

Human Impacts on an Estuary Ecosystem



Estuary Concept

Principle 2: Estuaries are dynamic ecosystems with tremendous variability within and between them in physical, chemical, and biological components.

Learning Objectives

- Examine estuaries as being part of important biological, chemical, and physical cycles such as food webs, nutrient cycles, and hydrologic cycles.
- Explore how estuarine ecosystems are affected by changes in global systems and cycles such as climate and weather cycles.
- This lesson is aligned to NGSS and California state standards (see page 6).

Teacher Preparation

See the project phenomena website to learn more about phenomena-based lessons. Use the Teacher Background Support to research the water and weather quality parameters that can cause fish kills before you start investigating with your students.

#ProjectPhenomena

The Phenomenon: [Fish Kills: San Diego Union Tribune Article](#)

Activity Information

Grade Level

9-12

Time Required

1-2 class periods

Topics

Ecosystem Interactions and Dependencies

Threats and Pressures

Water Chemistry

Phenomena

Data Activities

Overview

In an estuary, human interference can cause drastic changes and lead to population die offs, such as fish kills. Students investigate what could cause water quality to decrease enough to kill fish.

Teacher Background Support:

[Tijuana River National Estuarine Research Reserve \(NERR\)](#)

[San Diego Union Tribune Article \(3-18\) on Binational Sewage Problem](#)

[Temperature Effects of Solubility of Gases](#)

[Dissolved Oxygen Fact Sheet](#)

[Tijuana River Flow](#)

School programs are available at the Tijuana River NERR for FREE after attending a Teachers on the Estuary (TOTE) training. School programs can help your students get excited about the phenomenon and get a sense of place. Recommended activities for this phenomenon include Water Quality Monitoring and Weather Station. Visit our website [for information about TOTE and the field trip activities](#).

These are some connections to Other Phenomena:

Tides, coastal accretion, currents, storm surges, eutrophication, ecosystem services of estuaries, and heat expansion of water.

Procedure or Activity Steps

1. Show students the [San Diego Union Tribune Article: Fish Kills](#)
2. Brainstorm the **ANCHORING driving question** students ask (or that is surfaced) that will be investigated and answered by students. Examples include:
 - What are some of the primary factors that affect Dissolved Oxygen (DO)?
 - How can human activity create drastic changes in an ecosystem?
3. Use the Teacher Background Support resources to help students investigate the answers to these questions and come up with a model or explanation.
4. **Ideal Model and Explanation** or response to students' questions:

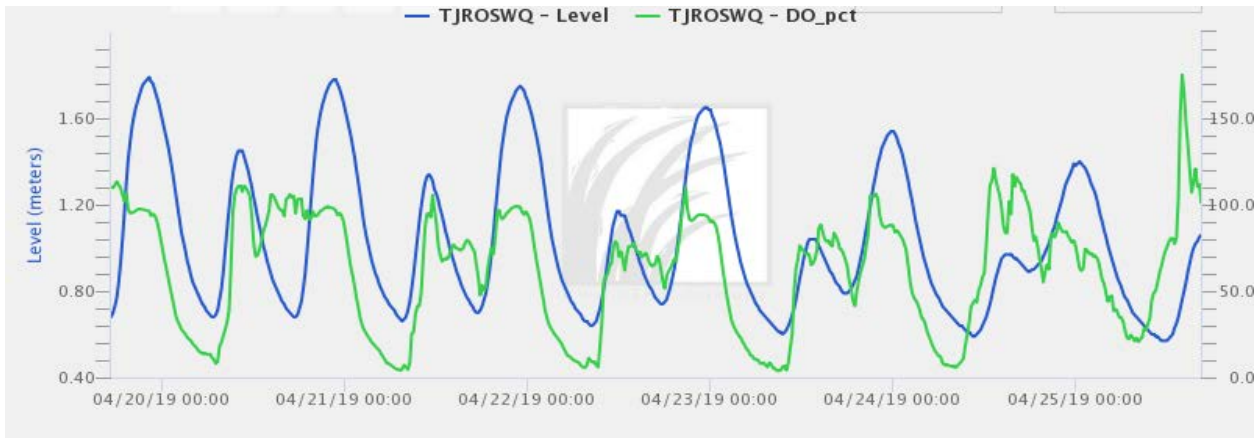
Natural Factors that affect DO:

- Balance of photosynthesis (which produces oxygen) and respiration (which uses oxygen) in estuarine waters - called "ecosystem metabolism"
- Mixing of water from the river, estuary, and ocean, all of which can have different oxygen levels
- Water temperature

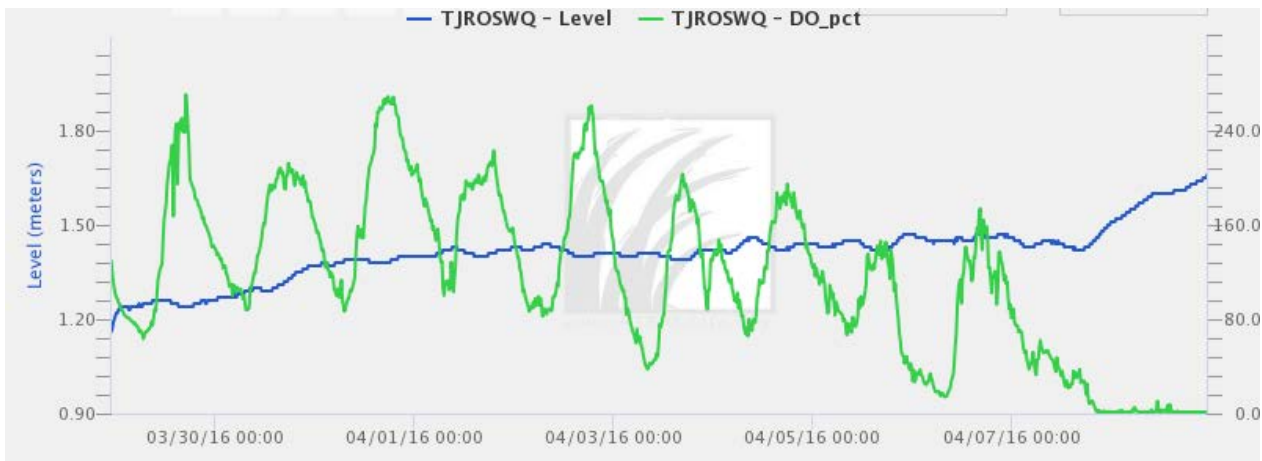
At any one time, oxygen levels in the estuary can be affected by many drivers simultaneously, including those above as well as salinity and pressure. In some systems, such as the relatively shallow, small estuaries in Southern California, there is often a strong signal of ocean water coming and going with the tides. In the graph below created using the [SWMP Graphing Tool](#), you can see a clear relationship between water level and dissolved oxygen. When the tides are high and ocean water has entered the estuary, oxygen levels are near 100% saturation. As the tides drop and ocean water leaves the estuary, oxygen tends to drop.

Materials Needed

- Computer and projector with internet connection and you tube access
- Whiteboard, flip charts, or electronic platform to record student brainstorming and explanation

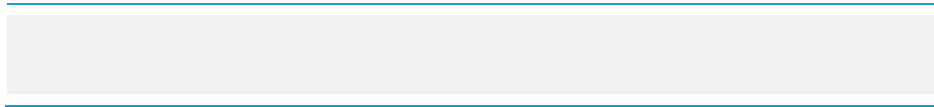


Ecosystem metabolism - the balance between oxygen production and utilization, is also a major driver of oxygen levels. This is most easily seen when tidal action into the estuary is blocked (in this case by the development of sand bar at the tidal inlet - see below). In this case, the clear patterns in oxygen are related to day - night cycles. During the day, levels increase as the production of oxygen by photosynthetic organisms outpaces oxygen utilization due to respiration (with oxygen actually becoming super-saturated). At night, oxygen levels decrease, as respiration dominates. Note that over the course of the week-and-a-half time series, oxygen levels are decreasing without tidal exchange (particularly over the last couple of days). This leads to severe ecosystem consequences, described below.



Human Impacts and DO and the relationship to fish species survivorship:

During El Niño events, water levels in the ocean tend to be up to 0.3 m higher than normal, due to thermal expansion of water and changing current patterns. These high water levels, coupled with large waves, allowed sand to be pushed into the tidal inlet and close the estuary to tidal circulation. Although El Niño events are natural, the response of the estuary to these has been influenced by human activity. One of the main factors keeping the estuary open to tidal



circulation is “tidal prism”, the volume of water coming and going with tides, thereby scouring the tidal inlet. The tidal prism of the Tijuana Estuary has been decreased, however, due to excessive sediment loading from the hillsides in Tijuana, Mexico. This decreased tidal action makes the estuary more vulnerable to mouth closure. Another human impact was a nearby beach replenishment project, which added larger grain sand than normally occurs in Imperial Beach. When this heavier material moved into the tidal inlet, it further decreased the ability of the mouth to stay open with the El Niño storms.

When the mouth closed, the estuary became eutrophic due to input of nutrient-rich water from the Tijuana River. The influx of high nutrient levels causes excessive growth of algae. Too much phytoplankton in the water column can cause the water to become cloudy, reducing the amount of sunlight available for underwater plants to photosynthesize. Large algal mats floating on the surface can block the light that underwater plants such as seagrasses need. Disturbances to seagrass communities can be harmful to other organisms like fish and crabs that depend on the grasses for food, shelter, and nursery areas. On sunny days, the algae’s photosynthesis pumps abnormally high levels of oxygen into the water. When algae die, it sinks to the bottom where it is decomposed by bacteria. This process removes oxygen from the water. As bacteria decompose algae, more oxygen is consumed. If too much oxygen is removed from deep waters, the small organisms feeding fish and crabs will die off. With the mouth closed, the sharks and rays couldn’t move out to the ocean where the dissolved oxygen was higher because the contaminated water was mixed with ocean water. The lack of escape caused the sharks and rays to die from suffocation.

Sample Student Activities and Projects

- [Dissolved Oxygen Cyberlab](#)
- [Survival in an Estuary](#)

Students can graph DO vs Level from March 12th to April 14th, 2016 by using the [SWMP Graphing Tool](#)

Standards

Alignment to Crosscutting Concepts

- Scale, Proportion and Quantity - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Stability and Change - Much of science deals with constructing explanations of how things change and how they remain stable

Alignment to Disciplinary Core Ideas

(Aspects of the Disciplinary Core Ideas that are needed to explain this phenomenon are in *italics*)

LS2.A: Interdependent Relationships in Ecosystems

Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are infinite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience - A complex set of interactions within an ecosystem can keep its numbers constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (ie the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

Alignment to Performance Expectations

HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

Alignment to Science and Engineering Practices

- Using Mathematics and Computational Thinking
- Engaging in Argument from Evidence
- Connections to the Nature of Science - Scientific knowledge is open to revision in light of new evidence

Connections to the California Environmental Principles & Concepts (EP&Cs):

Principal II - The long---term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

Principal IV - There are no Permanent or Impermeable Boundaries that Prevent Matter from Flowing Between Systems

The exchange of matter between natural systems and human societies affects the long-term functioning of both.

Concept A. The effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.

Concept B. The byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.

Concept C. The capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.

Connections to Education and the Environment Initiative (EEI) Curriculum (California):

Differential Survival of Organisms

California U.S. History and Social Science 11.9.7 **United States and Mexico: Working Together**
Overview of binational cooperation related to environmental impacts on US/Mexico border including water and air quality.

Connections to History/Social Studies:

25 Questions to Integrate Environmental Literacy into your History---Social Science Classroom
Industrialization and Urbanization:

2. What were the environmental effects of industrialization and urbanization?

Environmental Activism and Reform:

3. What challenges did environmental policymakers and activists face in trying to achieve environmental reform? Were there difficulties in establishing national or transnational collaborations on environmental issues?

Connections to CA Science Framework Instructional Segments:

Living Earth – Instructional Segment 1: Ecosystem Interactions and Energy

Guiding Questions:

- What factors affect the size of populations within an ecosystem?
- What are common threats to remaining natural ecosystems and biodiversity? How can these threats be reduced?