An Invaded Estuary

Watch the segment online at http://education.savingthebay.org/an-invaded-estuary
Watch the segment on DVD: Episode 2, 28:45–31:07
Video length: 2 minutes 40 seconds

SUBJECT/S

Science

History

GRADE LEVELS

6–8
9–12

CA CONTENT STANDARDS

Grade 6

Life Sciences—Ecology

5.d. Students know different kinds of organisms may play similar ecological roles in similar biomes.

5.e. Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Grades 9–12

Biology/Life Sciences—Ecology

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

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

VIDEO OVERVIEW

San Francisco Bay has the designation of being the most heavily invaded estuary in the world.

The Asian clam, *Corbula amurensis*

In this segment you'll learn:

- how the Transcontinental Railroad had an effect on the ecology of the Bay.
- ways in which exotic species enter the Bay.
- the prevalence of exotic species in the Bay.
- how often a new species arrives in the Bay.

TOPIC BACKGROUND

With the discovery of gold in California in 1848, San Francisco transformed in a matter of years from a small outpost into a bustling city. However, despite its growth, San Francisco remained isolated—accessible only by sea or a very long overland journey—until the completion of the Transcontinental Railroad. On May 10, 1869, the Union Pacific tracks joined the Central Pacific Railroad, completing the connection between the East and West coasts. The railroad brought with it some unexpected riders: exotic species that would make their home in San Francisco Bay.

Before the railroad, some exotic species entered the Bay on the hulls of ships or in their dry ballast. The earliest record of an exotic species on the Pacific coast was the barnacle, *Balanas improvisus,* which was collected in 1853. Later exotic species arrived in liquid ballast water that was discharged into the Bay. As the years passed, the increase in shipping led to more exotics arriving from different countries, and as transoceanic travel times shortened, more species survived the trip in the ballast water. Today, some organisms are shipped by air and end up in the Bay when people dump aquarium or fishing supplies in the water.

One abundant exotic species in Bay is the Asian clam, *Corbula amurensis*. Most likely introduced into the Bay as larvae discharged from a ship's ballast tank, *Corbula amurensis* represents 95 percent of the benthic biomass in many parts of the Bay. Due to its high densities and ability to rapidly filter phytoplankton and young zooplankton from the water, this clam has drastically reduced the biomass of plankton in the North Bay, affecting the food web.

More than 250 species of exotic organisms now reside in San Francisco Bay, and these species dominate many habitats. New species are arriving in the Bay at an average rate of one species every 14 weeks. The vast presence of exotic species has changed Bay food webs, biodiversity, and productivity. The shipping industry is working on methods to eliminate exotics, and the state of California has passed ballast water regulations—but the problem persists.

VOCABULARY

ballast water
water that is used to stabilize ships during a voyage

biomass
the weight of living organisms in an area

exotic
from another part of the world (referring to a plant or an animal)

invade
to penetrate or spread into

invertebrate
an animal, such as a mollusk, that does not have a backbone

transcontinental
extending across the continent

PRE-VIEWING ACTIVITY

- Student pairs discuss the meanings of the words “exotic” and “invasive.” Are they synonymous? Do they imply different things? Have the pairs write their own definitions of each of the words.

FOCUS QUESTIONS FOR VIEWING

- What were the biggest railroad cars in the 1870s and 1880s? *fish cars*
- The fish cars were designed to bring what back to the East Coast? *salmon and rainbow trout*
- Where can you find some of the most profound changes to San Francisco Bay? *underneath the surface*
- What species of shellfish were brought over from the East Coast? *oysters*
- On average, how often is an exotic species introduced into the Bay? *once every 14 weeks*
- How many exotic species are there in the tidal waters and Delta of San Francisco Bay? *more than 250*
- In many habitats of the Bay, what percentage of the biomass is made up of exotic organisms? *90 percent*

POST-VIEWING QUESTIONS

- Are all of the exotic species in the Bay harmful to its ecology? Why or why not?
- What makes an organism invasive? What are some examples of invasive species?
- This segment focuses on organisms that live in the water. Are exotic species a problem on land as well?
- How does the presence of exotic species affect Bay food webs? biodiversity?
- Why is it so difficult to prevent exotic species from entering Bay waters?

POST-VIEWING ACTIVITIES

- Find out about a well-known exotic species that lives in San Francisco Bay. Research where it came from, its impact on the native plant and animal life in the Bay, and if anything is being done to eradicate it. Create a slideshow presentation to share with the class.
- Investigate which plants on the schoolyard are exotic species. Use field guides to identify the plants and calculate what percentage of them are nonnative.
- Research what is being done to prevent exotics from entering the Bay. Design a poster or make a video to educate others about exotic species.

ABOUT THE AUTHOR

Phaela Peck is a science teacher, environmental educator, and writer based in San Francisco. She has an M.A. in environmental education and has developed curricula for numerous science and environmental education organizations in the Bay Area.

KQED Education engages with community and educational organizations to broaden and deepen the impact of KQED media to effect positive change.

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ADDITIONAL RESOURCES

Guide to the Exotic Species of San Francisco Bay, Andrew N. Cohen, San Francisco Estuary Institute
http://www.exoticsguide.org/
Find images and detailed information about nonnative species found in San Francisco Bay.

Marine Invasive Species Program (MISP), California State Lands Commission
http://www.slc.ca.gov/Spec_Pub/MFD/Ballast_Water/Ballast_Water_Default.html
Learn what the state of California is doing to manage marine invasive species.

"The Great Invaders," Glen Martin, *San Francisco Chronicle*
http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2006/02/05/CMG2BGKPN71.DTL
This article in the *San Francisco Chronicle* provides an overview of the problem of exotic species in the Bay and details a few interesting organisms.

The History and Effects of Exotic Species in San Francisco Bay, U.S. Geological Survey
http://sfbay.wr.usgs.gov/benthic_eco/exotic_species/how.html
The USGS website provides an overview of exotic species and a timeline displaying how and when they arrived in the Bay.

"San Francisco Bay Invaders," *QUEST,* KQED Public Media
http://www.kqed.org/quest/television/view/332
Watch another short video segment about exotic species in the Bay. Links to additional information and a teaching guide are also listed.

CREDITS

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NARRATOR: The coming of the Transcontinental Railroad would have a lasting effect, not only on the economy of California, but on the ecology of San Francisco Bay. Today, the most profound changes to San Francisco Bay over the past 150 years are hidden beneath its surface.

ANDREW COHEN: We began bringing in oysters from the East Coast of North America—oysters that were packed up on the Atlantic Coast into barrels, along with mud and water, all of that transported across the country.

JOHN MCCOSKER: They brought in boxcars full of oysters and other creatures; let them loose in the Bay. Now, the oysters didn't survive, but a lot of the other invertebrates and plants and other creatures involved with those animals did survive, and they have dramatically changed the ecology.

NARRATOR: San Francisco Bay is the most heavily invaded estuary in the world. Today, a new exotic species arrives, on average, once every 14 weeks.

COHEN: What we find in San Francisco Bay is a very large number of exotic organisms. There are over 250 exotic species in the tidal waters of the Bay and Delta that are not native to this system. We find that many of the habitats of the Bay are wholly dominated by exotic species. The exotics will form, in many cases, over 90 percent of the individual organisms, over 90 percent of the species, and over 90 percent of the biomass—the wet weight of living organisms.

SYLVIA EARLE: The transformation of the ecosystems in San Francisco Bay owing to the new arrivals that have come in ballast water and otherwise is really profound, but it doesn't happen in a vacuum. What has happened is that you've got a system that is in trouble already—because we have extracted the crabs, we've extracted the salmon, we've extracted the small fish, we've extracted the big fish, we've taken the sharks, we've taken, taken, taken. And what you've got is a system that is vulnerable. By chewing away at the integrity of the natural systems, we've made openings for these newcomers.