Teacher Guide—Earth Science Module
Activity 3: Estuary and Watershed

Featured NERRS Estuary:
San Francisco Bay
National Estuarine Research Reserve
http://nerrs.noaa.gov/Reserve.aspx?ResID=SFB

Activity Summary

In this activity, students investigate the nature of watersheds and their relationship to the dynamic changes that occur in estuaries due to drainage and runoff. Students begin by examining the San Francisco Bay Estuarine Research Reserve and tracing the extent of the watershed using Google Earth. Then they identify possible sources of pollution and contamination along the major rivers that feed into the bay. Students also examine water quality data in the San Pablo region of the estuary and identify changes that occur due to a storm event.

Learning Objectives

Students will be able to:

1. Identify the processes in the watershed that affect conditions in the estuary and explain some specific examples.
2. Apply their understanding of changes in the watershed and the resulting effects on the estuary to explain real-life situations regarding land use and weather in watersheds.
3. Understand how water quality factors are affected by natural and man-made sources of pollution and contamination.

Grade Levels

9-12

Teaching Time

4 (55 minute) class sessions + homework

Organization of the Activity

This activity consists of 4 parts which help deepen understanding of estuarine systems:

Exploring the San Francisco Watershed

What's Upstream Comes Downstream

Water Quality at the Mouth of the Watershed

Optional: Mapping Your Local Watershed

Background

San Francisco Bay is an extensive and shallow estuary that drains approximately 40% of California. Ninety percent of the water flowing into the bay comes from the Sacramento and San Joaquin rivers, whose headwaters are in the Sierra

Nevada Mountains. Both rivers flow into the Delta, a vast network of channels, agricultural lands and fresh water wetlands, and then into Suisun Bay where they begin mixing with salt water from the Pacific Ocean.

San Francisco Bay has lost approximately 80% percent of its historic tidal wetlands due to development pressures within and around the bay. Tidal wetlands are critical for flood prevention; sediment management; and habitats for small mammals, migratory birds and fish species, many of which are threatened or endangered.

Endangered species in the bay include the California clapper rail and salt marsh harvest mouse. The southwestern end of San Pablo Bay, near the town of San Rafael, was the site of a Chinese shrimp-fishing village where some 500 people lived in the 1880s, sending some 90% of their catch of bay shrimp back to China or to Chinese communities throughout the U.S. The location is now part of China Camp State Park. China Camp Park is part of the San Francisco Bay National Estuarine Research Reserve (NERR). The water quality data in this activity is taken from a monitoring station on this historic pier.

Preparation

Download Google Earth and install it on your classroom computer(s) or computer lab machines. To find a tutorial for using Google Earth, please read the box below.

Optional: Obtain topographic maps for plotting your local watershed for Part 4 of the activity.

You can obtain such a map from a nearby store or order one at <topomaps.usgs.gov/>.

Google Earth

This activity *requires* the use of Google Earth. If students have computer access, the use of Google Earth (http://earth.google.com/) can help them develop spatial skills.

To find the Tutorial "*Using Google Earth to Explore Estuaries*" go to Estuaries.noaa.gov, click the tab titled Curriculum and then the sub-tab titled Tutorials.

Materials

Students

- ❑ Need to work in a computer lab or with a computer and projector
- ❑ Copy of Student Reading Estuary and Watershed
- ❑ Copy of Student Worksheet Estuary and Watershed, Student Data Sheet 1 — Orienting Yourself to the San Francisco Estuary and Watershed
- ❑ Copy of Student Data Sheet 2 — Water Quality Data

Teachers

- ❑ Sheets of Mylar, acetate, or tracing paper
- ❑ Different colored markers
- ❑ Map(s) of the greater San Francisco area
- ❑ Download Google Earth <*http://earth.google.com/*>.

Equipment:
- ❑ Computer lab or
- ❑ Computer and Projector

Procedure

Part 1 — Exploring the San Francisco Watershed

1. Ask students what, if anything, they know about watersheds. If possible, walk outside your school and scanning your neighborhood, discuss your local watershed with students. Where does the water that passes through ditches, gutters, creeks, or steams near your school go?
2. Hand out all the student sheets (Student Reading — Estuary and Watershed, Student Worksheet — Estuary and Watershed, Student Data Sheet 1 — Orienting Yourself to the San Francisco Estuary and Watershed, and Student Data Sheet 2 — Water Quality Data) and materials, and have students read and look through them.
3. Have students follow the directions on the *Student Worksheet — Estuary and Watershed* to outline the general limits and confines of the San Francisco watershed. Explain to students that there are certainly watersheds within this huge area outlined on their image. Point out the Sacramento and San Joaquin Rivers if they have difficulty locating them.
4. Show students their starting point (Golden Gate Bridge) in Google Earth and have them complete Part 1 of the *Student Worksheet — Estuary and Watershed.*

   If students are using Google Earth for the first time, show them how to use the search tool, how to zoom in and out to change viewing altitude, and how to use the motion buttons to navigate around the image. (If necessary, refer to the *Student Reading — Using Google Earth to Explore Estuaries* in Activity 1 for a brief how-to guide.)
5. Review and discuss the Part 1 tasks and questions.

Part 2 — What's Upstream Comes Downstream

6. Have students complete Part 2 of the *Student Worksheet — Estuary and Watershed*, choosing one of the two rivers and taking a Google Earth trip to identify areas and man-made features that may be potential sources of pollutants and contaminants in a heavy rain/flooding event.
7. Review and discuss the Part 2 tasks and questions. Have students who studied each river report their findings to the class.

Part 3 — Water Quality at the Mouth of a Watershed

8. Ask students what might happen to the salinity and turbidity in the San Francisco Bay-Delta Estuary after a rainstorm. Go over the water quality factors students will be analyzing.
9. Have students complete Part 3 of the *Student Worksheet — Estuary and Watershed.*

The data given in this section reveals a major rain event in the San Francisco watershed during the first days of January (1st -3rd). Several inches of rain fell over the area over the

National Science Education Standards

Content Standard A: Science as Inquiry

A3. Use technology and mathematics to improve investigations and communications.

A4. Formulate and revise scientific explanations using logic and evidence.

A6. Communicate and defend a scientific argument.

Content Standard D: Earth and Space Science

D2. Geochemical Cycles

Content Standard E: Science and Technology

E6. Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

F4. Environmental quality

F5. Natural and human-induced hazards

two-day span.

10. Review and discuss the Part 3 tasks and questions.

Part 4 — Optional: Mapping Your Local Watershed

It is said that everyone lives in a watershed. Do streams or rivers in your community flow into an estuary? Have students map their own watershed and identify the estuarine features and geologic landforms that comprise it.

11. Hand out copies of the topographic map of your local watershed, new clear sheets of Mylar, acetate, or tracing paper, and the markers, and have students complete Part 4 of the *Student Worksheet — Estuary and Watershed.*

Check for Understanding

1. Discuss the following:
- ❑ How do agricultural areas, industrial sites, landfills, and sewage treatment plants affect water quality in a watershed?
- ❑ Explain how an estuary can act as a filtration system for runoff in a watershed.

2. Supply students with a road map of the eastern U.S. and project a satellite image of the Chesapeake Bay watershed. http://gallery.usgs.gov/photos/03_08_2010_bFVi0MLyx6_03_08_2010_0

Ask students to identify major urban areas around Chesapeake Bay and major rivers that drain the watershed. Ask students to predict where they would expect areas in the most danger of contamination and pollution if a major storm event such as a hurricane struck the region.

Optional Extension Inquiries

1. Investigate the National Estuarine Research Reserve closest to the location of your school. If possible, arrange to take your students on a field trip to the reserve.
2. Have your students construct a map of the watershed for the reserve using a topographic map of the region.
3. Have students locate possible sources of pollution and contamination in the watershed.
4. Establish a water-monitoring program at a stream or river near your school.
5. Report the results of your monitoring program to your town council or other governing body (water company).

Teacher Worksheet with Answers
Activity 3: Estuary and Watershed

Part 1 — Exploring the San Francisco Watershed

1a. Fly around the bay in a clockwise direction, identify the rivers that empty into the bay, and list them.

Answer: The Pentaluma River, Napa River, San Joaquin River, Sacramento River, and several streams and creeks empty into San Francisco Bay.

1b. Where is the source of the Sacramento River?

Answer: The source is in the Sierra Nevada Mountains.

1c. Where is the source of the San Joaquin River located?

Answer: *The source is in the Sierra Nevada Mountains.*

1d. Describe what kinds of human activity you see along sequence of bays and channels from San Pablo Bay to the junction of the Sacramento and San Joaquin Rivers.

Answer: There is widespread industrial activity, as well as golf courses, farmland, housing developments, parks, and other commercial enterprises along this stretch of the bay complex/estuary. Many ships and docks can be seen as well.

1e. Describe how the terrain up the rivers differs from the types of terrain along the coast. Can you detect any geologic landforms or features that might be a source for salts, minerals, or materials that would affect water quality in the estuary?

Answer: The terrain upriver is mostly farmland until the rivers enter more urban areas such as the cities of Sacramento and San Joaquin. Sewage treatment plants can be seen at the junction of the two rivers.

Part 2 — What's Upstream Comes Downstream

2a. List ten possible sources of pollutants or contaminants along the river. Record the source and a place name or latitude and longitude coordinates for each site.

Answer: Student responses will vary. Students may find factories, sewage treatment plants, farm fields (sources of fertilizer), golf courses (also a source of nitrates and phosphate fertilizer), parks, housing developments, and parking lots along both rivers' banks.

2b. What do you think is the most likely source of pollution and contamination along the river you investigated?

Answer: Most of the land is composed of fields upriver. Runoff from farms carries fertilizer and animal wastes into the river and subsequently into the estuary and bay complex.

2c. Can you see any evidence that contaminants are being released in the estuary and San Francisco Bay?

Answer: Students should be able to see sediment plumes in evidence at various places where the rivers enter Suisun and San Pablo Bays.

Part 3 — Water Quality at the Mouth of a Watershed

3a. Predict how this event would affect these water quality factors in the estuary:

Answer: Student answers will vary.

3b. Consult the *Student Data Sheet 2 — Water Quality Data* to look for evidence of a major storm event that occurred in 2006 and list its approximate dates.

Answer: A major rain and storm event appears to have taken place in October between the 12th and the 16th based on the enormous increase in turbidity and drop in salinity.

3c. What happened to each of the water quality indicators during and immediately following this event?

Answer:

- water surface temperature: *temperature dropped almost 2°F*
- pH : *changes slightly, drops .1 to .2 of a unit*
- dissolved oxygen: *stays about the same*
- Salinity: *salinity decreased due to the influx of fresh water and stayed low for many days*
- Turbidity: *quadrupled (200 to 800 NTUs)*

3d. How well did your predictions match what actually happened during the storm event?

Answer: Student answers will vary.

3e. What geologic landforms, features, farming, or industrial concerns affect the quality of water at the mouth of your local watershed?

Answer: Student answers will vary.

Part 4 — Mapping Your Local Watershed

4a. Compare the watershed model you made with the watershed formed by the Sacramento and San Joaquin Rivers. How are they similar? How are they different?

Answer: Answers will depend on your watershed and its characteristics.

4b. What geologic landforms, features, farming, or industrial concerns affect the quality of water in the estuary or mouth of your local watershed?

Answer: Answers will depend on your watershed and its characteristics.