

The Bay Starts Here!

How is your neighborhood connected to the Bay?

What is a watershed?

How does pollution move through watersheds, and through your neighborhood?

Objective

Students will understand what a watershed is and that it changes in scale. Students will learn about their local watershed and the greater watershed of the SF Bay. Students will understand how pollution affects their watershed.

Preparation

If you can preorder [printed maps](#) which might be a nice new experience for students. Otherwise, you can use Google maps and the Bay Area Watershed map: <http://explore.museumca.org/creeks/wb-resc.html>

Students will use maps to answer questions in **Part 1** of their packet.

Print out San Francisco Estuary Project fact sheet, or have the PDF ready. Students will use this sheet to answer questions in **Part 2** of their packet.

In **Part 3** students complete the Life of a Raindrop activity to show competency. They should understand the full cycle of rain from where it lands to where it ends and what can happen to it along the way.

Delivery

Tell students they'll be exploring maps and completing a scavenger hunt of sorts. They'll need to use the two maps to answer the questions to **Part 1** of their packet. Then challenge students to learn as much as they can by reading the SF Estuary Project Fact Sheet in **Part 2** of this exploration. Finally, students can share what they've learned about their local watershed in **Part 3**. The challenge is to be creative and tell a story about a rain drop that falls on the roof of their house or their school. Challenge them to use the names of local creeks and some of the vocab words they've learned.

Debrief

Is the life of your raindrop a happy story or a sad story? Why?

What are some of the different creeks that run through your watershed? Which creek do you live nearest to? Where do all the creeks end up?



Theme

Human Impact, SF Bay Watersheds

Age

5th, 6-8th

Duration

60-90 mins

Materials

Student packet

Printed maps or access to internet for students

San Francisco Estuary Project article

Standards

NGSS: 5-ESS2-1; LS2.B; ESS3.C

MS-ESS2.C; ESS3.C

EP&C's: P2-CA,C, D P4-CA, B, C

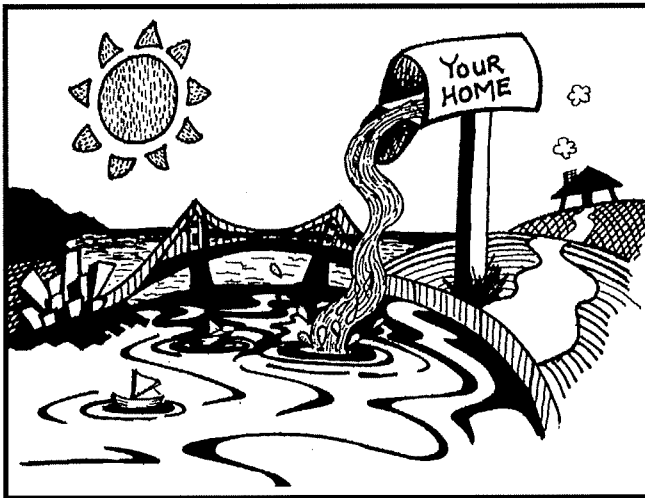
The Bay Starts Here!

Understanding Your Watershed

Student
Pages

INTRODUCTION

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



Tara Reinertson

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.

Management Concerns — page 2

Glossary — page 2

Wildlife at Risk — page 3

Current Issues — page 4

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.

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.

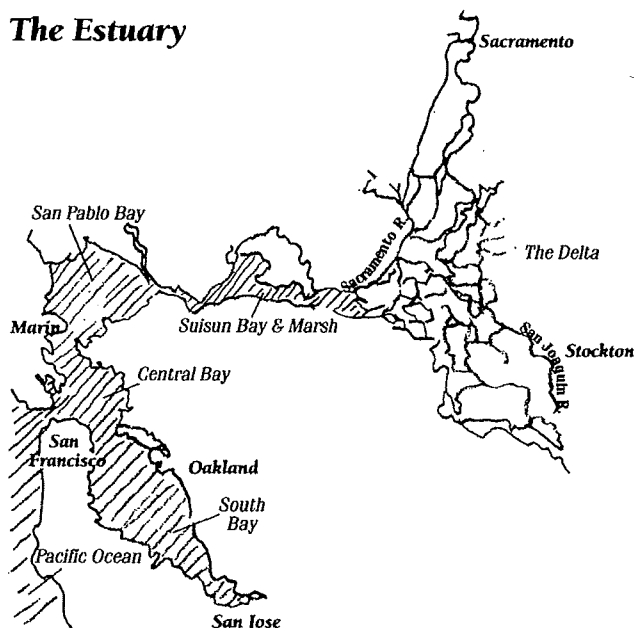
- The Estuary receives 90% of its freshwater from the Sacramento and San Joaquin Rivers and 10% from local drainage basins. Of the river flow, 80% comes from the Sacramento.

- 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.

The Estuary



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

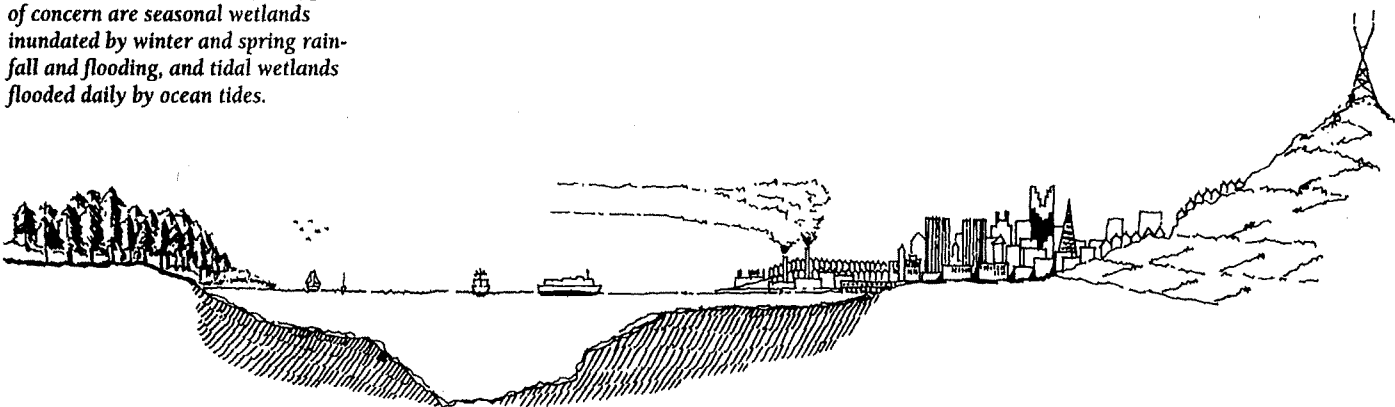
Wetlands provide vital nursery grounds for fish and crabs, and feeding and sheltering grounds for waterfowl and other wildlife. They also act as powerful natural filters and traps for sediments, making them vital not only to the estuarine ecosystem but also to water quality. Many of the Estuary's historic 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.

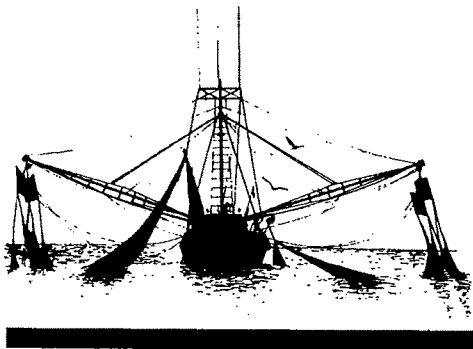
Dredging

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 runoff 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.

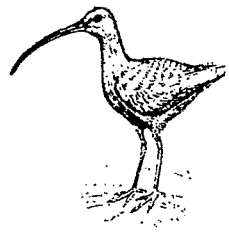
Plankton and Invertebrates The Estuary's food chain begins with minute drifting plants and animals known as plankton—which provide food for invertebrates such as shrimp, clams and worms. These small organisms sustain herring, bottom-feeding sturgeon and other larger aquatic creatures and form the basis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



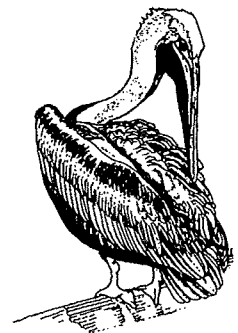
Birds The Estuary's wetlands feed and shelter millions of waterfowl, shorebirds and seabirds every year. As many as half the birds migrating the Pacific Flyway between the Arctic and Baja winter around the Estuary. On average, the region hosts 600,000–800,000 waterbirds at a time. Wintertime populations 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 Roulter 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 have 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 chameleon 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 *Potamocorbula amurensis*, 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.