three minutes to offer a rebuttal that includes a conclusion.
- Each person in the group will take careful notes of the other side's case in order to present a sound rebuttal.

As Judge Sawyer, you must hear all sides and decide the case on its merits. The rules of the court must be enforced and fairness must be shown to all sides. Announce your decision at the end of the trial.

Actual Decision

Judge Sawyer ruled in January 7, 1884 that "Where the value of plaintiff's land situated on a stream has been depreciated by defendant's discharge of large quantities of debris into the river, he is entitled to maintain a suit to restrain the further continuance of the acts. In granting relief, where the complainant's rights are certain and the invasion of them is clearly established, a court of equity cannot consider the inconvenience which will result to defendants from the relief; nor is it the province of the court to speculate upon or to consider or to suggest any possible modes by which defendants may avoid the injurious consequences of their acts, or to decide upon the conflicting opinions of scientific experts concerning the feasibility or sufficiency of such suggested modes. The only duty of the court is to grant the relief to which the complainant is entitled upon the law and facts of the case. This is a bill in equity to restrain the defendants, being several mining companies, engaged in hydraulic mining on the western slope of the Sierra Nevada mountains, from discharging their mining debris into the Yuba River whence it is carried down by the current into Feather and Sacramento rivers, filling up their channels and injuring their navigation; and sometimes by overflowing and covering the neighboring lands with debris, injuring, and threatening to injure and destroy, the lands and property of the complainant, and of other property owners, situated on and adjacent to the banks of these water-courses."

Key Points of the Decision

- The mining companies lost the suit and had to stop releasing debris into the rivers. The Judge did not say that they could not perform hydraulic mining just that they were not to release debris.
- The rights of the mining company for profit and the positive economic benefits of mining did not end the rights of the town and the farmers to pursue profit on their own land. Judge Sawyer also stated, "The state shall never… permit corporations to conduct their business in such a manner as to infringe the rights of individuals or the general well being of the State."
- "One must so use his rights as not to infringe upon the rights of another" is a fundamental principle of law and is stated in latin as "Sic utere tuo ut alienum non laedas."

The Great Hydraulic Mining Debate

The Sawyer Decision of 1884

Student Pages

INTRODUCTION

The Gold Rush turned California from a sparsely populated agrarian state into a booming industrial and agricultural economy. Much of the development we see today can be traced back to the patterns of settlement that occurred during and immediately after the Gold Rush. Gold miners created the need for food, lodging, transportation, and entertainment, and were instrumental in creating the state of California.

The Gold Rush also encouraged the creation of new technology to speed the removal of gold from the earth. One of the most important inventions of the time was hydraulic mining. Hydraulic mining was a way to move large amounts of soil that were suspected of containing gold from the mountain and into sluices. The miners used high-powered water hoses to spray hillsides. The water and dirt from the hillsides were then directed down through sluices. Sluices are small wooden canals lined on the bottom with ridges to catch the gold. Gold is heavier than dirt and falls to the bottom of the sluice where the miners could collect the small gold flakes and pebbles. The rest of the dirt and the water continued down through the sluice and into a nearby river.

Hydraulic mining began when the easily accessible gold found in streams or placer deposits were depleted. By 1870 there were 41,000 people hydraulically mining the Sierra Nevada. Hydraulic mining allowed mining to remain profitable but it also meant destruction to the rivers and the mountains.

Due to the tremendous pressure used by the miners to blast the rock, the hoses used in hydraulic mining could not be turned off. The hoses operated 24 hours a day and released soil, rock and dirt downstream continuously. A single hose would discharge 25 million gallons of water in 24 hours. In order to keep the miners working at night, huge bonfires were built to light the camps and keep the men warm. But, in order to supply the fires with fuel, the miners had to cut the surrounding forests thereby further increasing erosion of the mountains.

During the twenty years that hydraulic mining was in operation an estimated 1.5 (1,500,000,000) billion cubic yards of mining debris washed into Central Valley rivers. A cubic yard is a cube with each side measuring one yard. A cubic yard is enough material to fill a bathtub. The soil and dirt that was flowing downstream was too much for the rivers to contain. The rivers began to fill with dirt leading to less room in which the water could run. The sedimentation of the rivers caused massive flooding throughout the Central Valley. In response to the flooding, farmers and towns built huge levees to protect property from the river water. At the town of Marysville on the Yuba River, the bottom of the river was actually above the elevation of the town, and floods resulted when the levees broke. At the confluence between the Sacramento and Yuba Rivers a dam of sediment was created by the flowing debris causing the river to spread out throughout the Central Valley, flooding and destroying farms far away from the river.

Student Pages

How do we make sense of the amount of destruction involved with hydraulic mining? The next exercise will ask you to work in a group to solve the following problems.

1. A dump truck carries about 10 cubic yards of material. How many dump trucks would it take to move 1.5 billion cubic yards of material?

2. The interior of Candlestick Park can hold 2,503,111 cubic yards of material. How many times could you fill Candlestick Park with material washed out of the hills of the Sierra Nevada?

The Gold Rush brought more than miners to California; people also set up homes, hotels, businesses and farms in the lush Central Valley. The farmers and the towns needed the rivers from the Sierra Nevada to water their crops and to use in their homes. Hydraulic mining caused extensive environmental damage that was felt throughout the community. The clogged rivers led to massive damage including: extensive flooding of towns and farms, loss of fish habitat, and the inability to navigate the rivers by boat.

With your group, brainstorm the effects of hydraulic mining on each of the following: towns, farms and the environment.

Towns:

Farms:

Environment:

The miners profited from using huge amounts of water and causing massive erosion throughout Northern California. The estimated profit from the twenty years of mining was about $5 billion in today's dollars. This profit was passed on to the miners and to the individuals and corporations that provided money to the mining operation in the beginning. The people who invested in the mining did not have to pay the farmers when the crops were lost due to flooding nor did they pay to rebuild the towns after they were destroyed.

Student Pages

In economic terms, the companies were not paying for all the costs associated with the mining operation. The mining companies were only paying for the *direct costs.* Direct costs are expenses that a company must pay for in order to do business directly. For instance, if there is a donut shop, the donut shop owner must pay for the ingredients to make donuts, rent on the building, insurance, advertising and people to work behind the counter. But every business also has other *indirect costs*. In the case of the donut business, the owner does not have to pay for indirect costs. For instance, the indirect costs might be: the increase in traffic on the street from so many cars coming to buy donuts, the increase in health care costs from people eating too many donuts, or the loss of business to the bagel place down the street. The indirect costs are called *externalities.* Externalities are positive or negative costs that are not paid for by the business.

With your group, brainstorm the all the items you would need to run a hydraulic mining operation. Try to include all of the *direct costs.* You don't need to come up with a dollar figure for the items that you list.

Direct Costs

With your group, brainstorm all the externalities that may occur due to hydraulic mining:

Externalities

Look at the list you have created. How many of these externalities cost someone else in the community money? Put a star next to the externalities that would have cost farmers money. Put a circle next to the externalities that would have cost the townspeople money. Put a square next to the externalities that did not cost anyone money but which decreased the health of the environment. (Note: an externality may have more than one symbol next to it)

The Sawyer Decision

Role Card: Mr. Woodruff

In the fall of 1882, Edward Woodruff filed suit against the North Bloomfield Mine of the Yuba River seeking an end to hydraulic mining on the Yuba River. Judge Lorenzo Sawyer presided over the case and reached a verdict in 1884. Welcome to 1884 California. Review the impacts of hydraulic mining and the economic impacts that have occurred to the farmers and the townspeople of Marysville. The Yuba River is a tributary of the Feather River and eventually joins the Sacramento.

- Mr. Woodruff has owned for 20 years three distinct plots of land. One of the plots is in downtown Marysville where he has built a brick building known as the Empire Block. The Empire Block was built in 1854 at a cost of $40,000. He rents these buildings out to shopkeepers. The building is across the street from the ferry landing. The ferry landing is no longer usable by boats because the river is now too shallow. The ferry landing has moved to a mile downstream where it is still deep enough for boats from San Francisco and Sacramento to dock.
- Mr. Woodruff owns 952 acres a few miles below Marysville where there was formerly a steam boat landing for the loading and unloading of freight bound for the miners in the hills. The river has been filled with sediment to a depth of 12 to 15 feet and is no longer usable.
- Mr. Woodruff owns 700 acres on the western bank of the Feather River. 125 acres of these lands were flooded with gravel and sand in 1862, 1867-68, 1871-1872, and 1881. This farmland is one of the best in the county and produce large crops of grain. The grain used to be shipped out using the river landing in Marysville that is no longer usable.

Possible Witness:
Dr. Teegarden: Property owner in Yuba County and a State Senator. Owned 1,275 acres adjacent to Yuba River about 3 miles above Marysville. He built a levee at his own expense to stop the waters of the Yuba River from flowing onto his land. But, due to the flood of 1879 and 1880, all but 75 acres of his land has been covered in three to five feet of deep sand and utterly destroyed for farming purposes. He now lives in a small house outside of the levee which is liable to be swept away by rising river water. Dr. Teegarden has said "The main filling of this river has been in 1879 and 1880 but that river has been filling with sand ever since they started hydraulic mining." Dr. Teegarden has concerns because each year he has increased the height of his levees but the river keeps rising due to the sedimentation on the bottom of the river. Dr. Teegarden estimates that within ten years the river has risen five feet.

Case Notes

Tips for taking notes: Listen carefully to what is presented. Write in short sentences the main points presented. Leave plenty of space after each sentence to add any details you remember later. After the case is presented put your thoughts for rebuttal beside the main point in your group's column.

The Sawyer Decision

Student Pages

Role Card: Mayor of Marysville

In the fall of 1882, Edward Woodruff filed suit against the North Bloomfield Mine of the Yuba River seeking an end to hydraulic mining on the Yuba River. Judge Lorenzo Sawyer presided over the case and reached a verdict in 1884. Welcome to 1884 California. Review the impacts of hydraulic mining and the economic impacts that have occurred to the farmers and the townspeople of Marysville. The Yuba River is a tributary of the Feather River and eventually joins the Sacramento.

- Marysville was a fresh water port that received boats from the East Coast carrying supplies to miners while taking the grain grown in the valley to New York and even to Europe. The rivers are now so filled up that the boats cannot reach Marysville.
- In 1868 the people of Maryville built a levee around the town to protect it from encroachment of the debris coming down the Yuba River. The levees have had to be increased in height and width every year since 1868.
- In the flood of 1875 the levees broke and flooded Marysville to a depth of four feet. When the flood water receded, the town was buried in mud up to four feet and many buildings collapsed. The sewer of Marysville was destroyed.
- The citizens of Marysville have been taxed at a rate of 5% on their property which is spent on building and maintaining the levees.

Possible Witnesses:
Townspeople who have experienced damage to their homes due to flooding.

Case Notes

Tips for taking notes: Listen carefully to what is presented. Write in short sentences the main points presented. Leave plenty of space after each sentence to add any details you remember later. After the case is presented put your thoughts for rebuttal beside the main point in your group's column.

The Sawyer Decision

Student Pages

Role Card: North Bloomfield Mining Company

In the fall of 1882, Edward Woodruff filed suit against the North Bloomfield Mine of the Yuba River seeking an end to hydraulic mining on the Yuba River. Judge Lorenzo Sawyer presided over the case and reached a verdict in 1884. Welcome to 1884 California.

Though there have been impacts due to hydraulic mining, without mining the farmers and the business people would go out of business. The miners provide the towns with customers and lodgers which provides the townspeople and the farmers with money.

- There are lots of miners in the hills of the Yuba River. It is impossible to prove that the mining debris that has affected the town and the farmers is from the North Bloomfield Mining Company.
- Congress set money aside in 1882 to improve the depth of the Sacramento, Feather and Yuba River which shows that the State recognizes the importance of the mining industry.
- Much of the danger from floods is a result of the townspeople building inadequate levees. For instance Mr. Woodruff left his levee open to prove to his neighbors who wouldn't help pay for the levee that damage would occur during a flood.
- North Bloomfield Mining Company has built a 50 foot dam above Marysville to hold back the debris. Though the dam has completely filled in, the Mining Company has worked hard to limit the impact of the mining.

Possible Witnesses:
Mr. O'Brien is a miner and a levee builder. He built a levee paid for by the mining company to protect the town from flooding.

Miners who would be forced into unemployment if hydraulic mining was halted.

Case Notes

Tips for taking notes: Listen carefully to what is presented. Write in short sentences the main points presented. Leave plenty of space after each sentence to add any details you remember later. After the case is presented put your thoughts for rebuttal beside the main point in your group's column.

Water Water Everywhere...Not

The Competition for California's Water Supply

Overview
This activity takes students from a general understanding of the history behind water allocation decisions to the specific case of the decline of San Francisco Bay's fisheries. Students take part in a simulation activity about water allocation and then read articles and complete a worksheet to identify water rights issues.

Estimated Time
Pass the Jug: 1 hour
Issue Identification: 3 hours

Objectives
Students will be able to:
- describe how water is allocated in California.
- discuss the various issues that water allocation raises when competing interests need the same resource.
- recognize the complexities of California's plumbing and understand historical actions that have led to current issues affecting San Francisco Bay.

Materials
Part I: Pass the Jug: 1 paper cup or glass per student, 1 gallon water jug, photocopy of Water Users descriptions (cut into strips)
Part II: Issue Identification: Photocopies of articles for each small group of students and one copy of the student page for each student.

California Science Content Standards
Grades 9-12
Earth Sciences Standard Set 9.a: the resources of major economic importance in California and their relation to California's geology.
Earth Sciences Standard Set 9.c: the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

California History/Social Science Standards
Grade 8
Standard 8.8.4: the role of great rivers and the struggle over water rights.
Standard 8.12.1: patterns of agricultural and industrial development as they relate to climate, natural resource use, markets, and trade, including their location on a map.

Grades 9-12
Historical and Social Sciences Analysis Skills
Chronological Thinking
1. Students compare the present with the past, evaluating the consequences of past events and decisions and determining the lessons that were learned.

Historical Interpretation
5. Students analyze human modifications of landscapes and examine the resulting environmental policy issues.

Grade 11
Standard 11.8.6: the diverse environmental regions in North America, their relation to particular forms of economic life, and the origins and prospects of environmental problems in those regions.
Standard 11.8.7: the effects on society and the economy of technological developments since 1945, including the computer revolution, changes in communication, advances in medicine, and improvements in agricultural technology.
Standard 11.11.5: the impact, need and controversies associated with environmental conservation, expansion of the national park system, and the development of environmental protection laws, with particular attention to the interaction between environmental protection and property rights.

English/Language Arts Content Standards
Grades 8-12
Reading Comprehension
2.0 Students read and understand grade-level appropriate material.

Background

California's current water issues reflect the historical settlement of European Americans during the Gold Rush. The miners of the Gold Rush used water to mine the gold that was in the Sierra Nevada's through hydraulic mining – high pressure hoses directing water at hillsides. Mining required strong water rights that protected earlier water claims from claims that came later.

In order to protect their water claims from subsequent miners, California instituted a "first in time, first in right" water allocation system. This system is in use throughout the arid western states. In general it means that water is allocated based on who has the oldest claim. This water allocation system insured that the first miners were given precedence over later miner's water claims.

This system continued to shape water allocation decisions as agriculture replaced mining as the economic base. The earliest farmers received water rights that later farmers, cities, and environmentalists could not threaten.

Dividing up the freshwater of the state is complicated and difficult because each interest group has compelling reasons for needing more water. The problems of water allocation are worsened by never knowing how much water California will receive in any year. The late 1990s saw improved conditions due to increased rainfall, but it is only a matter of time until droughts return and conditions worsen. This activity asks your students to understand the issues surrounding water allocation and the forces shaping the future of San Francisco Bay and California. How much water should the farmers, the cities and the fish receive?

The Delta is the meeting place of three distinct interests all working towards their own vision of how the water of California should be spent. The farmers of the Central Valley need water in order to continue producing high quality food. Cities and counties need clean drinking water free of pollutants and salts. Environmentalists see the steady decline of both the water quality and the historic fisheries in the San Francisco Bay and Delta.

"The Sacramento-San Joaquin Delta is a 1,153-square-mile region located where California's two greatest rivers — the Sacramento and San Joaquin — converge and flow into San Francisco Bay. The Delta is a vital link for the state's water supply. Forty-two percent of the state's annual runoff flows through this maze of islands, marshes and sloughs. State and federal water facilities located in the south Delta pump water to supply farms and cities in central and southern California, providing water to about two-thirds of the state's population." (From the Water Education Foundation)

Teacher Procedure

Part I: Pass the Jug

1. Arrange students' seats in a row or around a table and give each student a cup. Starting at one end, have the first student pour out as much water as she or he wants/needs from the jug and pass the jug to the next student in line. Because of the limited amount of water in the jug, there might not be enough to go around.

2. Ask students to express how they feel about either receiving enough water or receiving no water. Explain that there is not always enough water available to meet everyone's needs.

3. Ask students what they could do as a group to make sure they all get water. Have them repeat the activity and put their plan into action.

4. Briefly explain riparian water rights. The Riparian Rights Doctrine gives people who own land bordering a water source the right to use that water however they choose. A more recent version of the doctrine requires people to justify their uses as reasonable.

They must also ensure that landowners downstream have their fair share of water.

5. Ask the students to explain how passing the jug relates to riparian rights.

6. After students have emptied their cups and the jug has been refilled, inform them that they will now simulate the allocation of water rights in the West. Explain how Prior Appropration Doctrine gives people who originally moved into an area and started using water the right to use their water first, whether or not their land borders the water source.

7. Have students form a line according to their birthdays (from January to December). Divide the students into 10 groups, with group 1 being the first 2 or 3 students in line, group 2 being the next 2 or 3, etc. Explain that this represents the concept of first in time, first in right.

8. Pass out the Water User Cards in order (Group 1 gets #1, etc.). Explain to the students that the descriptions are numbered according to who moved into the area first. Along with the right to use water, each description also states how the water is used and how much is needed.

9. Pass around the jug of water in the order of the numbered cards. Have students read aloud how they use water. Each group takes the amount of wter indicated on their card. Some water users, such as fisheries and hydroelectric power plants, utilize water without reducing water quantity; water managers call these users nonconsumptive (however, reservoirs associated with hydroelectric power plants do lose some water to evaporation.) Students who represent these water users should pour water into their cups and then pour most of it back into the jug, using the funnel.

10. When water runs out, have students express their opinions about this system. What are the benefits and the shortcomings? How does this compare to Riparian Water Rights? Why would Eastern states use Riparian Water Rights while Western States use Prior Appropations Doctrine? What is the major difference between the East and the West (amount and availability of water).

11. Explain that California uses a combination of Riparian and Prior Appropriation Doctrine, but there are still major debates over the uses of California's limited water supply. How or why would students change these systems? How should water be divided among water users in the West?

From Project WET, by The Watercourse and the Council for Environmental Education, 1995, pp. 392-396.

Part II: Issues Investigation

1. Divide Students into groups of four.

2. Distribute one set of articles for each group and one copy of the student pages to each student. Assist students as needed to complete the worksheet. (This activity can also be assigned for homework for each students to complete on their own.)

Additional Resources

Water Education Foundation: http://www.watereducation.org/

Cadillac Desert. Order from PMI/Home Vision Select. Phone: 1-800-343-4727. Or check your local library.

Water Users (Descriptions)

Number 1	You are a descendent of the first homesteader that moved into the area. You grow alfalfa and corn.	use 2 cups
Number 2	Your ancestor came to California during the Gold Rush and starting a Gold mining company. Your family runs this small, but lucrative, operation	use 2 cups
Number 3	Your great-great-grandmother came out to teach the children of the gold miners. You still live on the property she bought and need water for personal use and crop irrigation.	use 1 cup
Number 4	Your grandparents left their farm in the midwest to start a farm here. You help meet the needs of the growing community by growing walnuts and almonds.	use 2 cups
Number 5	You represent San Francisco, a town that grew into a city after the Gold Rush. You use water for homes and businesses in your city.	use 3 cups
Number 6	You represent a hydroelectric company with a dam upstream of town. The water you use passes through the dam to generate electricity. Show this by pouring most of your three cups of water back into the jug.	use 3 cups
Number 7	You are a high-tech farmer that grows a variety of crops on a large plot of land in the Central Valley.	use 5 cups
Number 8	You represent the suburbs that grew as people moved out of the city to find housing. You use water for homes and lawns.	use 2 cups
Number 9	You represent a computer company that uses water for industrial purposes.	use 2 cups
Number 10	You are an environmentalist that is fighting for water for the Bay's fisheries, especially for salmon.	use 2 cups

Water Water Everywhere... Not.

Student Pages

1. Look at the watershed map of California. How many creeks and rivers eventually flow into the Sacramento/San Joaquin River Delta and then to the San Francisco Bay?

2. Name at least five of the rivers that make up the San Francisco Bay's Watershed. Which of these rivers are dammed? Put a star next to the rivers that have at least 1 dam.

3. Read the article "How We Use the Estuary's Water." What groups are competing for the water in these rivers?

4. From the article, describe some of the benefits that dams and canals provide to California.

5. Describe some of the environmental impacts of such intensive use of the Bay's water.

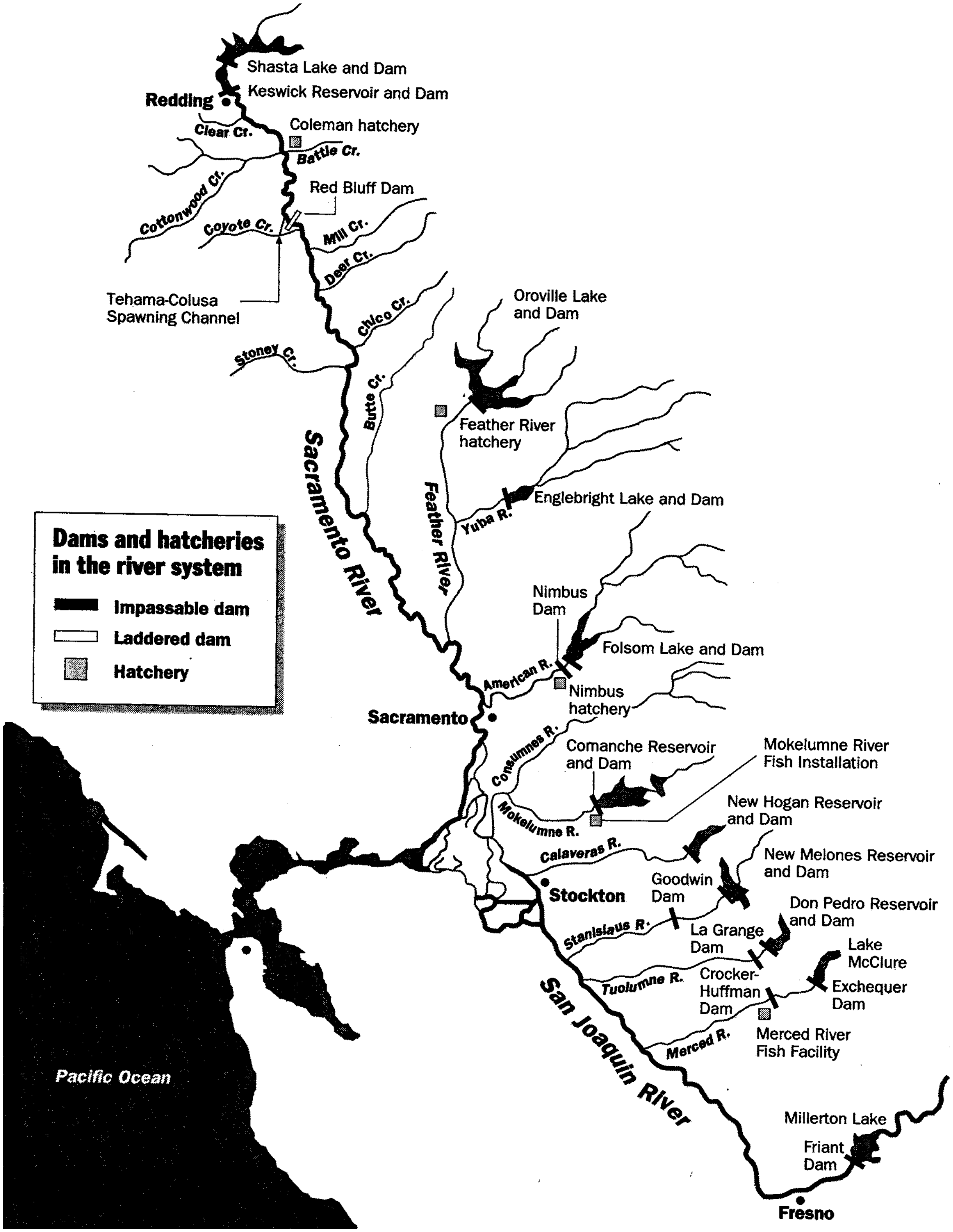
6. The pie is only so big (there is a limted amount of water in California). Create a pie graph in the circle showing the percent used for agriculture, cities (municipalities) and environment in a sample year, using the following amounts of acre feet (one acre foot of water covers one acre of land one foot deep).

Total amount of water: 20 million acre feet
Amount of water diverted for agriculture: 9 million acre feet
Amount diverted for use in cities: 2 million acre feet
Amount that flows to the Bay: 8.5 million acre feet
Other: .5 million acre feet

7. Read "Dying Fishery: Sign of Nature in Trouble" by Jane Kay in the San Francisco Examiner. From the article, list five historical reasons for the decline of the fisheries in San Francisco Bay.

8. Read the article "California's Big Water Plan" from the San Francisco Chronicle. What is the mission of the CalFed Bay-Delta Program?

9. What solutions can you think of to save the fisheries, while providing water for farms and cities?



from the San Francisco Examiner, Bay in Peril

SAN FRANCISCO ESTUARY PROJECT

How We Use the Estuary's Water

The Estuary and its watershed provide waterways for shipping and recreation, as well as vital fresh water to farms, cities, industries and other users throughout California. Such uses, combined with increasing pollution and human development, have placed significant stresses on the Estuary's fish and wildlife. The need to balance competing uses and ensure adequate protection for the estuarine ecosystem has never been more urgent. The San Francisco Estuary Project is working with public interest groups, elected officials and government agencies to promote environmentally sound management of the Bay and Delta.

History

Use of the Estuary's resources began with Native Americans, who found food and construction materials in its waters and wetlands. With the Gold Rush, hordes of newcomers began to take fish and wildlife in large numbers. Hydraulic mining operations striped away entire hillsides of gold-bearing gravel, causing enormous amounts of silt and sand to wash down the Sacramento River and into the Estuary. Most of the Estuary's wetlands were diked and converted to farming or urban uses.

Over the turn of the century, increasing amounts of Central Valley land were converted from cattle ranches and dry-farmed grain to irrigated agriculture. At the same time, Bay cities began diverting water from the Tuolumne and Mokelumne Rivers for municipal use.

Between 1950 and 1970, major physical alterations were made to the Estuary and its watershed in the form of dams, canals, pumping stations and other freshwater development and flood control facilities. Construction of the Central Valley and State Water Projects provided enormous benefits—fueling economic growth in agriculture, providing municipal and industrial water supplies, and enhancing the quality of life in California.

In time, however, such intensive use of the Estuary's waters had major environmental impacts including: the visible shrinking of the Bay's surface area, the elimination or alteration of over 88% of the Estuary's wetlands, the concentration of pollutants, the decline of fisheries, non-native species growth, and dramatic changes to the Estuary's flow regime.

Vital Fresh Water

Californians use almost 25 percent (21.1 billion gallons a day) of the fresh water consumed (water not returned to the system) in the United States. Two-thirds of the State's present demand for fresh water originates in the San Joaquin Valley and south of the Tehachapi Mountains. Two-thirds of the available supply is carried by Northern California rivers and streams. The Estuary's Sacramento–San Joaquin Delta is the important link between supply and demand. In recent years, more than half of the Estuary's natural river flow has been diverted for human and natural uses. Beneficial uses—uses with legal protection against degradation in water quality—include domestic, municipal, agricultural and industrial supply, recreation and navigation, and fish and wildlife habitat. With demand for the Estuary's limited freshwater supply increasing on all sides, California is now struggling to provide for all beneficial uses while protecting the health of the estuarine ecosystem.

The Estuary

San Francisco Bay and the Delta combine to form the West Coast's largest estuary. The estuary's watershed drains approximately 60,000 square miles, over 40 percent of the state. The Bay-Delta Estuary encompasses roughly 1600 square miles, contains about 5 million acre-feet of water at mean tide, and circulates 80-280 million cubic yards of sediment every year. More important, the Estuary is the location where the Sacramento and San Joaquin Rivers meet and flow into the Pacific Ocean. The mingling of fresh and salt water in this zone of tidal ebb and flow supports more biological diversity than is found in either salt water or fresh water alone.

California's Big Water Plan

Monday, July 5, 1999
San Francisco Chronicle

IT'S THE LIFEBLOOD of California and we're always in short supply.

More than any other element — more than gold or silicon — water has shaped the state's commerce, development, natural environment and quality of life.

For generations, farmers and cities from Sacramento to Los Angeles fought bitter water wars for their share of the precious fluid flowing from the western watershed of the Sierra Nevada.

In recent years, environmentalists joined the battle on behalf of wildlife, rivers and wetlands. If water is the state's blood, the San Francisco Bay and the Delta form the circulatory system of a fragile ecosystem that pumps 24 million acre-feet a year through the Sacramento and San Joaquin Rivers. (An acre-foot is 325,803 gallons, what an average family of five uses in a year.)

The flow through the Delta's vast network of waterways provides drinking water to 22 million, two-thirds of the state's residents, and irrigates 4 million acres of crops, including 45 percent of the nation's produce.

The Delta also supports more than 750 wildlife species on 738,000 acres of wetlands.

In 1995 the state and federal governments launched the CalFed Bay-Delta Program to fairly divide the water among the many claimants while protecting the Bay and restoring the vital but battered Delta. After four years of collaborative studies, hearings and important but piecemeal restoration projects, CalFed recently unveiled its grand blueprint to overhaul the system in the next 30 years at a cost of $10 billion.

The ambitious plan describes a delicate balance of conflicting interests of "stakehold ers" representing agriculture, municipalities and environmentalists. At the June 25 unveiling, few were completely satisfied, but to their credit the stakeholders are staying with the evolving process.

"Even though nobody is getting everything they want, the plan has something for all the affected groups," says State Resources Secretary Mary Nichols.

Farmers and cities fear they will not get enough. Enviros worry that without more fresh water the fragile Bay and Delta ecosystems may be damaged beyond recovery.

Everyone is aware of the harsh dilemma of a limited water supply. If enough water is diverted to preserve the Bay-Delta system and satisfy municipalities, the state's vast agriculture industry is likely to go thirsty.

To satisfy competing interests, CalFed's plan offers an array of options and compromises, including aggressive conservation, recharging underground aquifers, streamlining water transfers and creating "environmental water accounts" for endangered wildlife during critical dry times.

The CalFed proposal is a work in progress, but it's a good beginning to deal with the state's expanding water needs as the population swells to 52 million by the year 2030.

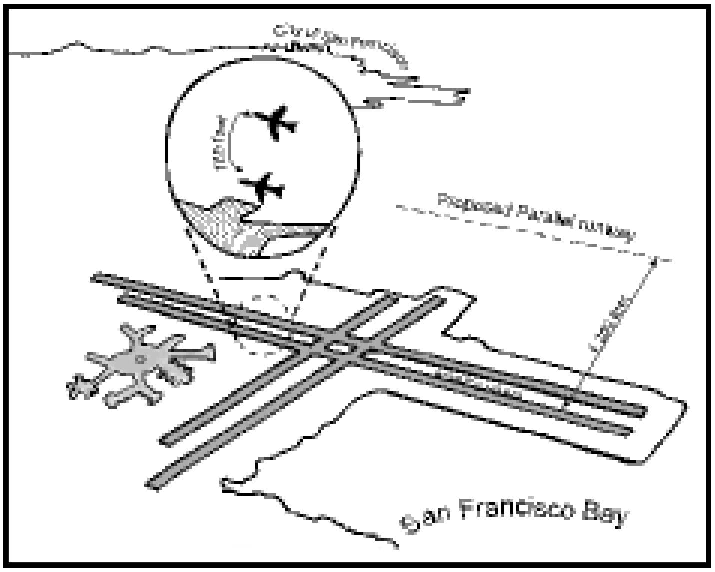
However, any long-term strategy must maintain the freshwater flow into the Bay and Delta, the vital core of the ecosystem.

It also must seek alternatives to building dams, which are expensive, threaten the environment and should be considered only as a last resort.

Airport Debate

Town Hall Meeting Style

TEACHER'S PAGES



Tara Reinertson

Overview
In this activity, your students will role play the different groups who have a stake in the outcome of a proposed airport expansion. Through a debate format, they will gain an understanding of the different perspectives and complex issues involved in making an important decision that has implications for both the environment and the community.

Central Questions
How can we sustain our natural environment in the midst of a growing economy? How can different interest groups reach solutions over complex issues?

Estimated Time
2 hours

Objectives
Students will be able to:
- *collect* information, *organize* it, *state* a position and *role-play* that position during a debate format
- *listen* to the stated positions of other students during the debate and *take notes* pertaining to that position
- *examine* and *question* the stated positions of other students and defend their own position during the debate
- *express their personal opinions* about the issue and *present a solution*

Materials
Students work in groups of 4 - 5
- Position cards (provided)
- Costumes

Vocabulary
bay fill, estuary, salt pond, mitigation, dike

California's Science Content Standards Grades 9-12
Biology/Life Sciences Standard 6.b: 6.b. how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

Investigation and Experimentation m: investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings....

California English/Language Arts Standards Grades 9-12
1.0 Listening and Speaking Strategies
Students deliver focused and coherent presentations of their own that convey clear and distinct perspectives and solid reasoning.
2.0 Speaking Applications
Students deliver polished formal and extemporaneous presentations that combine the traditional rhetorical strategies of narration, exposition, persuasion, and description.

Background

The San Francisco Bay Area provides homes and jobs to over 8 million people today. By the year 2005, that number will increase by another half million. If we were to look back in time at the region's rapid growth, it would become apparent that the San Francisco Bay Estuary has been greatly altered under the demands of a growing population and an expanding urban environment.

In fact, in the century that passed between the 1850s and the 1960s, 90% of the wetlands around the bay were lost to diking and fill. Finally in the 1960s, citizen protest over a shrinking bay led to the establishment of a government agency whose objective was to protect the bay from further degradation, (the Bay Conservation and Development Commission (BCDC). Since the inauguration of BCDC, development that requires filling in portions of the bay have become subject to regulation and require approval.

Because San Francisco International Airport's (SFO) recent proposal to extend its runways into the bay is a process that requires bay fill, it has become the subject of a hot debate.

SFO's Proposal:

SFO is proposing an expansion of its runways into the bay, a process that would require filling in approximately 350 - 2,000 acres of open bay adjacent to the airport.

Teacher Procedure

1. Present the idea of doing a class debate "town hall meeting style" to your students. Pass out a copy of the Student Pages for this activity to each student. Have them read through the Introduction, History, and Proposal sections. When they have finished reading, ask a student to read the Proposal out loud to the rest of the class. Discuss the history section and why it is relevant to the debate, (hint: it sets the historical stage for today's controversial debate).

2. Divide the class into 7 groups (4-5 students per group works well for this activity). Assign each group a role in the debate and hand out position cards describ ing the group they will be representing during the debate. Each student in the group should get a copy of the position card. Emphasize to the students that this activity requires them to put their personal views aside and adopt the views of the group they are representing. This is essential for a successful debate. (Fake names have been applied to some of the groups in the debate in order to avoid misrepresenting them.)

3. Explain the debate format (see debate format sheet) to the students so they will have a clear understanding of what is to come and what is expected of them. You might think about giving each group a copy of the format.

4. Ask the students in each group to choose one person to be the representative speaker for the group. Explain that this person will be responsible for presenting the group's position to the class and will be the one to field questions during the question and answer session following the presentations.

5. The group should now study their position carefully by reading their information cards they've received and then discuss the position they will take during the debate. All group members should contribute to the discussion. Each group should choose and write up three to five main points they will cover during the 5 minutes allotted to them for presenting their position at the beginning of the debate. Encourage students to elaborate on the points provided for them on the position cards. Note: Student should carefully read <u>all</u> the information on their position sheet because during the debate their spokesperson will have to field questions about their position.

6. **Costumes:** This is a great way to spice up

the debate and make it entertaining for the class. Have the groups come up with a costume for the speaker to wear during the debate. The costume should be creative and should reflect the position that will be role played by the speaker, (ie: formal dress for the SFO Director, casual look for the resident, etc.). You might think about providing costumes or you may want to schedule the actual debate for the following day in order to give students time to collect costume materials from home.

The Debate

1. **Opening Arguments:** Each representative has 5 uninterrupted minutes to present their group's position on the issue to the class. Members in the other groups take notes on the presentation and formulate questions to ask the representative during the question and answer session.

2. **Question and Answer Session:** Members of the audience direct questions at the representatives about their positions (questions should be directed to one particular representative rather than to the panel). It is important to establish a limit of 2 questions total per representative (or something thereof) in order to keep all of the representatives involved in the debate and to keep things timely.

The Outcome

This final part of the activity allows students to evaluate the proposal and the relevant issues surrounding it according to their "real life" beliefs. There are many ways you could have students complete this part. Below are two examples:

- Each student writes a short essay (a few paragraphs) focusing on what they believe to be the best solution to this hotly debated topic. The essay should be based upon what they heard during the debate.

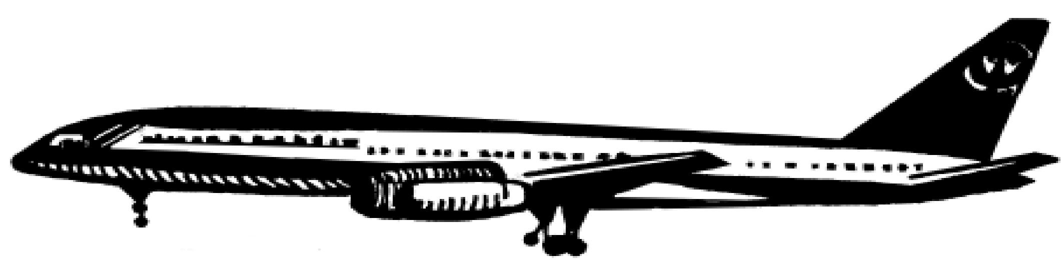
- Students work in groups, (perhaps negotiating), in order to come up with the most viable plan to proceed with based upon what they have heard during the debate.

Extensions

Write a paper explaining how the debate influenced your views on the subject. Did your opinion change during the debate? Why or why not?

Follow the airport runway expansion story in the news. Collect articles they find and have them share those articles with the class. Read the articles and identify the groups involved in the debate. Summarize each of their viewpoints.

Search for scientific information about the expansion's impacts. What do scientists say about the impact of new runways in the Bay?



Outline for the Debate

I. Preparation for the Debate

- Class Discussion about the history of development around the bay and why it's relevant to the debate **(15 min.)**

- Students are divided into groups. Each group selects a speaker representative. Using the position cards, each group writes 3 - 5 opening arguments for their representative **(25 min.)**

II. The Debate

- Representatives give their 5 minute opening arguments **(35 min.)**

- Representatives answer questions from the audience **(20 min.)**

III. The Outcome

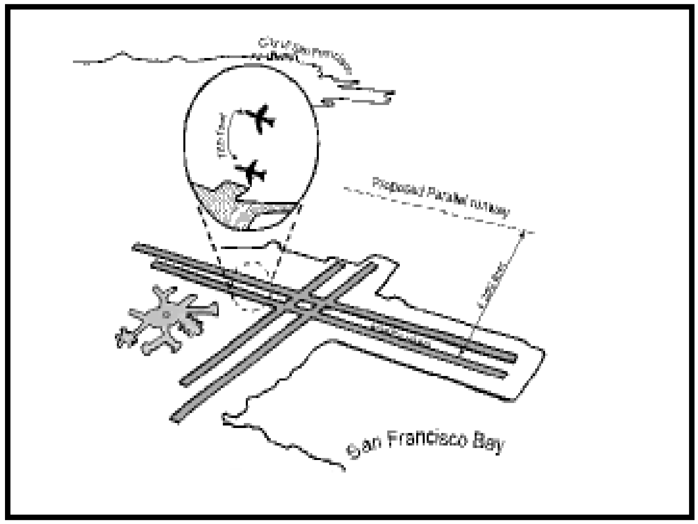
- Students evaluate the proposal using information gathered during the debate. (25 min.)

Airport Debate


Town Hall Meeting Style

Student Pages

INTRODUCTION



Tara Reinertson

Think back to the last time you argued with a friend over a political, social or environmental issue in the news. Every issue has many sides to it and you and your friend just did not agree on which side was right. Controversial issues arise all the time in our society. You probably read about them in the newspaper or watch them on the T.V. One way to hear all the sides of an issue is to hold a "town hall style" debate over it. This style of debate establishes a formal atmosphere in which community members can present, argue, and question the different viewpoints surrounding an issue.

During this activity, you and your classmates will debate a "real" issue facing Bay Area residents today: **Should San Francisco International Airport be permitted to build new runways out into the Bay?** In order to represent all the sides to this issue in fairness, some students will be asked to argue and represent views that may not coincide with their own beliefs. Keep in mind that during the debate everybody will be asked to put aside their own personal views and fully represent the positions assigned to them. This process will require stepping into the shoes of another person and trying to think, act and argue the way they would argue. At the end of the debate everyone will have the opportunity to express their own personal views about the issue. Take a note about your initial reaction to the proposal before the debate begins and then compare it to your perspective at the end of the debate. You may be surprised to see that your opinion may have changed during the debate.

MATERIALS

Your group will need:

• Position Card
• Costume

HISTORY RELEVANT TO THE DEBATE

The urban development that surrounds the bay today is a recent occurrence. In fact, if we went back in time only 150 years we would see miles and miles of open marshland surrounding this estuary, with little evidence of human disturbance. Things changed quickly though, with the discovery of gold in 1849. The Gold Rush brought thousands of people to the Bay area. Many of these newcomers, after attempting to "strike it rich", ended up settling in locations around the Bay.

In order to feed this massive influx of new residents, thousand of acres of wetlands were diked and converted to agricultural fields and salt ponds. Thus the Gold Rush signaled the beginning of an era in which the bay would be continuously altered to meet the demands of a growing population. For the next one hundred years, thousands of acres of wetlands and even open bay would be diked and filled in order to provide people in the region with food, bayside homes, airports, highways, landfills and other urban developments. By the 1960s only 10% of the original wetlands around the bay remained intact. Confronted by the issue of a shrinking bay, citizens protested at this time and a governmental agency was established to protect the bay from further degradation (the Bay Conservation and Development Commission).

Since the establishment of BCDC, environmental groups around the bay have become increasingly involved in matters concerning the estuary, especially issues of bay fill and wetlands loss. Realizing that today it is very hard to win approval for development that adversely affects the bay, San Francisco International Airport (SFO) has put forth an controversial expansion proposal that is certainly worthy of further examination and debate.

San Francisco International Airport (SFO) Proposal:
SFO is proposing an expansion of its runways into the bay, a process that would require filling in approximately 350 - 2,000 acres of bay adjacent to the airport.

Position Card

Director of San Francisco International Airport (SFO)

As Director of SFO, your goal is to increase business at the airport while adhering to FAA safety regulations. You would like to see the number of flights into and out of the airport each day increase in number. You would also like to improve service to customers by lowering the number of flight delays due to fog and other bad weather that plagues the airport during the year. Position ideas:

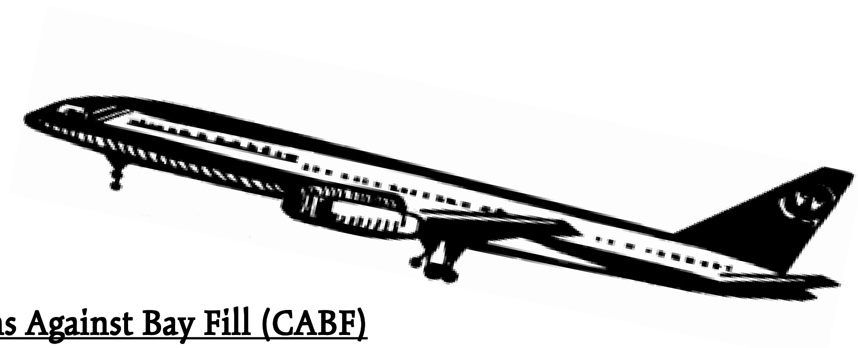
- ♦ New runways would end chronic delays at the airport. SFO currently has two sets of parallel runways. One set is used for departing flights and one set is used for arriving ones. There are two runways in each set separated by 750 feet (see diagram of airport). Because the FAA recommends that runways be at least 4500 ft apart for safe landings in bad weather, arriving flights can land on just one runway at these times rather than the two that are usually used. This situation creates some of the worst flight delays in the country, (SFO finished last among U.S airports in the number of flight delays of 15 minute or more).

- ♦ New runways would decrease noise for the residents living near the airport. The new runway would shift flights away from bayside housing. In particular, it would shift the direction of takeoffs by larger jets (which rattle windows of local residents and businesses as they take off through the San Bruno Gap).

- ♦ New runways would enable the airport to accommodate the larger jets of the future. Boeing and Airbus are developing aircraft capable of carrying 600 passengers, but the 267-foot wingspans would make simultaneous landings at the airport impossible with the present runway layout.

- ♦ New runways mean economic growth and stability for the residents of the area. The airport is the economic engine for the Bay Area and if the runway situation isn't fixed, the engine will slow down.

- ♦ Although no promises are being made, the airport is currently looking into a proposal by the Wetlands Restoration Network to restore 29,000 acres of salt ponds back into wetlands as mitigation for the area of bay fill required for the new runway.



Position Card

Director of Citizens Against Bay Fill (CABF)

As the Director of Citizens Against Bay Fill, you represent an organization that has a history of standing firm in your commitment to protect the bay from any more fill. Therefore you stand against this proposal. CABF views bay fill for runways as a quick-fix solution put forward by the airport in its desire to expand business. You believe that the right way to go about evaluating this proposal is to explore and exhaust all the alternatives to building a new runway on bay fill. Position Ideas:

- ♦ There are many ways to transport people and cargo but there is only one Bay. It has already been greatly diminished during the past century and it should not be made any smaller.

- ♦ This would be the largest landfill project in decades. It would affect fish migration, feeding cycles and the tidal patterns in the bay.

- ♦ Concerning the proposal by the Wetlands Restoration Network that the airport restore South Bay salt ponds back into tidal wetlands in exchange for bay fill: CABF believes that these salt ponds should be restored to tidal wetlands and other habitats as soon as possible and protected within the National Wildlife Refuge, but not as an exchange for the new runway. Bay fill can not be bought or traded for. The SFO expansion project must be proved necessary on it's own merits.

- ♦ There are no future size planes that the airport will not be able to accommodate. No new jumbo jets are in production and no airline has ordered any of a size that SFO couldn't already accommodate with their existing runways.

- ♦ There are workable alternatives to runways built on bay fill:

  --Distribution of flights to other regional airports such as Oakland and San Jose

  --A high speed ferry link between OAK and SFO would allow flights which cannot and at SFO in bad weather to be diverted to Oakland.
  A ferry could also let passengers on domestic flights into Oakland connect with international flights out of SFO and vice versa

  --Consolidation of commuter flights to SFO - fewer flights, larger planes

  --High speed trains to relieve short flights demand (i.e. to L.A, Portland, Seattle)

Position Card

Director of the Wetlands Restoration Network (WRN)

As Director of the Wetlands Restoration Network, you represent an organization that is committed to restoring as much of the bay's wetlands as is possible back to their original condition. With this mission, WRN has put forth a mitigation deal that the airport restore 29,000 acres of salt ponds to tidal wetlands in exchange for the area of bay fill required for the runway expansion. Although you wouldn't support the runway expansion by itself, you would support it if the airport agreed to this restoration project. Position ideas:

- By restoring such a large area of wetlands around the bay, this proposal would provide a giant step toward reversing a century long trend of environmental degradation of the bay. This is an opportunity to start getting some of the lost wetlands back.

- Only about two square miles of the bay have been recovered since laws were enacted to protect the bay from further fill. We are indebted to the groups that have stopped the filling of the bay, however, this proposal would recover a much larger area of wetlands (45 square miles) than has been recovered in a long time.

- The environmental groups against this proposed exchange of bay fill for wetlands are misrepresenting the size and environmental effects of this runway, while ignoring the proposed mitigation and its enormously beneficial consequences. Certainly any filling of the bay has negative impacts, but the plan is not only about a new runway. It is also about contributing to the health of the bay through the restoration of historic wetlands and the elimination of the environmentally-damaging salt industry which produces many tons of toxic waste a year.

Position Card

Director of Cargill Salt Company

As the Director of Cargill Salt Company, you're impartial toward the runway expansion. However, you have no desire to sell your profitable salt pond operation to the airport so that they can restore it to wetlands (a mitigation deal put forth by the Wetlands Restoration Network). You seek to protect the business and its employees in whatever ways you can. In addition, there have been accusations that your commercial salt ponds are creating tons of toxic waste so you want to paint a persuasive environmental picture to the public.

- The salt ponds provide important habitat to migratory birds. These salt ponds benefit a million migratory and resident shore birds, including ducks, egrets and cranes, which like the salty water

- This is an all natural salt production operation. There are very few places in the world where an all natural salt harvest can take place, and this is one of them.

- Providing food-quality salt in a unique location. This site is one of only two in the US where our company can harvest salt from coastal waters, and it is only site on the West Coast to produce food-quality salt.

- Buying out Cargill will mean job loss. Cargill has over 500 employees who would lose their jobs if the company was forced to sell the land to SFO.

Position Card

San Francisco County Supervisor (elected public official)

As a County Supervisor, you support the runway expansion. Keep in mind that you are a politician who must succeed in pleasing San Francisco's business community. The businesses want a long range plan that will provide growth and stability for them in this region. You must appear to be representing these interests so that you will remain popular and will be remembered when the next election comes up. Position ideas:

- ♦ Efficient service at San Francisco International Airport (SFO) is vital to the economic growth of the city. There are many businesses in San Francisco and in other cities around the country that rely on SFO to meet their traveling needs.

- ♦ Fewer flight delays at SFO would make San Francisco a more attractive location to do business. New runways would end the chronic delay problem that plagues the airport.

- ♦ New runways mean construction jobs and increased business for the airport. The airport has been the source for a lot of construction jobs recently through a project to expand its terminal buildings, and this trend would continue if the runway extension proposal succeeds. In addition, new runways would enable the airport to increase the amount of business it does, thus providing more jobs to people in the city.

- ♦ San Francisco County is very dependent on the success of the airport. The new runways will provide for the growth and stability of the county's economic future.

Position Card

President of the San Francisco Construction Union (SFCU)

As president of this construction workers union, you support the runway expansion because your job is to secure good work contracts for the union employees. Keep in mind that you are an elected official who must stay in good standing with the union employees (they elected you). With employment always on your mind first and foremost, you are not really concerned about environmental impacts this proposal might have.

- Runway expansion means more jobs. A project to build new runways at SFO means an increased number of jobs for the construction workers in the community.

- Runway expansion means consistent work for an extended period of time. If approved, this project will provide employment at the same location for many months.

- Local work is the best kind of work. Workers will have an easy commute and more time with their families. Other sites require them to travel great distances from home, sometimes even staying away from their families for several weeks at a time in order to finish a job.

- Runway expansion means an increase in work down the road for workers in other unions. Electricians, plumbers, fuel workers, bag loaders/unloaders, etc., will all have more work at the airport in the future if it expands business.

Position Card

Director of the Oakland International Airport (OAK)

As director of the Oakland International Airport (OAK), your goal is to increase business at the airport by attracting more daily flights there. You see San Francisco International Airport (SFO) as a major competitor for business in the Bay Area and therefore you fear that this expansion will just widen the gap between you and them. You think that the problems of flight delays and cancellations at SFO could be avoided if OAK received more of the air traffic (SFO argues that new runways are the solution to this problem).

- ♦ By scheduling more flights to other regional airports in the Bay Area, SFO would not get so congested when there is bad weather
- ♦ Oakland has fewer closures and delays because there is less fog there than there is at SFO.
- ♦ A high speed ferry link between OAK and SFO could be established to provide rapid transit for passengers who need to travel from one airport to another. For example, passengers who fly into OAK on a domestic flight and need to fly out of SFO on an international flight or vice versa. Or passengers who land at OAK in bad weather because SFO was closed and need to get to their car at SFO.

How Can We Save The Bay?

Explaining the Flow

TEACHER'S PAGES

Expanding upon the Curriculum Activities:

After using this curriculum guide to learn about the ecosystems and habitats of San Francisco Bay and its watershed, students will see many connections between their own lives and the watery world around them. Many times, this course of study will naturally lead the students to want to take action to protect what they are learning about. The action projects have all been written to complement the classroom activities in this guide. We have chosen projects that expand on concepts learned about California's watershed and San Francisco Bay habitats, and highlight how students can take an active role in protecting the aquatic environment around them.

Taking Action

We encourage you to take the next step in Bay education with your class by taking the knowledge learned inside the classroom and applying it outward. Doing a worthwhile project that complements classroom activities will make the study experience more meaningful and hands-on for your students. By sharing information and educating the rest of the school and community around you, your class will combine service to their community with subjects they are studying in class, making the whole picture more relevant to their daily lives.

The Pathway

The overall flow of the action projects is one that starts from the school and then goes beyond out into the local community and environment. The first few activities can be conducted on the school grounds and, by starting with these, we hope to meet the needs of teachers who do not have the time for or access to off-campus resources. We encourage student involvement in all aspects of these projects, from having them generate project ideas and direction to doing the research and outreach. Later activities include off-campus action and habitat restoration projects. This progressive approach will help your students to understand more about Bay issues while becoming actively involved in their solutions, effectively teaching them that they can have a positive impact in their community and that their actions do make a difference in their watershed.

Wetland and Watershed Art

Creating art to educate others about the beauty and importance of wetlands and watersheds

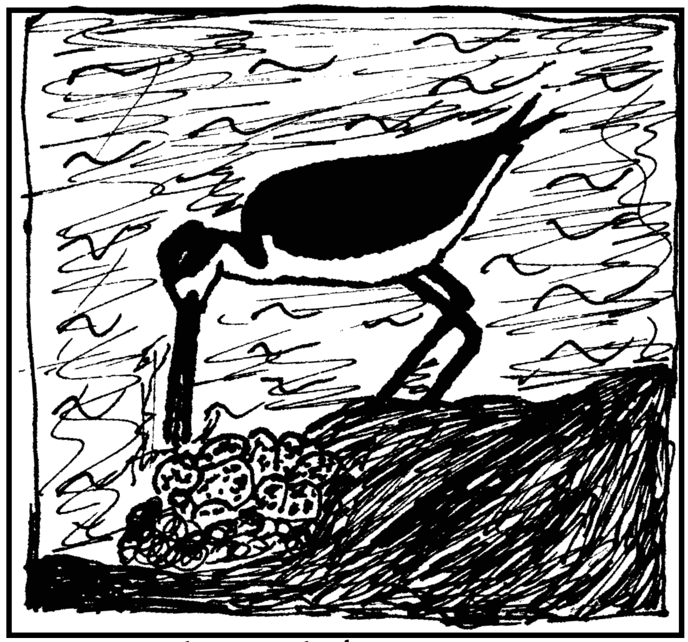
TEACHER'S PAGES

Overview

Art can be a very powerful educational tool. It is a method of telling a story, getting across a message, or evoking feelings based on images. Art is also an excellent way for your students to illustrate (literally) their knowledge about a particular subject. Making art factual as well as expressive is a great way for you to tap into many types of learning styles. Many students think in images, symbols, colors, pictures, patterns, and shapes. They like to perform tasks that that require "seeing with the mind's eye" – tasks that require them to visualize, imagine, pretend, or form imagery. On the other hand, many students are intimidated by art. Emphasizing the information that is represented by the art rather than the aesthetic value of it will put some kids at ease, and free their ability to create art without placing a judgement on it. Also, utilizing diverse methods of creating art will provide different students with a project they will enjoy. Sketch books, posters, murals, collages, trash art, sculpture and displays are all ways of creating art and can all be used educationally.

Central Questions

How can our class use art to express what they have learned about wetlands and watersheds? How can we use this art to educate others about the beauty of San Francisco Bay and the importance of protecting Bay habitats?



Amy Hutzel

Time Required

1 class period to a whole unit or semester or year depending on the type of project.

Materials Needed*

A variety of art supplies, such as:
Pencils
Colored Pens
Colored Pencils
Crayons
Watercolors
Paint
Paper (range of sizes – notebook to mural size),
Watercolor Paper
Display Boards
Scrap Materials (recycled & reused materials from organizations in resource section)
Trash Art (gathering items at clean-ups and items from home: cans, plastic, etc.)

*different materials will be needed depending on the project you choose and the resources that are available to you

What are some of the advantages of using

art and illustration in your other curricula? Here are some reasons why art can complement science and other subjects in the classroom and community, from Jack Laws' Guide to Field Sketching for Outdoor Education:

- kids enjoy it
- gets kids to look closely
- "accidental" recording of information
- develops art skills
- uses the right side of the brain
- appropriate for LD and LEP students
- facilitates authentic assessment

Preparation

There are many avenues down which you and your students can travel in art. It is creative expression, can be structured or unstructured, and in using our tactile senses and visual awareness we can capture time and place. It is easy to see the connection between nature and art, paying particular attention to one's environment and noticing details and patterns that emerge in the natural world. Areas like wetlands can be explored and recorded by paint brush, pen, or camera, inherently capturing details about habitat and ecosystems. Concepts like 'the watershed' can be better explained with a graphical representation (a map) to show it in its entirety. Sense of place is increased as people begin to recognize defining regional features and how they depend on the natural resources that are either plentiful or scarce. This is easily done when using the environment as an integrating concept, and focusing on a topic like San Francisco Bay as a regional treasure can provide many opportunities for the students to form a relationship with the natural world around them.

Important Questions

It is very important to first identify what other objectives you want to accomplish with your art project. You may decide by yourself or brainstorm with the students to answer these questions that we think are important in starting to plan a project:

- How will the project complement your current unit or subject area?
- Will the students' input and specific interests be included in the planning process of the project? How?
- Will the art be displayed or kept in the students own journals or workbooks?
- Will the project educate others about a particular issue or subject?
- Will the students share their work with others in the school?
- Will they share their work with the community?

Project Themes

San Francisco Bay
SF Bay Wetlands
Mudflats
Salt/ Freshwater Marshes
Creeks
Native plants
Upland Habitats
SF Bay Watershed Map
Biodiversity
Estuaries
History of San Francisco Bay and Sacramento/ San Joaquin Delta

Project Ideas

Nature journals
Posters
School wall murals
Creek mural with class
Marsh mural with class
Trash/recycled sculpture
Photography
Watershed wall
Poetry and art
Watercolors
Pastels
Natural items: seeds, grasses, leaves, soil, mud
Mud journals

Community Contacts & Resource List
The following organizations can help you to plan art projects for your class or school. Many have curriculum materials about leading art sessions and all can provide advice.

MOCHA – Museum of Children's Art
Oakland 510-465-8770
http://www.mocha.org/

Junior Center of Art & Science
Oakland 510-839-5777
http://www.juniorcenter.org/

River of Words
Berkeley 510-848-1155
http://www.riverofwords.org/

Friends of San Leandro Creek/Mural
San Leandro 510-577-6069
http://www.fslc.org/

Sources of Recycled and Reused Materials
East Bay Depot for Creative Use
Berkeley 510-547-6470 (store)
http://www.ciwmb.ca.gov/reuse/Profiles/EastBay.htm

Evaluation
There are many ways to evaluate and appreciate the art that your students have created. You may decide to have a show at school where they can display their projects, or choose to display them at a local museum or community center so your class can educate the community at large. Have the students reflect on what they learned about their subject through doing the art project, which may generate ideas for a bigger project like a mural for the school. Take care to limit critique of the art itself, so that it remains a fun and non-competitive creative activity.

Schoolyard Report Card

TEACHER'S PAGES

Overview
In this activity your students will evaluate the condition of their schoolyard based on what they've learned in previous activities. The assessment consists of a series of questions and observations that will allow your class to grade their schoolyard environment.

Central Question
How could we improve the schoolyard environment?

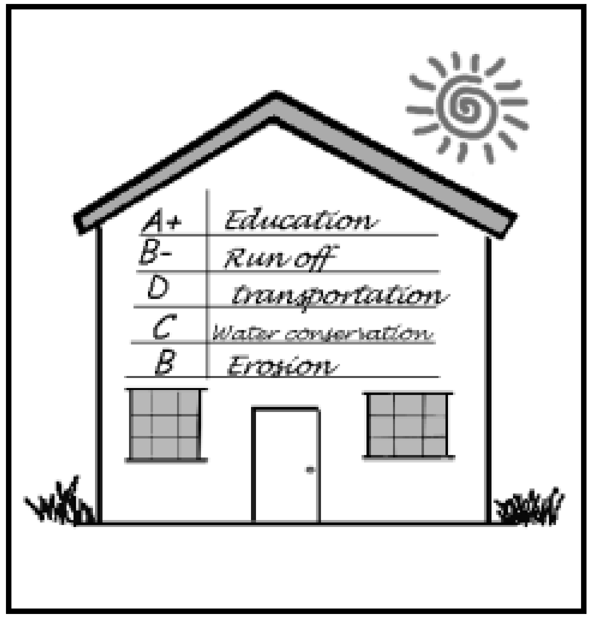
Estimated Time
1 hour

Objectives
Students will be able to:

- *evaluate* their local environment
- *identify* problems in their schoolyard environment
- begin to *develop* solutions to problems

Materials
for each group of 4 students:

- a copy of *Schoolyard Report Card*



Tara Reinertson

Background
Learning about the environment doesn't have to mean traveling far away into mountains or rain forests. Quite often, there is much to discover in your very own backyard. The great thing about this is that if problems are close to home, they are almost always able to be solved. This activity focuses on the environment immediately surrounding your school. As students rate various areas of the schoolyard for good land use, they will begin to identify problems and use their new skills to develop real solutions that they can implement to improve the environmental quality of their own schoolyard!

Teacher Procedure

1. Students will work in small groups. Before they go outside, you will want to define boundaries around the school.

2. Some of the questions require students to talk with school employees (a principal or maintenance person, for example). Decide ahead of time when the appropriate time will be for students to locate this person, and send one person from each group. Or, you may choose to invite these "consultants" to come to you.

3. Upon completion of this assessment, students are asked to brainstorm solutions to the lowest scoring items. Consider a full class brainstorm once they have had time for small group discussion. If you are going to do a schoolyard restoration project, this will be a good time to get students involved and excited from start to finish!

Journal Entry

Taking into account everything that you have learned about healthy environments, design the ideal schoolyard. Things to think about include: biodiversity, habitat, runoff, water quality, and recreational or educational values. Either write a description of this ideal schoolyard or draw a picture.

Bringing It Home

Have the students use Schoolyard Report Card as a guide to create an evaluation of the area immediately surrounding their house or apartment building. Are there things they could do in their own yard or neighborhood to reduce runoff, conserve water, or make other improvements?

Extension

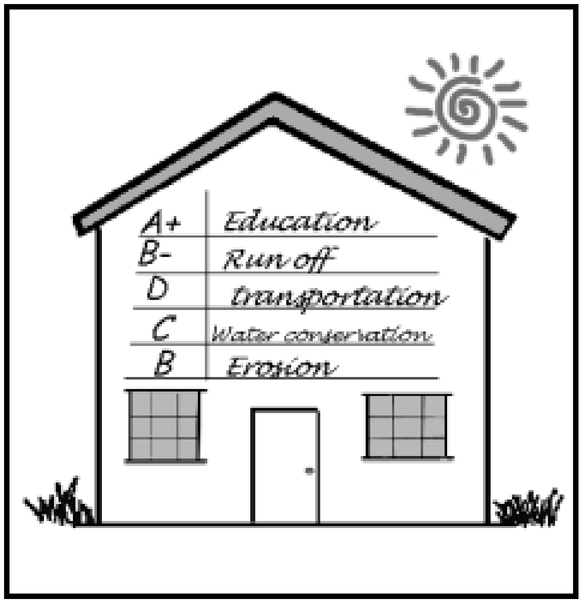
Once the students have determined what things around the schoolyard might be changed to make environmental improvements, work as a group to design and build a model of the ideal school and surrounding yard.

Schoolyard Report Card

Student Pages

INTRODUCTION

You have learned quite a lot about run-off, groundwater, erosion, and many other factors that affect water quality. In fact, you could probably already say a lot about the environmental quality of your own schoolyard! This activity will give you a chance to give a grade to your schoolyard. You will go outside with your classmates and answer the questions in this activity, based on what you see around your school. Depending on what you find, you may choose to make some improvements, with your school's permission, that will benefit your schoolyard and your local waterways.



Tara Reinertson

MATERIALS

Your group will need:

- a copy of "Schoolyard Report Card"

PROCEDURE

1. Before you go outside, assign someone in your group to record your answers on the report card.

2. Your teacher will set boundaries for you. Stay in them!

3. If you decide that a question is not relevant to your school, circle the N/A (not applicable) option and explain your choice.

4. Some of the questions may require you to talk with school faculty members (someone in the maintenance department, for example). Be sure to get permission from your teacher to do this.

5. Go to it!

Section I: Runoff and Erosion

1. What type of surface receives the water from your school's roof downspouts?

a) a patch of rocks or small concrete block on top of vegetation or mulch	10 points
b) directly onto mulch or vegetation	7 points
c) pavement or ground that is eroding	3 points
d) into the ground, sending runoff directly to a waterway without being filtered	0 points
e) N/A_______________________________________	

2. Looking at your schoolyard, estimate what percentage of the ground contains land surfaces that are unable to slow and absorb rainwater. (Remember "When Rain Hits the Land"!)

a) less than 10%	10 points
b) between 10% and 25%	5 points
c) greater than 25%	0 points
d) N/A____	

3. Pathways and heavily trafficked areas where vegetation cannot grow are:

a) covered with a surface that can filter or absorb	10 points
b) covered with an impervious surface such as cement or asphalt	5 points
c) bare, exposed soil	0 points
d) N/A____	

4. Look for patches of bare soil and signs of erosion such as areas where rainwater has carved out ditches or windows and walls with soil splashed on them. The schoolyard has:

a) very little erosion and few patches of bare soil	10 points
b) several patches of bare soil or areas where soil is eroding	5 points
c) large patches of bare soil and extensive erosion	0 points
d) N/A____	

Section 2: Vegetation

1. How much of the grass and vegetated areas in your school is mowed?

a) less than 50%	10 points
b) between 50% and 80%	5 points
c) over 80%	0 points
d) N/A_______________________________________	

2. The land surrounding places where water drains and collects such as storm drains, drainage ditches, and streams is:

a) well vegetated with trees and shrubs	10 points
b) vegetated with unmowed grass	7 points
c) mowed grass	3 points
d) bare soil, pavement, or concrete	0 points
e) N/A____	

3. Ask your school's lawn service or school maintenance people how the mowed grass on the school's grounds are fertilized.

a) grass clippings are left on the grounds as natural fertilizer	10 points
b) lawn fertilizers are used according to a formula derived from soil tests	7 points
c) lawn fertilizers are used according to instructions	3 points
d) lawn fertilizers are applied randomly	0 points
e) N/A ______________________________	

4. Generally, how well is the schoolyard vegetated with trees and bushes?

a) trees and bushes cover a significant part of the schoolyard	10 points
b) trees and bushes dot the landscape of the schoolyard	5 points
c) there are few or no trees on the schoolyard	0 points
d) N/A______________________________	

Section 3: Education

1. How many storm drains are labeled, "Don't Dump, Drains To Bay" to let people know that substances that enter them go into local waterways?

a) all storm drains are labeled	10 points
b) a few storm drains are labeled	5 points
c) no storm drains are labeled	0 points
d) N/A ______________________________	

2. How many different ways are there at your school to learn about local water quality or the environment? (Different ways to educate might include posters, literature, classes, clubs, plays, assemblies, etc.)

a) 3 or more	10 points
b) 1 or 2	5 points
c) no education about the environment	0 points
d) N/A ______________________________	

3. Look for candy wrappers, soda cans, and other litter in the schoolyard that could wash into storm drains or streams when it rains.

a) there is no litter in the schoolyard	10 points
b) some litter	5 points
c) a lot of litter	0 points
d) N/A ______________________________	

Section 4: Transportation

1. Determine the number of people employed at your school (teachers, maintenance staff, food service staff, administrators, etc.) by asking you principal or looking in a yearbook. Look at the school parking lot and determine the number of vehicles relative to the number of employees.

a) there are 50% fewer cars in the parking lot than employees	10 points
b) there are 25% fewer cars in the parking lot than employees	5 points
c) there is about one car per employee in the parking lot	0 points
d) N/A ______________________________	

2. Are there bicycle racks at your school and do people use them?

a) bike rack is full of bikes 10 points
b) school has a bike rack but there are very few bikes in it 5 points
c) school has no bike rack and there are no bikes in the schoolyard 0 points
d) N/A____

3. Is there any reward or encouragement for teachers or students who walk to school, ride their bikes, carpool, or take public transportation?

a) yes 10 points
b) no 0 points
c) N/A____

Section 5: Water Conservation

1. Does your school use any water-saving devices such as faucet aerators, toilet dams, low-flow showerheads, or garden hose nozzles?

a) there are two or more different types of water-saving devices 10 points
b) there is one type 5 points
c) there are no water-saving devices 0 points
d) N/A ____

Survey at least 10 people at your school about their water conservation practices at home.

2. At least half of these people have installed:

a) two or more water-saving devices at their residence 10 points
b) at least one water-saving device 7 points
c) no water-saving devices 0 points
d) N/A ____

3. Find out how many ways each person conserves water, such as turning off the water while brushing their teeth, collecting water from their showers to water plants taking 5-minute or shorter showers, or putting drinking water in the refrigerator to cool instead of letting the faucet run.

a) at least half of the people do two or more of these things 10 points
b) at least half of the people practice 1 water conservation technique 5 points
c) at least half of these people do not conserve water 0 points
d) N/A ____

****Bonus**** Are there any projects completed or in progress at the school that are aimed at reducing pollution?

a) 3 or more projects on school grounds 10 points
b) at least 1 project 5 points
c) there are no projects at the school 0 points

SUMMARY

Add up the points and use the key below to determine the grade for the area(s) you surveyed at your school. If you marked several questions as "not applicable", adjust the grading scale as necessary.

A=100 and above
B=80-99
C=55-79
D=30-54
F=below 30

How did your school rate in its land use practices? Grade:__________

CONCLUSION

1. If your school did not score an A, why not? Which of the five sections had the poorest results?

2. List below three areas or conditions that could be improved to give your school a better report card.

3. Think about what you would do to make these improvements if you could. In your small groups brainstorm solutions to problems that you have identified in this activity. Use the chart on the next page to list all of your ideas. You will be sharing these ideas with the rest of your class.

PROBLEM		SOLUTION
	⇨	

Fish, the Bay, and You

Seafood Consumption Information Project

Overview

One of the main issues in the San Francisco Bay is the pollution of the Bay from urban and industrial runoff and its effects on aquatic wildlife.

This project will educate your class about the dangers of eating seafood from the San Francisco Bay and how to eat fish from the Bay safely. It will teach your students techniques on how to cook the seafood to reduce the amount of toxic intake, and will provide facts on how contaminated fish affect the health of humans. After learning about safe seafood consumption themselves, your students can take action to educate others about safe seafood preparation by conducting cooking presentations.

Estimated Time

Part I: Video and Worksheet: half a class period and in-class assignment

Part II: Safe Seafood Cooking Presentations: actual presentation can last between 1-2 school periods, preparation and discussion may take a bit longer

Materials Needed

Part I

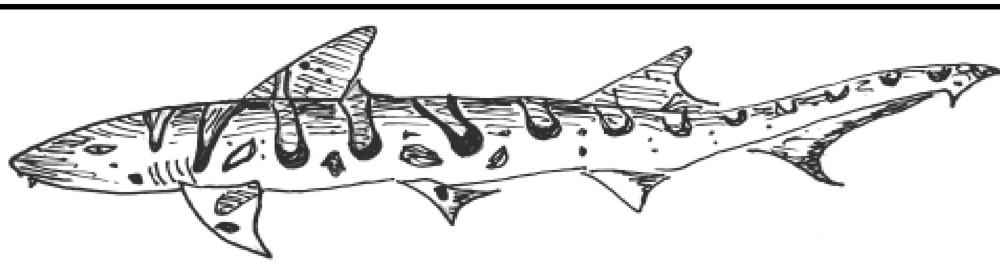
- Borrow SCIP (Seafood Consumption Information Project) Video from Save The Bay (510) 452-9261
- Copies of Estuarywise "101 Ways to Save the Bay" from San Francisco Estuary Project: http://www.abag.ca.gov/bayarea/sfep/sfep.html
- Copies of Student Worksheets

Part II

(Materials needed for one presentation)

- Fresh, whole fish from market (with scales, head, and guts, all intact)
- 1 sharp knife
- 1 small Barbecue, steamer, or stove*
- 1 frying pan (if you use stove)
- plates
- napkins
- table cloth
- gloves
- 1-2 Tablespoons vegetable oil
- 1 serving spoon or spatula
- 2 medium sized tomatoes
- 1 bunch cilantro
- 2-3 green onions
- 1 teaspoon chopped ginger root
- 1 Tablespoon soy sauce
- 1 small chili pepper, chopped
- salt to taste
- black pepper to taste

*the healthiest way to cook the fish is to steam it. This is because the fat of the fish can easily drain out when steaming or barbecuing. You can barbecue it if you don't have a steamer and use a stove as your last resort.



Background
With rapidly developing urban areas and industry intermingled with residential areas, environmental justice issues are receiving increased attention. Unfortunately many of the residents of these neighborhoods are not aware of the dangers industrial waste and pollution can have on their health or the health of their surrounding environment. Residents in highly industrialized areas also tend to be immigrants of lower economic status and with limited knowledge of English. Presently, environmentalists and health workers are faced with the challenge of educating the public to the dangers of urban pollution and waste.

In June 1995, a report was released on the concentrations of contaminants in certain fish species throughout the Bay. The San Francisco Water Quality Control Board has conducted a study to measure the levels of chemical contaminants in fish caught by anglers in San Francisco Bay.

Fish were collected for study by the Department of Fish and Game. The fillets of the fish were analyzed and harmful chemicals were found in certain parts of the fish. Fish collected are representative of fish that are commonly caught and eaten and are more likely to be contaminated because of their fat content and feeding habits. The fish collected were tested for over 100 chemicals. Of these chemicals, six were found at levels of concern. Theses chemicals were PCBs, mercury, dioxins, chlordane, DDT and dieldrin.

These contaminants are caused by pollution in the Bay. Every day thousands of pounds of pollutants enter the San Francisco Bay/Delta. They come from refineries, back yard waste, urban streets, mines, sewage treatment plants and farm fields. Many of these pollutants are carcinogenic, teratogenic, or mutagenic. Carcinogens are any chemicals that can cause cancer. Teratogens are chemicals which cause developmental malformations including birth defects and development problems in babies. Mutagens cause aggravated genetic mutations in humans of all ages. Presently, the majority of pollution entering the Bay comes from urban runoff.

Chemicals

PCBs are mixtures of related chemicals that were sold under the trade name of Aroclor. They were used as transformer fluids, lubricants, hydraulic fluids, and similar products. All PCB mixtures change over time. Negative effects such as small head size, reduced visual recognition, and delayed muscle development were found in children whose mothers came into contact with PCB's.

Dioxins are mixtures of chemicals, somewhat similar to PCBs. They come from chemical reactions in industrial process and from incineration of chemicals contaning chlorine. Exposure to dioxin in the workplace has produced chloracne, a severe skin rash.

Chlordane was used as a pesticide, particularly for termite control in homes. It is still found at significant levels in fish and in fatty tissues of animals and people. Acute exposure to chlordane affects the nervous system and, at very high doses, causes convulsions. Chronic exposures to chlordane can damage the liver and nervous systems.

DDT(DDD and DDE) has moderate to low acute toxicity. DDT is suspected of causing spontaneous abortion and premature births.

Dieldrin is an organic pesticide. Dieldrin is still found in soils and sediments because it is a very stable chemical. Acute exposures can cause excess excitability, tremors, convulsions, and liver changes. Liver damage also occurs from chronic exposure.

Methylmercury is an organic chemical formed in sediments and in animal tissues from metallic mercury or its salts. Trimming fat from fish will not lower exposure to this chemical as it will for other chemicals. Methylmercury concentrates in human kidneys. High levels may lead to kidney or circulatory failure, and damage to the central nervous system can occur at lower doses after long-time exposure.

Heath Concerns

These chemicals affect nervous system changes in developing fetuses, infants and small children (e.g., impaired mental and motor development), mainly associated with excessive mercury or PCB exposure, and potential increased risks of cancer due to exposure to PCBs, dioxins, and the pesticides. Adults should limit their consumption of San Francisco Bay sport fish to two meals per month at most. Adults should not eat any striped bass over 35 inches. Women who are pregnant or may become pregnant, or who are breastfeeding, and children under 6, should not eat more than one meal of Bay fish per month and, in addition, should not eat any meals of shark over 24 inches or striped bass over 27 inches.

For more information visit these web sites:

Office of Environmental Health Hazard Assessment http://www.oehha.org/fish.html

SF Weekly article http://www.sfweekly.com/issues/2004-12-15/news/news.html

SF Estuary Institute http://www.abag.ca.gov/bayarea/sfep/reports/soe/soe-index.html

SF Bay Regional Water Quality Control Board http://www.waterboards.ca.gov/sanfranciscobay/

Storm Drain Stenciling Project http://www.oaklandpw.com/keep_oakland_beautiful/storm_drain_stencil.htm

SF Estuary Institute http://www.abag.ca.gov/bayarea/sfep/sfep.html

Teacher Procedure

Part I: Video and Worksheet

1. Tell your class that you are going to show them a video about the San Francisco Bay and how pollution in the Bay affects wildlife and people.
2. Give your class some background information from the background section of the write up to get them thinking.
3. Pass out the worksheets to the students and explain that they should fill out the worksheet while watching the video.
4. Play the video.
5. Start a discussion. Ask your class:
   - How many of you fish or have family members that fish from the Bay?
   - How did the video make you feel?
   - What are some things we can do on a daily basis to prevent pollution in the Bay?
6. Pass out copies of Estuarywise "101 Ways to Save the Bay".

Evaluation

A good way to evaluate the students is to find out how their views have changed. Did they know about pollution in the Bay before watching the video? Have they ever thought about pollution getting into fish and moving up the food chain into people? Have the students brainstorm ways they can prevent pollution from getting into the Bay.

Part II: Safe Seafood Presentation Activity

Before planning any presentations, make sure your students understand the importance of this work. Historically the San Francisco Bay Area has been a place of transportation, industrialization and urbanization. These land uses have had a severe impact on the health of the Bay and the plants and animals that live in and near it. Unfortunately the main communities affected by this contamination have very little knowledge of the effects of these toxins and depend on fish as a source of food. This project presentation aims to target this community and educate the people about seafood that comes from the San Francisco Bay. We want to teach the public about safe fish preparation and how to avoid toxins that come from the Bay. It is important that residents and fisher people near the Bay are aware of the chemicals that exist in the Bay and how these chemicals affect the health of adults and small children. It is imperative that the community know the correct way to prepare fish to minimize chemical exposure.

A good way to begin is to make a list of important questions you want to ask your class before you give a presentation. Here are some ideas:

1. To what audience would you like to present this information?

2. What audience would benefit most from the information presented?

3. What day and time would you like to do your presentation?

4. Do you need to coordinate or collaborate with any group in order to do a successful presentation?

5. Can you get all of the supplies?

6. Who would like to do the presentation?

7. If you have many people, how would you like to divide up the parts of the presentation?

8. Have you practiced the presentation before you perform it in front of your audience?

9. Do you have enough knowledge to answer any questions about the presentation? (Read the Overview Section of the SCIP Video & Worksheet)

10. Where can you get more information about this issue? (Read the Community Contacts List)

Community Contacts

1. Save the Bay
   http://www.savesfbay.org
   Phone: (510) 452-9261
   Fax: (510) 452-9266
   -can provide information on how to do the presentation and provide posters and brochures with seafood contamination information

2. San Francisco Bay Regional Water Quality Control Board
   http://www.swrcb.ca.gov/~rwqcb2/
   The SWRCB can provide scientific data on pollution levels in the San Francisco Bay as well as data on probable sources of pollution.

Planning

Whether or not you realize it, you have already done a lot of the planning for this project! By showing the video and having your students go through the worksheet, your class already has a lot of the background information that they need. Next, you should start on a list of preliminary activities to get your project going:

1. Set details of the presentation
   - To whom are you going to present?
   - When are you going to do the presentation?
   - Where are you going to do the presentation (make sure the site of the presentation has electrical hook ups if you use a stove, and has running water nearby to rinse the fish)?

2. Read Background Information and familiarize your class with what they want to say.

3. Practice the Presentation.

Procedure

(the presentation should take about an hour)

1. Explain to the audience that your class is going to show them the proper way to cook fish from the Bay so they can avoid ingesting any harmful chemicals found in the fish.
2. Have your class tell the audience that due to a variety of sources of pollution (urban runoff, oil spills, sewage output, acid rain, agricultural waste, etc.) the waters in the San Francisco Bay are filled with a variety of chemicals that can affect the aquatic life in the Bay. The main chemicals found in a 1995 study by the San Francisco Regional Water Quality Control Board are PCBs, Chlordane, DDT, Dieldrin, and Methlymercury. Large quantities of these chemicals can have adverse effects on human health. A health warning has been issued stating that adults should not eat fish from the Bay more than twice a month and children under six and pregnant women should not eat fish from the Bay more than once a month. Adults should not eat striped bass over 35 inches long and children under six and pregnant women should not eat shark over 24 inches and striped bass over 27 inches long.
3. Now your class can tell the audience that if they do decide to fish from the Bay there are many methods of preparing the fish that will prevent them from consuming high amounts of chemicals.
4. Have them show the audience the fish you bought and explain that it is from the market and that many times when you buy a fish from the market you don't really know where it comes from.
5. Rinse the fish thoroughly with water.
6. Scale the fish by grabbing the tail of the fish and pushing forward against the scales with a knife to remove all of the scales. (Be careful the scales will fly!) Explain that some pollutants like oil can stick to the surface of the fish and coat their scales.
7. Gut the fish by making an incision starting from the bottom of the fish belly and continuing to slit the fish all the way to the throat.
8. Reach inside of the fish and pull/cut out all organs including the heart, lungs, stomach, intestines, liver, bladder, etc. Tell the audience that this is a very important step and that most of the contaminants are found within the digestive system of the fish. Discuss bioaccumulation with the audience and explain how the pollution begins in the tiniest aquatic organisms and as it travels up the food chain it becomes more and more concentrated. Therefore organisms towards the top of the food chain (like fish) have the most amount of chemicals in them from eating all of the smaller creatures.
9. Cut off the head, tail, and fins of the fish. (Remove the skin if you are not steaming or barbecuing the fish)
10. Now fillet the fish by slicing the side meat of the fish off of the bones. Carefully remove all of the tiny bones from the fillet.
11. Rinse the fillet and knife with water.
12. Now, using the knife, make little slits in the fillet. Tell the audience that a lot of the chemicals are also stored in the fat of the organisms so it is important to make slits in the fillet. When you cook the fish, the fat drips out of the fish and you are not consuming it. This is why steaming and barbecuing are the best ways to cook fish.
13. Using the Creek Keeper recipe (you may use any healthy recipe you want), your class can chop all of the vegetables and spices.
14. If using a barbecue or steamer, slice the fillets in half (not all the way) and stuff the fillets with the herbs and seasonings. Cover and barbecue or steam.
15. When cooked, remove the skin, it should peel off easily. Then serve.
16. If using a stove, heat the pan and add the oil.
17. Fry the fish in the pan, and when golden season with herbs and spices and sauté with vegetables.
18. Let cook in pan for 5 minutes, until vegetables are cooked and serve.

"Food" for Thought

While the audience is enjoying the fish your class can ask them questions to keep them thinking.

1. Do you or anyone you know fish from the Bay?
2. If so, do you eat the fish you catch?
3. Why or why not do you eat the fish you catch?
4. Have you ever heard warnings about eating fish from the Bay?
5. Did these warnings make you stop eating fish from the Bay, or at least reconsider?
6. Did you know how to cook a fish safely before you saw this presentation?
7. Now that you know this information do you think you will change your behavior?
8. What are some ways that we can reduce the amount of chemicals entering the Bay?
9. What are some changes you can make in your own life to reduce the amount of pollution entering the Bay?

Follow-Up and Extensions:

Audience:

- Have your class pass out safe seafood brochures and posters. These can be obtained from Save the Bay, (510) 452-9261
- They can also pass out copies of "Estuarywise". These can be obtained from the San Francisco Estuary Project: http://www.abag.ca.gov/bayarea/sfep/sfep.html
- Tell your class to encourage the audience to teach their family and friends the proper method to cook fish safely.

Class/Students:

- Students can post posters and pass out brochures about safe seafood consumption at local fishing spots.
- Students can also do the Storm Drain Stenciling Activity. The write up is found on the Earth Team 2000 web site http://www.earthteam.net under action projects: toxics. The directions can be found on the web site at the end of the "Fishing for Food" project.

Fish, the Bay, and You

Seafood Consumption Information Project

Student Pages

1. Do **you** fish from the San Francisco Bay? ______________________________

2. If so, do **you** eat the fish that you catch? ______________________________

3. Why did the government put out a health warning?

   ____

4. List 3 side effects from eating contaminated fish from the Bay?

   a.____

   b. ____

   c. ____

5. How can you reduce the amount of chemicals you consume from the fish?

   ____

6. Name three parts of the fish that you must remove:

   ____

7. How does poking holes in the fillets of the fish reduce the amount of toxic intake?

   ____

   What is the maximum amount of fish from the Bay a healthy adult can eat per month? __________

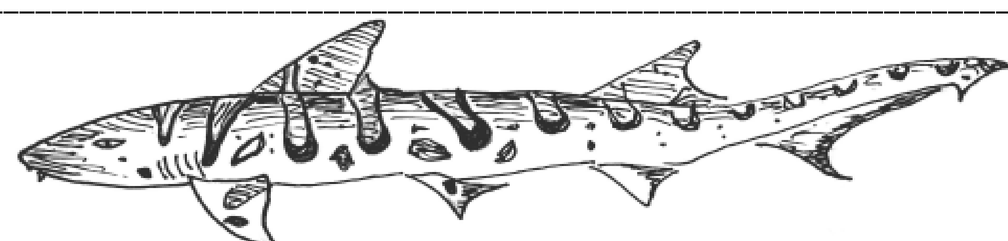
   Children?_______________ Pregnant women?___________________

8. Why do you think this video is important?

   ____

9. What do you think are some other good ways to educate people about the dangers of fishing in the Bay?

   ____

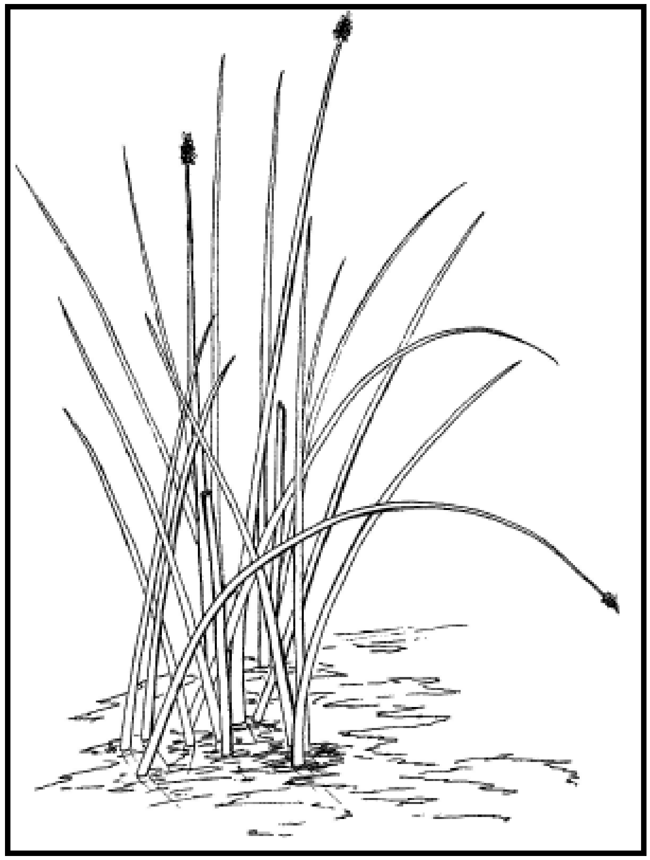


Urban Creek Survey

Exploring Your Own Backyard

Overview

The purpose of this action project is to help students find out more about a local creek that runs close to their school, and to get to know the health of their creek by walking a section of it and observing it first-hand. Based on student observations and research about issues affecting the creeks of San Francisco Bay, your class can choose an appropriate project that would help to improve the health of your local creek.



Central Questions

What is the name of a creek that flows close to my school? What can I find out about the health of this creek? In what ways does this creek connect my neighborhood to the San Francisco Bay? How can I improve the health of my local creek?

Estimated Time

Part I: Mapping Your Creek: 1 hour
Part II: Researching Your Creek: several days or as a homework assignment
Part III: Walking Your Creek: half to full day

Objectives

Students will be able to:

- locate creeks on maps and trace their paths
- research the natural history of a local creek using a variety of sources
- observe the conditions of their creek and rate the overall health of the creek

California's Content Standards

Grade 6: Shaping the Earth's Surface

2. Topography is reshaped by weathering of rock and soil and by the transportation and deposition of sediment. As the basis for understanding this concept, students know:
   a. water running downhill is the dominant process in shaping the landscape, including California's landscape.
   b. rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.

Grades 9 - 12: Ecology

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept, students know:
   a. biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.
   b. how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

Background

The San Francisco Bay and Delta combine to form the largest estuary on the west coast of the United States, covering 1600 square miles that includes nine bay area counties. An estuary is a place where fresh water and salt water mix together to form brackish water, creating an environment that is unique and provides habitat for many different species. The San Francisco Estuary is an immensely productive ecosystem that supports diverse communities of plant, animal, and aquatic life that are all part of a complex food web. The estuary is an important stop for migrating birds on the Pacific Flyway, and over two thirds of all the state's salmon must pass through the San Francisco Estuary on their journey from fresh water creeks and rivers to the Pacific Ocean. The estuary also provides many benefits and uses to humans, including providing drinking water to over 20 million Californians and irrigating 4.5 million acres of farmlands and ranches.

The events of the California Gold Rush in the mid-nineteenth century greatly affected the San Francisco Estuary, most dramatically by leading to a major increase in the population of the region. Today the San Francisco Bay Area is home to over six million people, making it the fourth largest metropolitan area in the country. Many problems now face the estuary because of increased development and population growth, including loss of habitat, water diversion, pollution and bay fill. By far the most widespread problem is non-point source pollution: the polluted run-off that drains from our streets, cars, homes, and businesses, often through the storm drain system that empties directly into creeks and waterways that then flow into the Bay.

To learn more about San Francisco Bay history and ecology, check out these web sites:

- Save the Bay http://www.savesfbay.org
- The Bay Model http://www.spn.usace.army.mil/bmvc/
- San Francisco Estuary Institute http://www.abag.ca.gov/bayarea/sfep/sfep.html
- The Bay Institute http://www.bay.net

Teacher Procedure

This project starts with researching which creek flows nearest to your school, and finding out about where the creeks travel and how they connect your schoolyard to the Bay. You will need to use maps and information that can be obtained from local organizations like Save The Bay, the internet and other sources.

It would be a good idea to read over this project and make a list of things you will need to get (like maps) before you start. Also, you will need to contact certain organizations for information and for things like permission to walk your creek. By looking over the whole project now, you will get a better idea of the timeline of when to do what.

After the students have done some research about the creek, your class will take a survey walk along your creek where they will observe firsthand their impressions of the creek and its' health. This information may lead into several different projects, which range in size from something small like a creek clean-up to something larger like a water quality monitoring project.

**** There are SAFETY CONCERNS to consider when you actually go out and explore your creek.** You will need to get permission for access to walk a section of your creek, and make sure that you follow all safety guidelines. By working with your county creek coordinator or clean water program representative, you will find out what locations would be the safest, most accessible, and would not harm the environment by going there. For example, some sections of creek might be important fish habitat that you would not want to disturb. Find out as much as you can **before** your field day!

Part I: Mapping Your Creek

maps, etc.), you will be able to find out a variety of information about your creek and its' location.

Some excellent sources for maps of the San Francisco Bay area are:

- Oakland Museum Creek Web Page http://www.museumca.org/creeks/
- The Bay Model Web Page http://www.spn.usace.army.mil/bmvc/
- The Bay Trail Web Page http://www.abag.ca.gov/bayarea/baytrail/baytrail.html
- The San Francisco Estuary Institute Web Page http://www.abag.ca.gov/bayarea/sfep/sfep.html
- California Automobile Association (AAA)
- Water Education Foundation http://www.watereducation.org/

Once you have obtained the maps, try and answer these questions about your area using the maps:

1. Find the location of your school and your home on the maps.
2. Locate the scale of the map. Approximately how many miles as the crow flies are you away from the San Francisco Bay?
3. Locate where the salt water enters the Bay.
4. Locate and name three large rivers that enter into the Bay.
5. Find and name all of the creeks that flow near your school.
6. How close is your school to the nearest creek that runs above ground? What is the name of this creek? Find where this creek originates. Into what part of the Bay does the creek empty?
7. What cities, towns, and roads does this creek flow through on its way to the Bay?
8. Find a creek on your map that runs underground. What is the name of that creek? Why might it flow underground?
9. What do you think are the main human influences, both positive and negative, affecting your local creek?

Part II: Researching Your Creek: Getting connected with people that can tell you more about your creek!

Now that you have found out the name of your creek and a little information about the San Francisco Bay, it is time to find out more of the specifics. There are many local and state agencies, citizens groups, neighborhood groups, and environmental organizations that work with creeks. Most people are happy to share what they know, and you can get a lot of information by tapping into your local resources.

Many people have personal experiences with San Francisco Bay, and can relate stories and other information from past experiences. Have the students research local creek history by making use of a variety of sources. They can ask their classmates, friends, parents, teachers, and other people they know if they have ever been to a creek or stream in the neighborhood. What was it like? What types of animals live there? Has the creek changed much since they first became acquainted with it? Where does the creek flow? Have they ever seen trash or other pollutants in the creek? How might this affect both wildlife and humans living near the creek?

Here are some contacts students can use to look for information about your specific creek:

- Oakland Museum Creek Page http://www.museumca.org/creeks/
- Aquatic Outreach Institute http://www.aoinstitute.org
- Urban Creeks Council 415-540-6669

You may also want to contact your local Public Works Department and ask for information about your creek, and to request a storm drain map and any other maps that show the creek.

Part III: Walking Your Creek

Planning your creek walk: gathering more information, permission to walk a section of creek, and thinking about safety.

As you plan to walk a section of your creek, it is important to remember that **safety** should be your **#1 Priority**! Especially during the winter months when it rains a lot, if you are not careful about details like checking the weather and characteristics of your creek, you may be putting yourself in an unsafe situation. It is very important to work with an expert on your creek, who can both tell you the best place to plan your walk, and if there are any special concerns about that section of creek. Call your local clean water program and find out who is in charge of creek access and programs. It may be possible to combine your creek walk with one that is already scheduled through an organized group.

Good contacts for information and permission for access:

- Your local Water District
- Your county Creek and/or Clean Water Program
- Your county Public Works Department
- Your local Friends of ______ Creek program*
  *Aquatic Outreach Institute
  (http://www.aoinstitute.org)
  is a good resource

Creating your Creek Survey questions: what is important to you?

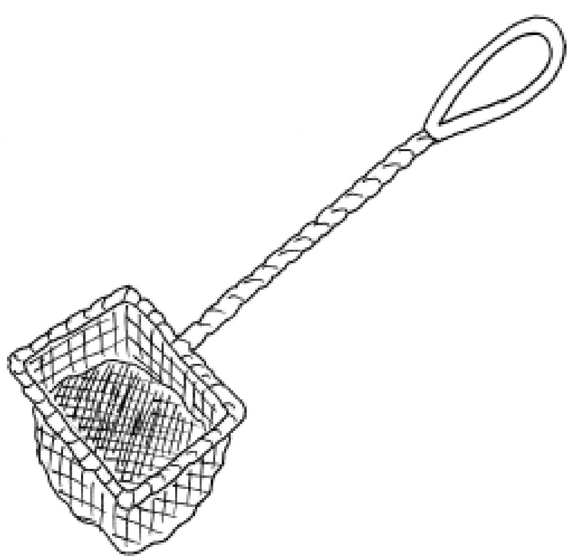
There are many resources available to help you create your own list of survey questions you would like to answer about your creek. In particular, look at the Urban Stream Survey put out by the Isaac Walton League's Save Our Streams Program. Students can order a copy of the **Science Project Guide for Students** for free! You can find this by looking at their website, http://www.iwla.org/sos, and clicking on the Save Our Streams Program, or by calling 1-800-BUG-IWLA. They have several publications that offer help in creating stream survey questions and monitoring.

Make your survey reflect the interests of your school and community.

Ask everyone who is participating what everyone would like to find out about the creek and compile your list accordingly. The survey will be that much more relevant if it addresses the interests and concerns of your peers. Make enough copies for everyone to have their own data sheet to keep records on, and encourage a lot of active observation on your field day.

Walking the Creek

Now that you have gathered all of your information and picked a date and site for your creek walk, it is time to go do it! You may wish to walk the creek as a whole group, or it may make more sense to split up into groups to cover more area. Make sure you decide on these details with your teacher or other coordinator. Make sure that everyone brings a notebook and pen in order to record information and observations



while you are there.

In general, it is a good idea to follow these **safety guidelines** when at the creek:

1. Always monitor with at least one partner. Always let someone else know where you are, when you intend to return, and what to do if you don't come back at the appointed time.
2. Always obtain permission to visit your creek site. This will require talking with any of the contacts listed above, and possibly to any landowners who might own private property along the creek.
3. Watch for hostile dogs, wildlife (snakes), and insects such as ticks, hornets, and wasps.
4. Carry a first aid kit and make sure someone knows how to use it.
5. Watch for poison oak, stinging nettle, and other types of vegetation that may cause rashes, irritation, or scratches.
6. Never drink the water in a stream. Bring your own water from home.
7. Please don't walk on unstable streambanks. Disturbing these banks can accelerate erosion and may prove dangerous if a bank collapses.
8. Be very careful not to disturb streamside vegetation. Also, be aware of areas of sensitive habitat by talking with your creek expert beforehand.
9. Be very careful when working near swiftly flowing streams, do NOT attempt to wade into or across them when the water is swift or above knee height.
10. **If at any time you feel uncomfortable about the condition of the stream or your surroundings, stop your survey and leave the site. YOUR SAFETY IS THE MOST IMPORTANT THING!**

These safety rules are recommended by the San Francisco Estuary Institutes' guide to Volunteer Monitoring Protocols.

Assessing the Results: Rating the overall health of your creek, deciding on the most important issues affecting the creek, and creating an action project to address one or more of these issues.

After your Creek Survey, it is important to assess and compare everyone's results. Talk about the group's observations, and discuss what you think are the most important issues affecting the creek. These may be things like trash, pollution, development, habitat loss, urban run-off, etc. Brainstorm ideas for solutions to some of these problems, and create a list of project ideas to help the creek. You may decide to organize a creek clean-up day, develop presentations and artwork to educate others about your creek, or start a creek water quality monitoring project. Many of the organizations listed above can provide help, resources, and information about action projects. A great extension project is to turn your results into a project monitoring the aquatic insects and water quality of your creek.

Keeping An Eye On Our Creeks

Water Quality Monitoring

Overview

The water quality monitoring project is highly relevant for classes and student groups interested in hands-on, scientific, outdoor, service-learning projects. Water use and watersheds are important concepts especially in regards to the San Francisco Bay. The main source of pollution entering the Bay is urban runoff. Projects such as water quality monitoring can help residents and local officials record how urban runoff and pollution affects their local creek. Students can take an active role in watershed protection by participating in the project and making their data available to local government and creek groups as well as the public.

Central Questions

How healthy is the water in our local creeks?
How can we protect our local creeks?

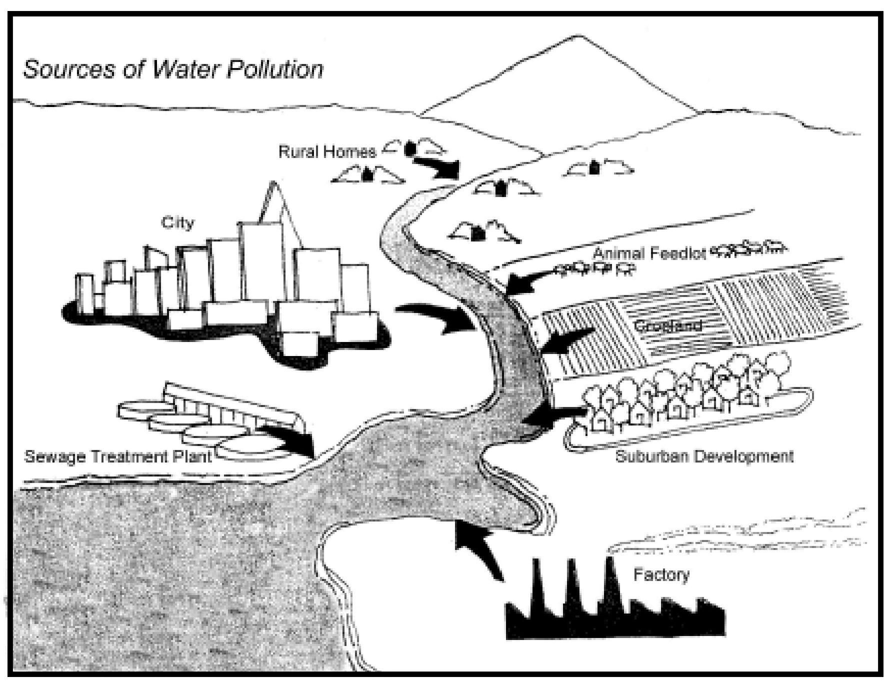
Estimated Time

1-2 full field days, depending on if you do the Urban Creek Survey as a preliminary activity or not. Your class can also extend the monitoring project to last a few months, a semester, a year, or however long you prefer.

Materials Needed

- Water quality monitoring test kits*
- Gloves
- Goggles
- Copies of Student Pages
- Clipboards
- Pencils
- Paper towels
- Waste water bottle (an empty plastic bottle)
- Local creek maps (Oakland Museum, US Geological Survey, The Bay Model, AAA, etc.)
- Plastic cups

*Water quality monitoring kits can be purchased from a variety of companies, and can cost from $10 and up depending on what tests you decide to do, how many you want to do, and what kind of equipment you decide upon. We provide contact information for purchasing kits on the next page.



Objectives

Students will be able to:

- conduct a variety of water quality tests
- analyze the results of their tests
- assess the health of a local creek using data they have collected
- work with other organizations to contribute to the health of the Bay Area's waterways

California's Science Content Standards

Grade 6

Ecology (Life Science)

5.e. The number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

Investigation and Experimentation

7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content of the other three strands, students should develop their own questions and perform investigations. Students will:
   a. develop a hypothesis
   b. select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data
   c. construct appropriate graphs from data and develop qualitative statements about the relationships between variables
   d. communicate the steps and results from an investigation in written reports and verbal presentations
   e. recognize whether evidence is consistent with a proposed explanation
   h. identify changes in natural phenomena over time without manipulating the phenomena (e.g., a tree limb, a grove of trees, a stream, a hillslope)

Grade 8

Reactions

5. Chemical reactions are processes in which atoms are rearranged into different combinations of molecules. As a basis for understanding this concept, students know:
   e. how to determine whether a solution is acidic, basic or neutral.

Investigation and Experimentation

9. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content the other three strands, students should develop their own questions and perform investigations. Students will:
   a. plan and conduct a scientific investigation to test a hypothesis
   b. evaluate the accuracy and reproducibility of data
   e. construct appropriate graphs from data and develop quantitative statements about the relationships between variables

Grades 9-12

Chemistry

Acids and Bases

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept, students know:
   a. the observable properties of acids, bases and salt solutions
   d. how to use the pH scale to characterize acid and base solutions

Investigation and Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content of the other four strands, students should develop their own questions and perform investigations. Students will:
   a. select and use appropriate tools and technology (such as computer-linked probes, spread sheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data
   b. identify and communicate sources of unavoidable experimental error
   c. identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions
   d. formulate explanations using logic and evidence.
   j. recognize the issues of statistical variability and the need for controlled tests
   k. recognize the cumulative nature of scientific evidence
   l. analyze situations and solve problems that require combining and applying concepts from more than one area of science

Preparation

Getting started is always the hardest part of any action project because it requires a lot of planning and organization. A good way to begin is to make a list of important questions you want to ask your class, and answer them before you begin. Here is a list of questions we think will be helpful, feel free to add questions you think are pertinent but not listed below:

Important Questions

1. What tests would you like your class to conduct?
   (some of the major tests are: pH, temperature, turbidity, nitrates, conductivity, dissolved oxygen, salinity, phosphates, and fecal coliform)
2. Where are you going to get your equipment?
3. How often will your class be able to monitor?
4. To whom will your class report their results?*
5. How often will your class report their results?
6. Is anyone else monitoring that creek? If so, can your class partner up with them on the project?*

* Refer to resource list and the community contact sheet provided below to help you answer some of these questions.

Water Quality Test Kit List

1. LaMotte Company
   http://www.lamotte.com/pages/edu/index.html
   Phone: 800-344-3100

2. Hach Company
   http://www.hach.com
   Phone: 800-227-4224

3. Chemetrics
   http://www.chemetrics.com
   prodinfo@chemetrics.com
   Phone: 800-356-3072

Community Contacts

1. Save The Bay
   http://www.savesfbay.org
   Phone: 510-452-9261

2. Oakland Museum On-line Guide to San Francisco Bay Area Creeks
   http://www.museumca.org/creeks/
   helpful web site for local creek group contact numbers and addresses

3. Urban Creeks Council- East Bay Chapter
   http://www.urbancreeks.org/
   510-540-6669
   helpful for local creek group contact numbers and addresses and for historical creek and watershed information

4. Friends of the San Francisco Estuary
   http://www.abag.ca.gov/bayarea/sfep/about/friends.html
   (510) 622-2337
   advice on water quality, monitoring project set up, and equipment

Background Information

What tests should my class do?

We recommend doing about 5-6 main tests to get a clear picture of the health of your creek. Some of the main tests are pH, temperature, turbidity, dissolved oxygen, nitrates, phosphates, conductivity, and fecal coliform. Each test will come with its own equipment designed to test its variable. The equipment ranges from a simple thermometer to a more complicated kit filled with chemicals and titrators, etc. Water quality test kits will come with instructions for each test with the equipment.

A great resource for water quality testing is Mark Mitchell and William Stapp's Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools, ISBN 0-7872-3730-2, Kendall Hunt, 1997.

What do these tests mean?

pH is a measure of hydrogen ion concentration in liquids and substances. Each measured liquid or substance is given a pH value on a scale of 0-14 (acid to base). Readings less than seven are considered acidic, with 0 being most acidic. Readings greater than 7 are considered basic with 14 being most basic. Pure de-ionized water has a neutral value of 7. Pure rainwater has a pH of 5.6, whereas most natural waters fall into the range of 6.5-8.5. Your creek readings should fall into the range of 6.5-8.5. Increased amounts of NOx and SOx from burning of fossil fuels cause acid rain which can affect the pH.

Temperature is a measurement of how hot or cold something is. Water temperature is a very important measure of water quality. Extreme water temperatures affect the amount of oxygen that can be dissolved in water for aquatic wildlife to breath, the rate of photosynthesis for aquatic plants, metabolic rates of aquatic organisms, and the sensitivity of water organisms to toxics. Some reasons for changes in temperature are thermal pollution, decreased amounts of trees shading creek banks, and soil erosion.

Turbidity is a measure of the relative clarity of the water, the greater the turbidity the murkier the water. Increases in turbidity are caused by an increase in total suspended solids in the water, which reduces the transmission of light for aquatic wildlife. High turbidity causes less diversity in aquatic life, waters become warmer causing oxygen levels to fall. Soil erosion, water discharge, urban runoff, and algal growth can increase turbidity.

Dissolved Oxygen is a measure of the presence of oxygen in the water. DO is essential for a healthy diversity of aquatic life. Though some organisms can survive at very low levels of oxygen, many fish and stressed communities require higher levels of DO. Most of this oxygen in the water comes from the atmosphere and aquatic plants. Changes in DO levels can be attributed to changes in temperature, changes in the volume of water moving down a creek, and a build-up of organic wastes from pesticides and fertilizers.

Nitrates measure the amount of nitrogen in the water system. Nitrogen is an element needed by all living plants and animals. It is used as a nutrient to build proteins. Increases in nitrate levels can be attributed to decomposition of aquatic plants and animals, excretions of aquatic organisms, sewage, and fertilizers. High levels of nitrates can lead to eutrophication (algal blooms, low oxygen levels) in a water system.

Phosphates are essential nutrients for plants and animals. They also occur naturally in the water at certain levels due to their presence in soil particles. They are used by plants for growth and fundamental metabolic reactions. Sources such as sewage, fertilizer, industrial wastes, soil erosion, and drainage swamps and marshes cause an influx in phosphorous which can lead to eutrophication.

Conductivity measures the water's ability to conduct electricity.

Fecal Coliform is a type of bacteria found in the feces of humans and other animals. It can enter water systems through direct discharge from animals, agricultural and storm runoff carrying animal waste, and from sewage output. If fecal coliform is high then there is a greater chance that pathogenic organisms are also present. Fecal coliform by itself is not harmful, but can be harmful if it is accompanied by pathogenic organisms. These pathogens can enter a creek through sewage output or animal waste. Coliform standards for human use: drinking water (1 TC), total body contact/swimming (200 TC), partial body contact/boating (1000 TC), and treated sewage effluent (less than 200 TC).

How can my class tell if our creek is healthy?

In addition to doing water quality testing, there are some basic ways to determine the health of the creek. Simple observation can help your class get an idea of how healthy the creek is for plants and animals. Your class should notice what plants and animals (including insects) are living along the creek, and how healthy the habitat along the creek looks. Your class should also note what the creek banks and channel look like and ask questions such as: are the creek banks eroded?, what kind of material is along the creek bank, dirt, concrete, etc.?, is the creek meandering or straight?, are there any culverts?, is the creek mainly above or underground?, what human activity occurs on or near the creek banks?, what kinds of land use practices occur near the creek (ex. agriculture, roads, factories, etc.). These kinds of questions and observations can help your class make some predictions regarding the health of the creek and the results of their water quality monitoring.

Planning

Ask yourself and your class if there are any other important questions to consider. Next, start on a list of preliminary activities to get your monitoring project going:

1. Selecting a Creek/Mapping Exercise
   Read and carry out the Urban Creek Survey Action Project in this curriculum.

2. Read the Background Information Section to properly orient yourself

3. Preparing Tests

- If purchasing test kits, remember to purchase ahead of time because they take time to ship to your school
- Read instructions for tests ahead of time and practice doing the tests so that you are comfortable with them before your class goes out on their monitoring trip
- Double-check that you have all the necessary supplies

Getting Connected

- Establish a relationship with other local groups who are involved with your creek. It is always good to create partnerships to help your class along with their action project.
- Refer to the Community Contact list above to help you locate city officials as well as local volunteers who work on the creek and may be willing to help or give you some advice on your class monitoring project.
- Some main agencies to contact are the Urban Creeks Council (who can help refer you to other local creek groups with similar interests), Friends of the San Francisco Estuary (who can give you advice on how to use the test kits), the city government (who can give you historical information on the creek and could possibly use your results to help monitor the creek), and your county's pollution prevention program. You can find their contact information in the community contacts section of this write-up.

Procedure

Now that you are ready for your class to begin monitoring, here are the main procedures you should follow:

1. Set a date and time to begin your first monitoring outing.
2. Gather the materials and take your class out to the site where you have chosen to collect the water sample. Make sure your class dresses appropriately for outdoor activity!
3. Observe the site and make a hypothesis about the health of the creek. What problems may exist and how could our testing reveal if there are problems.
4. Read through the instructions of your test kits with your class to familiarize yourselves with the testing procedures. You may want to have your class collect more than one water sample so that your class can practice and in case they make any mistakes.
5. Have your class gather the water samples in the plastic cups and begin testing.
6. Have your class record their results on the data sheets.

7. Discuss the results with them. Ask the students: are the results surprising? Can you tell if the creek is healthy or unhealthy from this information?
8. Have your class save their data sheets to write reports and chart data. They can also store data in the computer in spreadsheet or database format.
9. Make sure the class disposes of testing results/altered creek water in plastic waste water bottle and then flush the wastewater down drain. DON'T POUR TEST RESULTS BACK INTO CREEK IT WILL POLLUTE THE CREEK!

   (if testing at multiple sites repeat steps #1-9 at each site)
10. Plan the next monitoring outing. Try to plan your class outings at regular intervals (i.e. once a week, once a month, etc.) Do the testing at the same time of the day and obtain the sample from the same location every time to maintain consistency.

Evaluation

Every action project needs some sort of evaluation process to determine whether the project is successful and generating accurate results. This is another good reason to make connections with other local groups who are doing monitoring so that you can compare your students' data, equipment, and testing procedures to determine the accuracy of your results. It is also good to discuss the project with your students throughout the process, in order to work out any kinks and get feedback on how to improve it.

Extensions

1. As a follow-up students can generate graphs to record their data and discuss the meaning of the graphs.
- What trends are noticeable when looking at the test results over time?
- What are some natural processes that affect the results (such as seasons, possible tidal influence, floods, etc.)?
- What are some unnatural processes (human-induced) that affect the results (urban runoff, dumping, thermal pollution, etc.)?
- Does the creek seem healthy?
- Do the results surprise you? If so, why?

2. Students can create a water quality monitoring journal to help them track the health of the creek and to help them present their data in a professional scientific manner.

3. Students can organize a school-wide creek clean-up or grow native plants (see the activity in this curriculum) to improve the health of the creek.

Keeping An Eye On Our Creeks

Water Quality Monitoring

Student Pages

Water Quality Data Form

Location____

Field Investigators' Names____

Date______________________________ Time_____________________

Unusual Conditions (large storms, construction, etc.)_____________________________

____

Inches of rain in last 72 hours___________________ Air Temperature__________________

Test Conducted	Equipment Used	Results/Measurement	Units (ppm, ppt, degrees celsius, etc.)
Water Temperature			
Water Depth			
Turbidity			
pH			
Dissolved Oxygen			
Nitrates			
Phosphates			

Growing Natives

Native plant propagation in the classroom

TEACHER'S PAGES

Background

Propagating and planting native plants to help restore habitats around the San Francisco Bay provides a very real solution to some of the Bay's biggest issues. Invasion of non-native species and loss of habitat have both caused a drastic reduction in native plant populations around the Bay. Loss of native plants results in decreased habitat and food supplies for native organisms, disrupting the natural food chain and delicate ecological balance of Bay communities.

Central Questions

Why are native plant species important in habitats? What species are native to the San Francisco Bay Area? How can our class help protect native plant populations?

Time Required

This project can vary greatly depending on the level of depth and amount of time you want to spend. Keep in mind that studying native plants and their role in the ecosystem is a great way to learn about habitats and the environment even if you don't have a lot of time to spend on a long-term project. Helping to restore native plant communities can be as simple as a half-day or one-day volunteer project at a local nursery, or as involved as building raised beds or a greenhouse on your school grounds to propagate native plants. The project may last anywhere from one day, one week, one unit, one semester, or be an integral part of your whole school year.

California Science Content Standards

Grade 6

Ecology (Life Science)

5. Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept, students know:
   a. energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and then from organism to organism in food webs.
   b. over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment.

Grades 9 - 12

Ecology

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept, students know:
   a. biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.
   b. how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.

Getting Started

Taking on a native plant propagation project can seem overwhelming. It is very important to make good use of community resources and programs that are designed to help you in your botanical endeavors.

Growing native plants from seed in the classroom provides an enjoyable hands-on science activity that then can be coupled with action through restoration.

Raising plants that are native and that play a unique role in their local ecosystem presents students with an interdisciplinary opportunity that is related to real-world issues and events. As students observe and examine basic botanical processes and participate in the care for their plants' success, they become educated in a variety of ways. This type of study increases observational skills, enhances traditional research methods, better reaches tactile learners, and can easily be led by students. Growing things in the classroom, whether plants, frogs, or fish, is not age-specific and is successful with different learning styles. Activities and study can be adapted to complement a variety of subjects, including the sciences, arts, writing, natural history, and service learning.

The learning experience is complete when the student plants their seedlings in the ground where it will provide food and habitat for other native animals, birds, and aquatic insects. The native willow or cordgrass is then seen as an integral part of a larger habitat, playing a unique role and providing a niche that nothing else can.

Important Questions

Growing native plants helps keep the environment healthy for many reasons. As you start to plan a native plant project, it is important to realize why you are doing it so that you can share this effectively with the students.

Why grow natives? Louise Lacey of the Growing Natives Institute has provided these thoughts in answer to the question:

1. Native flora brings native fauna.
2. When native plants are growing together in their own plant community configuration, without fertilizer and cultivation, the soil regains its health. Everything from earthworms to beneficial bacteria return.
3. It's much more economical, for several reasons:
   - No soil preparation is necessary, not even plowing or rototilling. Weed removal is necessary though.
   - Native plants are well-adapted to local conditions, to tolerate drought, etc. Natives never need fertilizing, cultivating, or irrigating once they are established.
   - Pruning is also minimal, because natives usually grow to their mature form and then stay that size, whereas hybrids continue to grow and grow.
   - While initial maintenance is more intensive (those pesky weeds), long term maintenance is extremely low because once a native community is established, weeds can't get in.

Which native plants should we grow?
Here is a partial list of beneficial natives:

Riparian	Wetland
Oak	Gum Plant
Box Elder	Alkali Heath
Buckeye	Marsh Rosemary
White & Red Alder	Saltgrass
Willow	Pickleweed
Dogwood	Cordgrass
Big Leaf Maple	Jaumea
Toyon	Eelgrass
Monkey Flower	Coyote Brush
Sycamore	Arrowgrass

Where can we plant the natives once we have propagated? Are there areas around the school or in your community that need planting? It is a good idea to talk with community experts, like your local resource conservation district, for information and advice on where to plant your native plants. Many resource professionals will be able to tell you the specific needs in your community, or if there are existing projects that your class could take part in. This project provides a solution to a relevant need in the community, and putting kids in touch with real-life restoration projects and professionals will help them to feel like they are a part of a bigger picture. By focusing on a local problem like loss of native plant habitat, the students will realize that what they are learning about is related to important local issues and is meaningful and necesssary.

Resource List

There are many excellent resources for raising native plants and establishing school gardens. These organizations can provide assistance for your project and some can even provide classroom visits or field trips.

Native Plant Information

California Native Plant Society
http://www.cnps.org
List of local chapters on website

"Kids In Gardens" Program
Aquatic Outreach Institute
http://www.aoinstitute.org
510-231-5655

SLUG
San Francisco League of Urban Gardeners
http://www.grass-roots.org/usa/slug.shtml

Return of the Natives
http://watershed.csumb.edu/ron/
Education program, extensive native plant nursery, demonstration restoration garden, yearly Symposia in Restoration for high school students, summer internships, quarterly newsletter, "War on Weeds", weekly events

Watershed Institute
http://watershed.csumb.edu/

Regional Parks Botanic Garden
Tilden Regional Park
http://www.nativeplants.org/

Golden Gate National Parks Nurseries
http://www.ggnpa.org/volunteer/nurseries.html
You can schedule a class visit to one of the five native plant nurseries in the Park, where students will help propagate native plants for habitat restoration.

Save The Bay
Community-Based Restoration Program
http://www.savesfbay.org/educationprograms/restoration/
510-452-9261
Propagation of native upper salt marsh plants for restoration in wetlands.

Internet Curriculum Resources

Project Learning Tree
http://www.plt.org

EPA Environmental Education Center
http://www.epa.gov/teachers

CalAlive! Biodiversity Program
http://www.calalive.org

Bank stabilization/ creek restoration

Your local Resource Conservation District

CA Dept of Fish & Game
http://www.dfg.ca.gov

USDA Soil Conservation Service
http://www.usda.gov

Urban Creeks Council
http://www.urbancreeks.org/
510-540-6669

Planning
A plant propagation project requires good planning to be successful. The size and scope of your project will dictate how much planning will be necessary to make it a worthwhile experience for your students. Here is a list of questions to think about as you plan:
1. What do I want to accomplish?
2. How long do I want to spend on this project?
3. How will it fit into my curriculum?
4. Do I want to take part in another project off-campus, or create an on-campus propagation project?
5. On or off-campus, who will I partner with to obtain seeds, propagate plants, and transplant, etc?
6. Are there any other community groups that may be able to help with tools, volunteering, expertise, etc.?

Evaluation
As with all of our action projects, evaluation is a key component to completing the learning cycle. If your students have been growing native plants in the classroom, there are many obvious ways to evaluate the project. Have the students record information about watering, growth, plant development, etc. Each student may keep a journal to keep track of the life of their plant, and here they can include any recorded information, as well as drawings and artwork about their plant. You may decide to have them study the habitat where this plant lives, what conditions it will need to survive, what animals it will provide food for, and how urban issues are affecting its' survival.
The study of native plants can lead your class into many other topics for discussion. By exploring their place in the ecosystem, you will be able to teach about local habitats, food chains, interdependance, and human issues that are having an impact on the ecosystem. Your students will not only learn about native plants, but will have the chance to learn more about the bigger picture of the whole watershed and what they can do to protect it.

Glossary

Abiotic: The non-living components of an ecosystem, such as light, soil, water and air.

Acid: Any substance that has a pH level below 7, or that has more free hydrogen ions (H+) than Hydroxide ions (OH-).

Adaptation: A change in the structure or behavior of a species over time in response to a change in its environment.

Algae: Simple, aquatic plants without roots, stems, and leaves, but with chlorophyll.

Alien: See Non-native.

Anadromous Fish: A fish that is born in fresh water, spends its life in salt water, and migrates back to fresh water to spawn.

Aquifer: An underground lake or pond containing fresh water.

Bay Fill: The process of dumping soil and other materials into the Bay and wetlands in order to change them into dry land on which to build.

Benthic Organisms: Species that live on the bottom of lakes, ponds, oceans, and tidal zones.

Bioaccumulation: The process of gathering certain substances (usually pollutants) in higher and higher concentrations within a living organism.

Biodiversity: The number of different kinds of living things in an area. The more variety among the different kinds of living things, the higher the diversity.

Biotic: The living components in a habitat (e.g., plants, vertebrates, invertebrates, etc.).

Brackish Water: Containing a mix of fresh and salt water.

Consumer: All animals which cannot make their own food and are dependent on plants (or animals that eat plants) as a source of energy.

Decomposer: An organism (such as bacteria) that breaks down dead plants and animals into more basic elements, releasing nutrients.

Density: The compactness or crowdedness of matter (e.g., water molecules) in a given area.

Dike: A low wall made of dirt used to separate sections of a body of water from the the main body. Dikes are often used in salt ponds and bay fill.

Dissolved Oxygen: The amount of oxygen in the water, measured in parts per million, or ppm. Although most fish can survive low dissolved oxygen for short periods of time, most fish need at least 5 ppm to be healthy and grow.

Drainage: 1) A watershed, or 2) The ability of a substance to pass water through it. Gravel has good drainage, while clay has poor drainage.

Ebb Tide: The return of tide water toward the sea; the out-going tide.

Ecology: The study of the interrelationship of organisms and their environments.

Ecosystem: The plants and animals living in an area together with their surroundings, considered as a system of relationships.

Erosion: The process by which land surfaces are worn away by the movement of water, wind, waves, etc.

Estuary: A semi-enclosed body of water where fresh and salt water mix.

Evolution: A theory that the various types of animals and plants have their origin in other preexisting types and that the distinguishable differences are due to modifications in successive generations.

Exotic: See Non-native.

Extinction: The wiping out of an entire species of plant or animal.

Flood Tide: The return of tide water toward the land; the incoming tide.

Genetics: The study of genes, DNA, and their influence on organisms.

Groundwater: Water that has percolated through the land's surface and resides in aquifers or underground waterways.

Habitat: The native environment of an animal or plant; the kind of place that is natural for the life and growth of an animal or plant.

Hydric Soils: Undrained clay-like soils.

Hydrophytes: Vegetation that is adapted to living in wet conditions.

Impervious: The quality of not soaking up liquids.

Indigenous: See Native.

Introduced: See Non-native.

Invasive: See Non-native.

Limiting Factor: Any environmental factor (food, pollution, etc.)whose presence or absence prevents the growth of a plant or animal population.

Migration: When animals (such as fish, birds, butterflies, or whales) instinctively travel from one place to another often over great distances, to spawn or reach feeding grounds.

Mitigation: Improving one area in order to compensate for the damaging of another.

Native Species: Any plant or animal that originated within a particular ecosystem.

Natural Selection: The process through which the individual members of a species that are best suited to survive in their environment are the most reproductively successful. Thus, they pass on more of their genetic material to future generations of the species. Natural selection is the driving force behind evolution itself.

Niche: The particular set of environmental conditions that a specific species has evolved to inhabit most successfully.

Non-native Species: Any plant or animal species that was introduced into an ecosystem by humans; one that did not inhabit that ecosystem before being introduced.

Non-point Source Pollution: Widespread overland runoff containing pollutants; the contamination does not originate from one specific location, and pollution discharges over a wide land area.

Nutrient: Any substance which provides energy for growth (such as food, vitamins, minerals). When materials decompose, their nutrients are released.

pH: The acidity or alkalinity of the water. pH is measured on a scale of 0-14; less than 7 is acidic; over 7 is basic; and 7 is neutral.

Percolation: The movement of a liquid through a substance which filters it.

Phylogeny: The evolutionary history of a species.

Phytoplankton: Small plants that drift in the water current.

Plankton: Small plants and animals that drift in the water current.

Point Source Pollution: Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types.

Populations: Distinct groups of a particular species.

Pollutants: Anything that lessens or spoils the quality of the water, air, or land that it touches.

Producers: An organism with chlorophyll which uses light energy and nutrients to make its own food; the first level in food chains. Green plants are producers

Run-off: Water that flows over or through the land in a watershed.

Salinity: The saltiness of the water, measured in parts per thousand, or ppt. For example, fresh water is 0 ppt and the water in the ocean is 35 ppt. The water in the Bay is a mix of fresh and ocean water, with varying salinity.

Sediment: Dirt, silt, or sand that flows off the land and settles to the bottom of a waterway or is suspended in the water.

Spawn: Method of reproduction used by fish in which the female lays eggs and the male fertilizes them.

Slough: A slow moving meandering channel with muddy banks through a marsh.

Tides: The "rising and falling" of the ocean primarily due to the motion of the moon and the sun.

Watershed: The area of land that drains into a river and its tributaries; the area of land from which rain or melting snow drain into a river stream or other body of water.

Zooplankton: Small animals that drift in the water current.

Content Standards Matrix

Every activity in this curriculum covers some of the California content standards. This matrix shows the grade level and subject of the content standards met by each activity. Please note that this is a guide to content standards only, and that all of the activities can be easily adapted for grades 6-12.

	SUBJECT			GRADE LEVEL								
ACTIVITY	Science	Language Arts	History/Social Science	4	5	6	7	8	9	10	11	12
Watershed Journal		X		X	X	X	X	X	X	X	X	X
The San Francisco Bay's Watershed in Your Hands	X			X	X	X						
Wetlands in a Pan	X					X						
When Rain Hits the Land	X					X	X	X				
The Bay Starts Here	X	X	X			X	X	X	X	X	X	X
Mapping Your Watershed	X					X			X	X	X	X
Three Ways to be 3-D	X					X			X	X	X	X
It Goes with the Flow	X	X	X			X	X	X	X	X	X	X
Peanut Butter and Jelly Geology	X					X	X		X	X	X	X
Liquefaction in Action	X					X	X		X	X	X	X
Dirt All Around	X			X		X		X				
What Happened Here Before	X	X				X	X		X	X	X	X
A Healthy Bay is a Wealthy Bay	X	X	X					X	X	X	X	X
Life in the Bay	X	X				X	X		X	X	X	X
Help Wanted	X	X				X						
Adapted for Survival	X						X		X	X	X	X
Survival or Extinction	X						X		X	X	X	X
Earth Day Birthday Party	X	X				X	X	X	X	X	X	X
Creature Double Feature	X	X				X			X	X	X	X
Salmon Challenge	X						X		X	X	X	X
Saving the Bay	X	X	X						X	X	X	X
The Great Hydraulic Mining Debate	X	X	X					X	X	X	X	X
Water Water Everywhere...Not	X	X	X					X	X	X	X	X
Airport Debate	X	X							X	X	X	X

California Content Standards

A unit of study focusing on San Francisco Bay's Watershed can address many of California's Content Standards. The following pages contain excerpts from science, history/social studies, and language arts standards for grades 6 - 12 which could best be included in a unit on the Bay's Watershed. Before designing your pathway for teaching about the Bay's Watershed, read through the standards for the grade level(s) you teach. This may help you integrate the standards into the unit, or could show ways that the Bay's Watershed could be integrated into lessons you already teach. Along with this list, each activity has a summary of the standards it addresses. Not all of the applicable standards are addressed by an activity in this curriculum, but we have tried to include activities representative of many subject areas and spanning from grade 6 to grade 12. To read the complete texts of California's Content Standards for all subjects, see http://www.cde.ca.gov/board/.

Although most education about the environment occurs in science classes, the richness of San Francisco Bay's Watershed, which encompasses nearly half of the state of California, cannot be conveyed through a single discipline. Our Watershed is home to our history and culture, economy, literature, politics, and ecology. It is for this reason that Save The Bay's San Francisco Bay Watershed Curriculum employs an integrated approach in teaching students about environmental issues. Working with other teachers in other disciplines or teaching thematically will allow you to use the Bay's Watershed as an integrating context for learning.

Teaching about the Bay's Watershed may include:

- ✔ history lessons about native Californians, the gold rush, the rise of agriculture, or the water wars,
- ✔ social science lessons about the way decisions are made about controversial issues such as expanding San Francisco Airport's runways, or an analysis of the history of an environmental organization and the ability of citizens to bring their influence to bear on government,
- ✔ language arts lessons reading and analyzing one of California's many "environmental" writers, writing a research paper about an animal that lives in the Bay, or giving a persuasive speech about an issue affecting the Bay,
- ✔ earth science lessons about the formation of the Bay's watershed through plate tectonics, erosion, and sedimentation,
- ✔ chemistry lessons about water quality,
- ✔ and biology lessons about the evolution and ecology of life in the Bay.

Research suggests that the brain searches for interconnections that create understanding[1] and that learning is more meaningful to students if they understand how concepts are related to one another[2]. This curriculum integrates several subject areas within each activity as a method of demonstrating complex themes. By transcending the boundaries of traditional disciplines, this Watershed Curriculum allows students to grapple with real-life interconnections that necessitate higher-order thinking skills[3].

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[1] R. Caine and G. Caine, *Making Connections: Teaching and the Human Brain,"* Alexandria: Association for Supervision and Curriculum Development, (1991).

[2] D.D. Bransford, N.F. Vye, L.T. Adams, & G.A. Perfetto, *Learning Skills and the Acquisition of Knowledge,* in Foundations for a Psychology of Education, Eds: Lesgold and R. Glaser, Hillsdale: Lawrence Arlbaum Associates, Publishers, (1989).

[3] S.M. Drake, *Planning integrated curriculum: the call to adventure*, Alexandria: Association for Supervision and Curriculum Development (1993).

Excerpts from the California Science Content Standards

Note: The standards shown here appear out of sequence because we have retained the numbers from the original text.

Grade 4

Standard Set 2: Life Sciences

All organisms need energy and matter to live and grow. As a basis for understanding this concept, students know:

2.a. plants are the primary source of matter and energy entering most food chains.

2.b. producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.

2.c. decomposers, including many fungi, insects, and microorganisms, recycle matter from dead plants and animals.

Standard Set 3: Life Sciences

Living organisms depend on one another and on their environment for survival. As a basis for understanding this concept, students know:

3.a. ecosystems can be characterized by their living and nonliving components.

3.b. in any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

3.c. many plants depend on animals for pollination and seed dispersal, and animals depend on plants for food and shelter.

Standard Set 5: Earth Sciences

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

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

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

Grade 5

Standard Set 3: Earth Sciences (Earth's Water)

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

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

3.c. water vapor in the air moves from one place to anothe rand can form fog or clouds, which are tiny droplets of water or ice, and can fall to Earth as rain, hail, sleet, or snow.

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

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

Grade 6

Standard Set 1: Plate Tectonics and Earth's Structure

Plate tectonics explains important features of the Earth's surface and major geologic events. As the basis for understanding this concept, students know:

1.e. major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate motions.

1.f. how to explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes).

Standard Set 2: Shaping Earth's Surface

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

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

2.b. rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.

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

2.d. earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

Standard Set 4: Energy in the Earth System

Many phenomena on the Earth's surface are affected by the transfer of energy through radiation and convection currents. As a basis for understanding this concept, students know:

4.a. the sun is the major source of energy for phenomena on the Earth's surface, powering winds, ocean currents, and the water cycle.

Standard Set 5: Ecology (Life Sciences)

Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept, students know:

5.a. energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and then from organism to organism in food webs.

5.b. over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment.

5.c. populations of organisms can be categorized by the functions they serve in an ecosystem.

5.d. different kinds of organisms may play similar ecological roles in similar biomes.

5.e. the number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

Standard Set 7: Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content the other three strands, students should develop their own questions and perform investigations. Students will:

7.a. develop a hypothesis.

7.b. select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

7.c. construct appropriate graphs from data and develop qualitative statements about the relation ships between variables.

7.d. communicate the steps and results from an investigation in written reports and verbal presentations.

7.e. recognize whether evidence is consistent with a proposed explanation.

7.f. read a topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple scale map.

7.g. interpret events by sequence and time from natural phenomena (e.g., relative ages of rocks and intrusions).

7.h. identify changes in natural phenomena over time without manipulating the phenomena (e.g., a tree limb, a grove of trees, a stream, a hillslope).

Grade 7

Standard Set 3: Evolution

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

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

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

3.c. how independent lines of evidence from geology, fossils, and comparative anatomy provide a basis for the theory of evolution.

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

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

Standard Set 4: Earth and Life History

Evidence from rocks allows us to understand the evolution of life on Earth. As the basis for understanding this concept, students know:

4.a. Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.

4.b. the history of life on Earth has been disrupted by major catastrophic events, such as major volcanic eruptions or the impact of an asteroid.

4.c. the rock cycle includes the formation of new sediment and rocks. Rocks are often found in layers with the oldest generally on the bottom.

4.d. evidence from geologic layers and radioactive dating indicate the Earth is approximately 4.6 billion years old, and that life has existed for more than 3 billion years.

4.e. fossils provide evidence of how life and environmental conditions have changed.

4.f. how movements of the Earth's continental and oceanic plates through time, with associated changes in climate and geographical connections, have affected the past and present distribution of organisms.

4.g. how to explain significant developments and extinctions of plant and animal life on the geologic time scale.

Standard Set 7: Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content the other three strands, students should develop their own questions and perform investigations. Students will:

7.a. select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

7.b. utilize a variety of print and electronic resources (including the World Wide Web) to collect information as evidence as part of a research project.

7.c. communicate the logical connection among hypothesis, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.

7.d. construct scale models, maps and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

7.e. communicate the steps and results from an investigation in written reports and verbal presentations.

Grade 8

Standard Set 5: Reactions

Chemical reactions are processes in which atoms are rearranged into different combinations of molecules. As a basis for understanding this concept, students know:

5.e. how to determine whether a solution is acidic, basic or neutral.

Standard Set 8: Density and Buoyancy
All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept, students know:
- 8.a. density is mass per unit volume.
- 8.b. how to calculate the density of substances (regular and irregular solids, and liquids) from measurements of mass and volume.
- 8.c. the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid it has displaced.
- 8.d. how to predict whether an object will float or sink.

Standard Set 9: Investigation and Experimentation
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content the other three strands, students should develop their own questions and perform investigations. Students will:
- 9.a. plan and conduct a scientific investigation to test a hypothesis.
- 9.b. evaluate the accuracy and reproducibility of data.
- 9.c. distinguish between variable and controlled parameters in a test.
- 9.d. recognize the slope of the linear graph as the constant in the relationship y=kx and apply this to interpret graphs constructed from data.
- 9.e. construct appropriate graphs from data and develop quantitative statements about the relationships between variables.
- 9.f. apply simple mathematical relationships to determine one quantity given the other two (including speed = distance/time, density = mass/volume, force = pressure x area, volume=area x height).
- 9.g. distinguish between linear and non-linear relationships on a graph of data.

Grades 9-12

<u>Chemistry</u>

Standard Set 5: Acids and Bases
Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept, students know:
- 5.a. the observable properties of acids, bases and salt solutions.
- 5.b. acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.
- 5.d. how to use the pH scale to characterize acid and base solutions.

Standard Set 6: Solutions
Solutions are homogeneous mixtures of two or more substances. As a basis for understanding this concept, students know:
- 6.a. the definitions of *solute* and *solvent*.
- 6.d. how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.

<u>Biology/Life Sciences</u>

Standard Set 6: Ecology
Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept, students know:
- 6.a. biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.
- 6.b. how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.
- 6.c. how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.

6.d. how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles via photosynthesis and respiration.
6.e. a vital part of an ecosystem is the stability of its producers and decomposers.
6.f. at each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat and this can be represented in a food pyramid.
6.g.* how to distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.

Standard Set 8: Evolution (Speciation)
Evolution is the result of genetic changes that occur in constantly changing environments. As a basis for understanding this concept, students know:
8.a. how natural selection determines the differential survival of groups of organisms.
8.b. a great diversity of species increases the chance that at least some organisms survive large changes in the environment.
8.d. reproductive or geographic isolation affects speciation.

Earth Sciences
Standard Set 9: California Geology
The geology of California underlies the state's wealth of natural resources as well as its natural hazards. As a basis for understanding this concept, students know:
9.a. the resources of major economic importance in California and their relation to California's geology.
9.c. the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

Investigation and Experimentation
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content the other four strands, students should develop their own questions and perform investigations. Students will:
a. select and use appropriate tools and technology (such as computer-linked probes, spread sheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
b. identify and communicate sources of unavoidable experimental error.
c. identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
d. formulate explanations using logic and evidence.
f. distinguish between hypothesis and theory as science terms.
g. recognize the use and limitations of models and theories as scientific representations of reality.
h. read and interpret topographic and geologic maps.
i. analyze the locations, sequences, or time intervals of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
j. recognize the issues of statistical variability and the need for controlled tests.
k. recognize the cumulative nature of scientific evidence.
l. analyze situations and solve problems that require combining and applying concepts from more than one area of science.
m. investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

Excerpts from the California History/Social Science Content Standards

Note: The standards shown here appear out of sequence because we have retained the numbers from the original text.

Grade 4

CALIFORNIA: A CHANGING STATE

Students learn the story of their home state, unique in American history in terms of its vast and varied geography, its many waves of immigration beginning with pre-Columbian societies, its continuous diversity, economic energy, and rapid growth....

4.1 Students demonstrate an understanding of the physical and human geographic features that define places and regions in California.

1. Identify the locations of the Pacific Ocean, rivers, valleys, and mountain passes and explain their effects on the growth of towns.
2. Use maps, charts, and pictures to describe how communities in California vary in land use, vegetation, wildlife, climate, population density, architecture, services, and transportation.

4.2 Students describe the social, political, cultural, and economic life and interactions among people of California from the pre-Columbian societies to the Spanish mission and Mexican rancho periods.

1. Discuss the major nations of California Indians, including their geographic distribution, economic activities, legends, and religious beliefs; and describe how they depended on, adapted to, and modified the physical environment by cultivation of land and use of sea resources.
3. Describe the Spanish exploration and colonization of California, including the relationships among soldiers, missionaries, and Indians (e.g., Juan Crespi, Junipero Serra, Gaspar de Portola).

4.3 Students explain the economic, social, and political life in California from the establishment of the Bear Flag Republic through the Mexican-American War, the Gold Rush, and the granting of statehood.

1. Identify the locations of Mexican settlements in California and those of other settlements, including Fort Ross and Sutter's Fort.
3. Analyze the effects of the Gold Rush on settlements, daily life, politics, and the physical environment (e.g., using biographies of John Sutter, Mariano Guadalupe Vallejo, Louise Clapp).

4.4 Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.

2. Explain how the Gold Rush transformed the economy of California, including the types of products produced and consumed, changes in towns (e.g., Sacramento, San Francisco), and economic conflicts between diverse groups of people.
6. Discuss the effects of the Great Depression, the Dust Bowl, and World War II on California. Describe the development and locations of new industries since the ninteenth century, such as the aerospace industry, electronics industry, large-scale commercial agriculture and irrigation projects, the oil and automobile industries, communications and defense industries, and important trade links with the Pacific Basin.
7. Trace the evolution of California's water system into a network of dams, aqueducts, and reservoirs.

Grade 5

UNITED STATES HISTORY AND GEOGRAPHY: MAKING A NEW NATION

Students in grade five study the development of the nation up to 1850, with an emphasis on the people who were already here, when and from where others arrived, and why they came.... Studying the cause, course, and consequences of the early explorations through the War for Independence and western expansion is central to students' fundamental understanding of how the principles of the American republic form the basis of a pluralistic society in which individual rights are secured.

5.1 Students describe the major pre-Columbian settlements, including the cliff dwellers and pueblo people of the desert Southwest, the American Indians of the Pacific Northwest, the nomadic nations of the Great Plains, and the woodland peoples east of the Mississippi River.

1. Describe how geography and climate influenced the way various nations lived and adjusted to the natural environment, including locations of villages, the distinct structures that they built, and how they obtained food, clothing, tools, and utensils.
2. Describe their varied customs and folklore traditions.
3. Explain their varied economies and systems of government.

5.3 Students describe the cooperation and conflict that existed among the American Indians and between the Indian nations and the new settlers.

4. Discuss the role of broken treaties and massacres and the factors that led to the Indians defeat, including the resistance of Indian nations to encroachments and assimilation (e.g., the story of the Trail of Tears).

Grades 6-8 Introduction: Historical and Social Sciences Analysis Skills

The intellectual skills noted below are to be learned through, and applied to, the content standards for grades six through eight. They are to be assessed *only in conjunction with* the content standards in grades six through eight. *In addition to the standards for grades six through eight, students demonstrate the following intellectual reasoning, reflection, and research skills:*

Chronological and Spatial Thinking

3. Students use a variety of maps and documents to identify physical and cultural features of neighborhoods, cities, states, and countries and to explain the historical migration of people, expansion and disintegration of empires, and the growth of economic systems.

Research, Evidence and Point of View

5. Students detect the different historical points of view on historical events and determine the context in which the historical statements were made (the questions asked, sources used, author's perspectives).

Grade 6
WORLD HISTORY AND GEOGRAPHY: ANCIENT CIVILIZATIONS

Students in grade six expand their understanding of history by studying the people and events that ushered in the dawn of the major Western and non-Western ancient civilizations. Geography is of special significance in the development of the human story. Continued emphasis is placed on the everyday lives, problems, and accomplishments of people, their role in developing social, economic, and political structures, as well as in establishing and spreading ideas that helped transform the world forever. Students develop higher levels of critical thinking by considering why civilizations developed where and when they did, why they became dominant, and why they declined. Students analyze the interactions among the various cultures, emphasizing their enduring contributions and the link, despite time, between the contemporary and ancient worlds.

6.1 Students describe what is known through archaeological studies of the early physical and cultural development of humankind from the Paleolithic era to the agricultural revolution.

1. Describe the hunter-gatherer societies, including the development of tools and the use of fire.
2. Identify the locations of human communities that populated the major regions of the world and describe how humans adapted to a variety of environments.
3. Discuss the climatic changes and human modifications of the physical environment that gave rise to the domestication of plants and animals and new sources of clothing and shelter.

Grade 8

UNITED STATES HISTORY AND GEOGRAPHY: GROWTH AND CONFLICT

Students in grade eight study the ideas, issues and events from the framing of the Constitution up to World War I, with an emphasis on America's role in the war. After reviewing the development of America's democratic institutions founded in the Judeo-Christian heritage and English parliamentary traditions, particularly the shaping of the Constitution, students trace the development of American politics, society, culture and economy and relate them to the emergence of major regional differences. They learn about the challenges facing the new nation, with an emphasis on the causes, course and consequences of the Civil War. They make connections between the rise of industrialization and contemporary social and economic conditions.

8.8 Students analyze the divergent paths of the American people from 1800 to the mid-1800's and the challenges they faced, with emphasis on the West, in terms of:

2. the purpose, challenges and economic incentives associated with westward expansion including the concept of Manifest Destiny (e.g., Lewis and Clark expedition, accounts of the removal of Indians and the Cherokees' "Trail of Tears," settlement of the Great Plains) and the territorial acquisitions that spanned numerous decades
4. the role of the great rivers and the struggle over water rights

8.12 Students analyze the transformation of the American economy and the changing social and political conditions in the United States in response to the Industrial Revolution, in terms of:

1. patterns of agricultural and industrial development as they relate to climate, natural resource use, markets, and trade, including their location on a map
5. the location and effects of urbanization, renewed immigration, and industrialization (e.g., effects on social fabric of cities, wealth and economic opportunity, and the conservation movement)

Grades 9-12 Introduction: Historical and Social Sciences Analysis Skills

The intellectual skills noted below are to be learned through, and applied to, the content standards for grades six through eight. They are to be assessed *only in conjunction with* the content standards in grades six through eight. *In addition to the standards for grades six through eight, students demonstrate the following intellectual reasoning, reflection, and research skills:*

Chronological and Spatial Thinking

1. Students compare the present with the past, evaluating the consequences of past events and decisions and determining the lessons that were learned.
3. Students use a variety of maps and documents to interpret human movement, including major patterns of domestic and international migration, changing environmental preferences and settlement patterns, the frictions that develop between population groups, and the diffusion of ideas, technological innovations, and goods.

Historical Interpretation

3. Students interpret past events and issues within the context in which an event unfolded rather than solely in terms of present-day norms and values.
4. Students understand the meaning, implication, and impact of historical events and recognize that events could have taken other directions.
5. Students analyze human modifications of landscapes and examine the resulting environmental policy issues.

Grade 11

U.S. HISTORY AND GEOGRAPHY: CONTINUITY AND CHANGE IN THE TWENTIETH CENTURY

Students in grade eleven study the major turning points in American history in the 20th century. Following a review of the nation's beginnings and the impact of the Enlightenment on U.S. democratic ideals, students build upon the tenth grade study of global industrialization to understand the emergence and impact of new technology and a corporate economy, including the social and cultural effects. They trace the change in the ethnic composition of American society; the movement towards equal rights for racial minorities and women; and the role of the United States a major world power. An emphasis is placed on the expanding role of the federal government and federal courts as well as the continuing tension between the individual and the state. Students consider the major social problems of our time and trace their causes in historical events. They learn that the United States has served as a model for other nations and that the rights and freedoms we enjoy are not accidents, but the results of a defined set of political principles that are not always basic to citizens of other countries. Students understand that our rights under the U.S. Constitution comprise a precious inheritance that depends on an educated citizenry for their preservation and protection.

11.6 Students analyze the different explanations for the Great Depression and how the New Deal fundamentally changed the role of the federal government.

3. Discuss the human toll of the Depression, natural disasters, unwise agricultural practices and their effect on the depopulation of rural regions and on political movements of the left and right with particular attention to the Dust Bowl refugees and their social and economic impact in California.
4. Analyze the effects and controversies of New Deal economic policies and the expanded role of the federal government in society and the economy since the 1930's (e.g., Works Progress Administration, Social Security, National Labor Relations Board, farm programs, regional development policies and energy development such as the Tennessee Valley Authority, California Central Valley Project, Bonneville Dam).

11.8 Students analyze the economic boom and social transformation of post-World War II America.

6. Discuss the diverse environmental regions in North America, their relation to particular forms of economic life, and the origins and prospects of environmental problems in those regions.

11.11 Students analyze the major social problems and domestic policy issues in contemporary American society.

5. Trace the impact of, need for, and controversies associated with environmental conservation, expansion of the national park system, and the development of environmental protection laws, with particular attention to the interaction between environmental protection and property rights.

Grade 12

PRINCIPLES OF AMERICAN DEMOCRACY

Students in grade twelve pursue a deeper understanding of the institutions of American government.... An emphasis is placed on analyzing the relationship among federal, state and local governments, with particular attention paid to important historical documents such as *The Federalist*. These standards represent the culmination of civic literacy as students prepare to vote, participate in community activities and assume the responsibilities of citizenship.

12.3 Students evaluate, take and defend positions on what the fundamental values and principles of civil society are (i.e., the autonomous sphere of voluntary personal, social, and economic relations not part of government), their interdependence, and meaning and importance for a free society.

1. Explain how civil society provides opportunities for individuals to associate for social, cultural, religious, economic, and political purposes.
2. Explain how civil society makes it possible for people, individually or in association with others, to bring their influence to bear on government in ways other than voting and elections.

12.7 Students analyze and compare the powers and procedures of the national, state, tribal, and local governments.

5. Explain how public policy is formed, including the setting of the public agenda and how it is carried out through regulations and executive orders.
6. Compare the process of lawmaking at each of the three levels of government, including the role of lobbying and the media.

12.8 Students evaluate, take and defend positions on the influence of the media on American political life.

1. Discuss the meaning and importance of a free and responsible press.
2. Describe the role of electronic, broadcast, print media, and the Internet as means of communication in American politics.
3. Explain how public officials use the media to communicate with the citizenry and to shape public opinion.

Excerpts From the Introduction to the California English-Language Arts Content Standards

An Essential Discipline

The ability to communicate well—to read, write, listen, and speak—runs to the core of human experience. Language skills are essential tools not only because they serve as the necessary basis for further learning and career development but also because they enable the human spirit to be enriched, foster responsible citizenship, and preserve the collective memory of a nation.

Students who read well learn the tempo and structure of language early in their development. They master vocabulary, variance in expression, and organization and skill in marshaling evidence to support an idea. National Institutes of Health studies indicate that students who are behind in reading in grade three have only a 12 to 20 percent chance of ever catching up.

Fluent Readers and Skilled Writers

Students must read a broad variety of quality texts to develop proficiency in, and derive pleasure from, the act of reading. Students must also have experience in a broad range of writing applications, from the poetic to the technical.

Musicians cannot compose concertos (or play those composed by others) without first learning the scales and practicing them as well as reading and playing the music of the great composers who have survived the test of time. The same is true of young readers and writers and their relationships with the great writers who have preceded them.

Reading and writing technical materials, moreover, are critical life skills. Participation in society—filling out forms, voting, understanding the daily newspaper—requires solid reading and writing competencies. Similarly, most jobs demand the abilities to read and write well. Collegiate and technical courses generally require a high level of proficiency in both abilities. In an emergency, reading and writing with speed and accuracy may literally mean the difference between life and death.

Reading and writing offer the power to inform and to enlighten as well as to bridge time and place. For example, interpreting and creating literary texts help students to understand the people who have lived before them and to participate in, and contribute to, a common literary heritage. Through literature, moreover, students experience the unique history of the United States in an immediate way and encounter many cultures that exist both within and beyond this nation's borders. Through reading and writing students may share perspectives on enduring questions, understand and learn how to impart essential information, and even obtain a glimpse of human motivation. Reading and writing offer incomparable experiences of shared conflict, wisdom, understanding, and beauty.

In selecting both literary and informational texts for required reading and in giving writing assignments (as well as in helping students choose their own reading and writing experiences), local governing boards, schools, and teachers should take advantage of every opportunity to link that reading and writing to other core curricula, including history, social science, mathematics, and science. By understanding and creating literary and technical writing, students explore the interrelationships of their own existence with those of others.

Students need to read and write often, particularly in their early academic careers. Reading and writing something of literary or technical substance in all disciplines, every day, both in and out of school, are the principal goals of these standards.

Confident Speakers and Thoughtful Listeners

Speaking and listening skills have never been more important. Most Americans now talk for a living at least part of the time. The abilities to express ideas cogently and to construct valid and truthful arguments are as important to speaking well as to writing well. Honing the ability to express defensible reflections about literature will ensure comprehension and understanding. Not long ago listening and speaking occupied central places in the curriculum, but only a few schools have maintained this tradition. The time has come to restore it.

English Language Learners

Nearly 25 percent of children in California enter school at various ages with primary languages other than English. The standards in this document have been designed to encourage the highest achievement of every student. No student is incapable of reaching them. The standards must not be altered for English language learners, because doing so would deny these students the opportunity to reach them. Rather, local education authorities must seize this chance to align specialized education programs for English language learners with the standards so that all children in California are working toward the same goal. Administrators must also work very hard to deliver the appropriate support that English language learners will need to meet the standards.

A Comprehensive Synergy

Reading, writing, listening, and speaking are not disembodied skills. Each exists in context and in relation to the others. These skills must not be taught independently of one another. Rather, they need to be developed in the context of a rich, substantive core curriculum that is geared not only toward achieving these standards per se but also toward applying language arts skills to achieve success in other curricular areas. The good news is that reading, writing, listening, and speaking are skills that invariably improve with study and practice. Mastery of these standards will ensure that children in California enter the worlds of higher education and the workplace armed with the tools they need to be literate, confident communicators.

English-Language Arts Content Standards
Excerpts from the Standards for 6^{th} – 12^{th} grades
(Subcategories and Written and Oral English Language Conventions not included)

Grades 4-5

WRITING

1.0 Writing Strategies
Students write clear, coherent sentences and paragraphs that develop a central idea. Their writing shows they consider the audience and purpose. Students progress through the stages of the writing process (e.g., prewriting, drafting, revising, editing successive versions).

2.0 Writing Applications (Genres and Their Characteristics)
Students write compositions that describe and explain familiar objects, events, and experiences.

Grades 6-8

READING

1.0 Word Analysis, Fluency, and Systematic Vocabulary Development
Students use their knowledge of word origins and word relationships, as well as historical and literary context clues, to determine the meaning of specialized vocabulary and to understand the precise meaning of grade-level-appropriate words.

2.0 Reading Comprehension (Focus on Informational Materials)
Students read and understand grade-level-appropriate material. They describe and connect the essential ideas, arguments, and perspectives of the text by using their knowledge of text structure, organization, and purpose. The selections in *Recommended Readings in Literature, Kindergarten Through Grade Eight* illustrate the quality and complexity of the materials to be read by students. In addition, by grade eight, students read one million words annually on their own, including a good representation of grade-level-appropriate narrative and expository text (e.g., classic and contemporary literature, magazines, newspapers, online information). In grade six, students continue to make progress toward this goal.

3.0 Literary Response and Analysis
Students read and respond to historically or culturally significant works of literature that reflect and enhance their studies of history and social science. They clarify the ideas and connect them to other literary works...

WRITING

1.0 Writing Strategies
Students write clear, coherent, and focused essays. The writing exhibits students' awareness of the audience and purpose. Essays contain formal introductions, supporting evidence, and conclusions. Students progress through the stages of the writing process as needed.

2.0 Writing Applications (Genres and Their Characteristics)
Students write narrative, expository, persuasive, and descriptive texts of at least 500 to 700 words in each genre. Student writing demonstrates a command of standard American English and the research, organizational, and drafting strategies outlined in Writing Standard 1.0.

LISTENING AND SPEAKING

1.0 Listening and Speaking Strategies
Students deliver focused, coherent presentations that convey ideas clearly and relate to the background and interests of the audience. They evaluate the content of oral communication.

2.0 Speaking Applications (Genres and Their Characteristics)
Students deliver well-organized formal presentations employing traditional rhetorical strategies (e.g., narration, exposition, persuasion, description). Student speaking demonstrates a command of standard American English and the organizational and delivery strategies outlined in Listening and Speaking Standard 1.0.

Grades 9-12

READING

1.0 Word Analysis, Fluency, and Systematic Vocabulary Development

Students apply their knowledge of word origins to determine the meaning of new words encountered in reading materials and use those words accurately.

2.0 Reading Comprehension (Focus on Informational Materials)

Students read and understand grade-level-appropriate material. They analyze the organizational patterns, arguments, and positions advanced. The selections in *Recommended Literature, Grades Nine Through Twelve* (1990) illustrate the quality and complexity of the materials to be read by students. In addition, by grade twelve, students read two million words annually on their own, including a wide variety of classic and contemporary literature, magazines, newspapers, and online information. In grades nine and ten, students make substantial progress toward this goal.

3.0 Literary Response and Analysis

Students read and respond to historically or culturally significant works of literature that reflect and enhance their studies of history and social science. They conduct in-depth analyses of recurrent patterns and themes. The selections in *Recommended Literature, Grades Nine Through Twelve* illustrate the quality and complexity of the materials to be read by students.

WRITING

1.0 Writing Strategies

Students write coherent and focused essays that convey a well-defined perspective and tightly reasoned argument. The writing demonstrates students' awareness of the audience and purpose. Students progress through the stages of the writing process as needed.

2.0 Writing Applications (Genres and Their Characteristics)

Students combine the rhetorical strategies of narration, exposition, persuasion, and description to produce texts of at least 1,500 words each. Student writing demonstrates a command of standard American English and the research, organizational, and drafting strategies outlined in Writing Standard 1.0.

LISTENING AND SPEAKING

1.0 Listening and Speaking Strategies

Students formulate adroit judgments about oral communication. They deliver focused and coherent presentations of their own that convey clear and distinct perspectives and solid reasoning. They use gestures, tone, and vocabulary tailored to the audience and purpose.

2.0 Speaking Applications (Genres and Their Characteristics)

Students deliver polished formal and extemporaneous presentations that combine the traditional rhetorical strategies of narration, exposition, persuasion, and description. Student speaking demonstrates a command of standard American English and the organizational and delivery strategies outlined in Listening and Speaking Standard 1.0.

Save The Bay's
Watershed Education Program

Save The Bay

Save The Bay was founded in 1961 to stop uncontrolled Bay fill and to open up the shoreline to public access. Its mission today is: *to preserve, restore, and protect the San Francisco Bay and Sacramento/San Joaquin River Delta Estuary as a healthy and biologically diverse ecosystem*. A membership supported organization, Save The Bay has become a leading voice for the Bay by raising public awareness of threats to the Bay/Delta ecosystem. Save The Bay is fighting to keep the Bay alive and healthy for all of us.

We Protect the Bay
We have stopped thousands of acres of landfill in the Bay, and we continue to fight against development that threatens Bay habitat. Save The Bay forces polluters to clean up toxic chemicals in the Bay so people can fish, windsurf, sail, and swim safely.

We Restore Bay Wetlands
We are making the Bay bigger and healthier by targeting 200,000 acres of Bay and Delta for restoration. Those areas were diked and drained long ago for farming or salt production. We work with landowners, businesses, citizens, and government agencies to restore these "Baylands" to wetlands, which provide vital food and habitat for endangered species -- and provide precious open space for future generations.

We Keep Rivers Flowing into the Bay
We fight for rivers and streams that the Bay needs to remain healthy. Save The Bay helped stop the Peripheral Canal and won increased water flows for endangered salmon in the Bay-Delta. We promote conservation programs to meet California's water needs without building new dams that would damage the Bay and all its inhabitants.

We Teach People About the Bay
An informed public is the Bay's best protection. We provide outdoor classrooms for adults and students to learn about the Bay, its wildlife and ways to protect it. Our *Canoes In Sloughs* program helps young people explore and discover the Bay.

We Open the Shoreline to You
The Bay belongs to all of us. Save The Bay promotes public access and recreation all around the Bay. We help to create and protect waterfront parks and trails so that everyone can continue enjoying the Bay.

Canoes In Sloughs

Bay Area students can now explore the San Francisco Bay's wetlands and sloughs to study the Estuary's plant, fish, and animal life as part of Save The Bay's Watershed Education Program. Our on-the-water Canoes in Sloughs field trips serve sixth through twelfth grade students throughout the Bay Area. The emphasis is on experiential activities involving educational tools, including water quality testing kits, dip nets, maps, and field guides.

The experiential nature of *Canoes In Sloughs* is premised upon the findings of educational researchers that experiential learning programs help to:

- Foster and enhance the effectiveness of in-class instruction by demonstrating the applicability of theoretical constructs;[1]
- Bolster students' sense of self-accomplishment through the mastery of skills;[2]
- Enhance the retention and recall of facts and skills;[3]
- Positively affect students' attitudes towards science and environmental concepts.[4]

Canoes In Sloughs is unique as the first experiential education program in the Bay Area that is on-the-water, tailored for middle and high school students, and designed to address California's Science Content Standards, using the Bay as an integrating concept. *Canoes In Sloughs* sparks student knowledge and interest in the ecosystems of the San Francisco Bay by linking them to their local watershed and engaging them in meaningful hands-on activities.

Save The Bay also conducts one-day and week-long teacher workshops which teach local teachers about the Bay's watershed and give teachers the tools to bring this knowledge into their classrooms. Save The Bay's one-day teacher trainings enhance participants' roles as educators in the San Francisco Bay Area, providing teachers with on-the-water educational experiences, resource materials, and support for integrating Bay curriculum into the classroom. The week-long summer Institutes are journeys through the San Francisco Bay Watershed, from the foothills of the Sierra to the Golden Gate, with on-the-water experiences, expert speakers, hands-on activities, and action project ideas throughout the week. The Institutes focus on the cultural, political, and biological history of San Francisco Bay's Watershed and how to integrate this into the classroom.

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[1] D.A. Kolb, *Experiential Learning: Experience As The Source Of Learning And Development* (1986), p. 4.

[2] Melvin Tuman, *Valid and Invalid Rationales,* in Morris T Keeton, Experiential Learning (1976), p. 56-58, 60.

[3] A. Mackenzie & R. White, *Fieldwork in Geography and Long term Memory Structures*, paper presented at the American Educational Research Association (1981).

[4] *Field Trips: Just Another Day in the Park?,* Legacy, July/August 1997, at 17; *see also* R.J. Salvador, D.W. Countryman & B.E. Miller, *Incorporating Problem-Based Experiential Teaching in the Agriculture Curriculum*, 24 J. Natural Resource & Life Science Education, (1995), p. 62.

Save the Bay's Education Methodologies

The Critical Pathway

Save The Bay believes that education is the critical pathway for creating a new generation of environmentally responsible citizens. Save The Bay has developed an approach to achieve behavior change through a carefully designed program, based on a model from Chesapeake Bay Foundation which focuses on teacher training, curriculum, student field trips, and action projects. The methodologies we use now are a result of many years of research, trial, and evaluation by the Chesapeake Bay Foundation.

The model is designed to change behavior and is based upon a paper by Harold R. Hungerfold and Trudi L. Volk, entitled *Changing Learner Behavior Through Environmental Education*. Hungerfold and Volk ask the question: "How might responsible environmental behavior be operationalized?" They first look to the objectives for environmental education in order to define an environmentally responsible citizen:

Tbilisi Intergovernmental Conference on Environmental Education, 1977
Objectives for Environmental Education

Awareness
to help social groups and individuals acquire an awareness and sensitivity to the total environment and its allied problems (and/or issues).

Sensitivity
to help social groups and individuals gain a variety of experiences in, and acquire a basic understanding of, the environment and its associated problems (and/or issues).

Attitudes
to help social groups and individuals acquire a set of values and feelings of concern for the environment and motivation for actively participating in environmental improvement and protection.

Skills
to help social groups and individuals acquire skills for identifying and solving environmental problems (and/or issues).

Participation
to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems (and/or issues).

Using these objectives, which call for active participation on top of basic knowledge, attitudes, and skills, Hungerford and Volk define variables which ultimately lead to behavior change. Their model goes beyond the basic idea that knowledge leads to awareness or attitudes which lead to action, and defines three categories of variables that contribute to behavior: entry-level variables, ownership variables, and empowerment variables, as shown in a behavior flow chart.

Hungerford and Volk's Behavior Flow Chart: Major and Minor Variables Involved in Environmental Citizenship Behavior

Entry-level variables

Major variable	Minor variables
Environmental sensitivity	Knowledge of ecology
	Attitudes toward pollution, technology, and economics

Ownership variables

Major variables	Minor variables
In-depth knowledge about issues	Knowledge of the consequences of behavior - both positive and negative
Personal investment in issues and the environment	A personal commitment to issue resolution

Empowerment variables

Major variables	Minor variables
Knowledge of and skill in using environmental action strategies	In-depth knowledge about issues
Locus of control (expectancy of reinforcment)	
Intention to act	

Citizenship Behavior

Hungerfold and Volk close with the following:

> One of the serious impediments to the kind of instruction recommended... is... that... it differs substantially from typical educational practice... Typically, issue awareness does not lead to behavior in the environmental dimension. This means we must look to a new model of instruction if behavior is important. And, because all environmental behavior is somehow issue related, it appears as though issues must be the focus of instruction beyond environmental sensitivity, ecological foundations, and issue awareness.
>
> If environmental issues are to become an integral part of instruction designed to change behavior, instruction must go beyond an "awareness" or "knowledge" of issues. Students must be given the opportunity to develop the sense of "ownership" and "empowerment" so that they are fully invested in an environmental sense and prompted to become responsible, active citizens.[1]

Save the Bay's Watershed Education Program Model

All of our programs are carefully designed around a "model" of how to most effectively reach a behavior change. We have found that the best education is a sequence of experiences and activities that use the following model as a framework.

Environmental Sensitivity
- Educational experiences are designed to develop empathy, respect and caring for the Bay and its watershed through direct hands-on exposure.
- Participants are given the opportunity to experience the Bay using all their senses by exposure to guided experiences on the water.

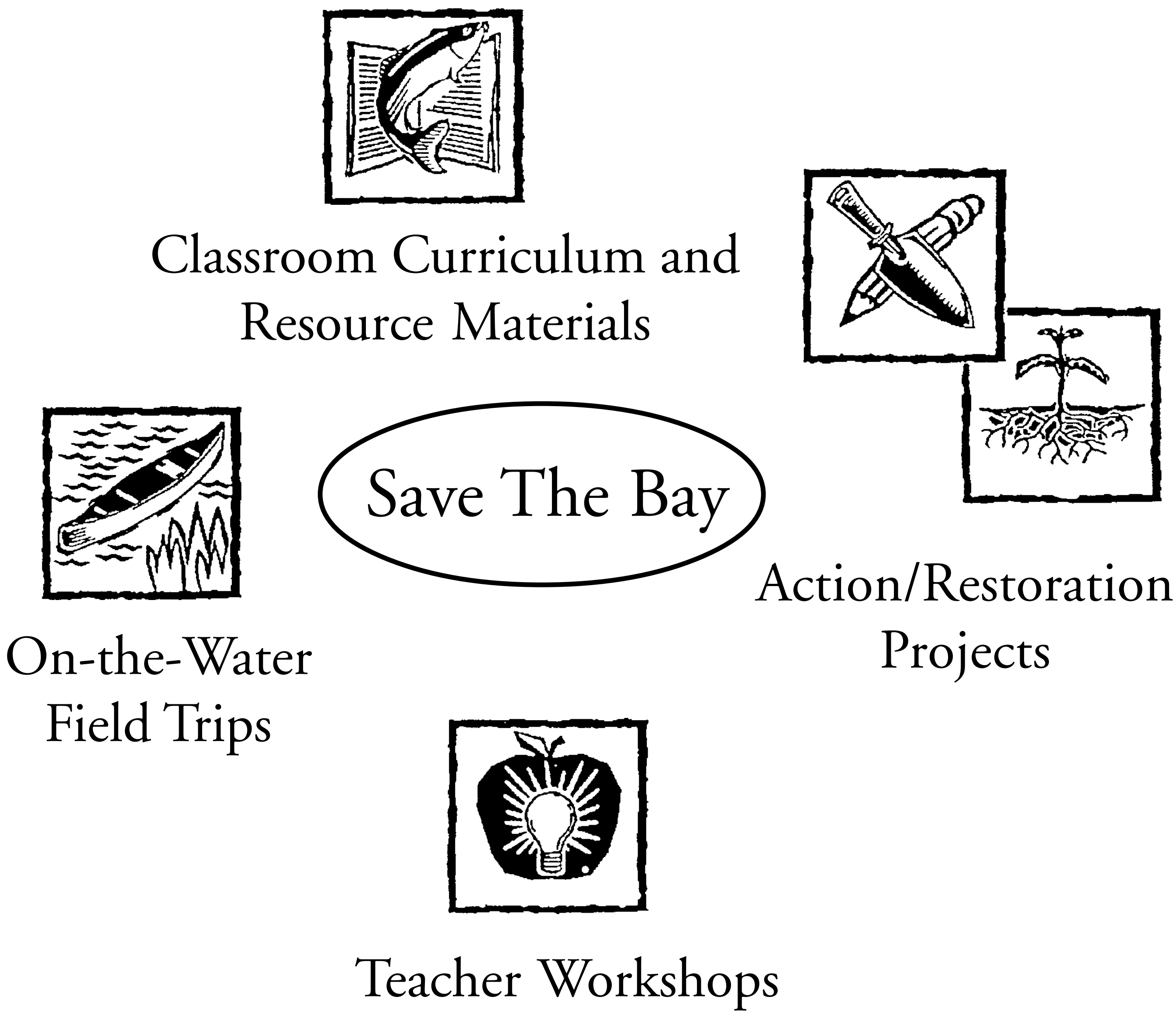
Environmental Knowledge
- Knowledge is stressed in many ways - knowledge of how an ecosystem works, knowledge of issues and history and knowledge of action strategies.
- Knowledge is gathered in the field and through pre-trip preparation in the classroom.
- Educational experiences are designed to impart knowledge necessary for making thoughtful decisions and skills for taking action to "Save The Bay."

Environmental Ownership
- Educational experiences connect people to the resource.
- Field trips help to develop an understanding of how one's own actions affect the Bay (both positively and negatively).
- Save The Bay stresses local issues on its trips so that the participants are more likely to have personal investment. For example, if we are offering a program in a location where recreational fishing is popular, we might use water as a central topic and local issues about the importance of clean water, spawning grounds and plenty of fresh water. The key word is relevance.
- Education provides motivation to learn about Bay issues and avenues for making a difference. Programs encourage ownership of the Bay and provide opportunities to relate to it through personal values, aesthetics, and a cultural understanding of the Bay.

[1] H.R. Hungerfold & T.L. Volk, *Changing Learner Behavior Through Environmental Education,* in Journal of Environmental Education, 21(3) (1990), pp. 8-21.

Empowerment to Act

- Educational experiences are designed to develop a citizenry that not only feels able to make a difference, but also has the thinking and action skills needed to act in environmentally responsible ways.
- Field trips use team building activities that raise participants' self-esteem and illustrate the necessity of individual responsibility in community action.
- Education stimulates a change in behavior or a change in the way participants think and act towards the environment.
- Any field trip is followed by a sustainable, meaningful, and relevant service learning project that the participants initiate, develop, and implement.
- Programs highlight issues that participants can help solve, so that their actions will easily be understood as making a difference. Students are conserving water, driving less, and looking at how their families use fertilizers and household chemicals.



San Francisco Bay Watershed Curriculum

Save The Bay is proud to be launching a Watershed Curriculum designed to prepare teachers and students for their field trip. These curriculum materials are best used as a preparation or follow-up to a field-based experience, but also work quite well alone. Much of this curriculum was developed and written by the Chesapeake Bay Foundation and Save The Bay is pleased to have Chesapeake Bay Foundation as a mentor. The activities in this guide are meant to heighten student awareness of local environmental issues, specifically those that have an impact on the San Francisco Bay. By developing a sense of ownership of, and subsequent responsibility for, their local land and waterways, students take a big step in helping to improve the quality of the entire Bay watershed. A recent nationwide study supports the use of the local environment as a context for education, stating that

> Students learn to read, write, and do math more effectively within an environment-based context than within a traditional educational framework… The learning effects… include:
> - Better performance on standardized measures of academic achievement in reading, writing, math, science, and social studies;
> - Reduced discipline and classroom management problems;
> - Increased engagement and enthusiasm for learning; and
> - Greater pride and ownership in accomplishments."[1]

Tara Reinertson

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[5] G.A. Lieberman and L.L. Hoody, *Closing the Achievement Gap: Using the Environment As An Integrating Context For Learning* (1998), at 22.

ADDITIONAL RESOURCES

If you or your students are interested in finding out more about San Francisco Bay and the environmental impacts affecting it, consider the following additional resources:

Related Field Trips and Resources for Teachers

- ***Aquatic Outreach Institute*** offers a San Francisco Bay Activity and Resource Guide for teachers. http://www.thewatershedproject.org/ or (510) 231-5655
- ***Audubon Canyon Ranch*** provides field trips at three nature preserves in Marin and Sonoma Counties. http://www.egret.org/ or (415) 868-9244
- ***Bay Shore Studies at Richardson Bay Audubon Sanctuary*** offers field trips for Grades 4-8 http://www.basa.info/pub/basa_org/50 or (415) 388-2524
- ***The Bay Model in Sausalito*** offers field trips and is a place to purchase books and maps of the San Francisco Estuary. http://www.spn.usace.army.mil/bmvc/ or (415) 332-3871
- ***The California Coastal Commission*** works to protect California's coastal and marine resources. They provide programs such as, Adopt-A-Beach and Coastal Cleanup Day. They also provide educational materials, such as Save Our Seas Curriculum, A Marine Resource Directory and a Loan Library. http://www.basa.info/pub/basa_org/111 or (415) 597-5888
- ***The California Academy of Sciences*** provides a lending library for educators. http://www.calacademy.org/research/library/naturalist_center/ or (415) 321-8090
- ***Don Edwards National Wildlife Refuge*** http://desfbay.fws.gov/environ.htm
- ***City of San Jose*** Educator Resources http://www.sanjoseca.gov/esd/schools/index.htm
- ***EarthTeam*** http://www.earthteam.net/links/for_teachers/index.html
- ***East Bay Regional Park District*** field trips and programs. http://www.regparksfdn.org/field_opportunities.html or (510) 544-2212
- ***Environmental Education Websites*** http://www.sanjoseca.gov/esd/schools/schools_websites.htm
- ***Friends of the San Francisco Estuary*** teacher workshops, estuary outreach, field sessions, and restoration projects. http://www.abag.ca.gov/bayarea/sfep/programs/ested/index.html#estenc or (510) 622-2337
- ***Geologic and Human History by SF Museum*** http://www.cr.nps.gov/seac/appeals.htm
- ***Marine Science Institute*** provides a variety of field trips both on and off the water. http://www.sfbaymsi.org or (650) 364-2760
- ***Palo Alto Baylands*** offers guided naturalist led walks and programs. http://www.paloaltoonline.com/things_do/baylands.shtml or (650) 329-2506
- ***Project WET Curriculum and Activity Guide***, http://www.watereducation.org/ or (916) 444-6240
- ***San Francisco Bay-Delta Estuary Project*** offers brochures and booklets on many issues that affect the bay, as well as a slideshow and a video tape about the estuary. http://www.abag.ca.gov/bayarea/sfep/

Videos

STB = available through Save the Bay. Phone: (510) 452 - 9261

- ***San Pablo Baylands, The Last Great Expanse of Historic Wetlands in the Bay Area*** (STB)
- ***Fabulous Wetlands. Starring Bill Nye the Science Guy***. http://dep.disney.go.com/educational/store/detail?fromsearch=1&product_id=68C04VL00
- ***Cadillac Desert.*** Order from PMI/Home Vision Select. (800) 343-4727. Or check your local library.

Bay and Water Related Web Sites

- *The Directory of Environmental Education Resources*
  http://www.einet.net/hytelnet/FUL008.html
- *EELink-Environmental Education on the Internet*
  http://www.eelink.net/
- *Know Your Watershed*
  http://www.ctic.purdue.edu/KYW/
- *National Directory of Citizen Volunteer Monitoring Program*
  http://yosemite.epa.gov/water/volmon.nsf/Home?readform
- *The National Institutes for Water Resources*
  http://niwr.montana.edu/
- *San Francisco Estuary Project*
  http://shark.sfei.org/
- *U.S. Water News Online*
  http://www.uswaternews.com/homepage.html
- *USGS SF Bay*
  http://sfbay.wr.usgs.gov/
- *Water Wiser*
  http://www.awwa.org/waterwiser/