Don't Shut Your Mouth

Activity Information

Grade Level

6-8

Time Required

1- 2 (45 minute class sessions)

Topic

Ecosystem Interactions and Dependencies, Water Chemistry, Water and Landforms, Data Activities

Overview

In this activity, students will compare and contrast the estuary mouth closures taking place at Los Peñasquitos Lagoon and Tijuana River Reserve. By comparing these two different sites, students learn how mouth closures affect aquatic life in the estuaries. Specifically, students will see how mouth closures affect specific measurements of water quality, such as dissolved oxygen, within the estuaries.

Estuary Concept

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

Learning Objectives

- Movement of sediment at the mouth of an estuary will either open or close the estuary's access to its lake or ocean.
- Lack of tidal flushing can cause water conditions, such as dissolved oxygen, in a lagoon to deteriorate. This can harm aquatic life inside the estuary.
- If an estuary mouth is unable to open naturally, it is sometimes necessary to open the mouth artificially by dredging.

Teacher Background

San Diego County - Los Peñasquitos Lagoon

Los Peñasquitos Lagoon is a small estuary in San Diego, California. Human activity in the area of the lagoon has caused changes to this sensitive ecosystem. The construction of a railroad trestle, highway, and parking lot all interfere with the lagoon mouth, the place where the estuary drains and ocean water comes and goes with the tides. This causes the lagoon mouth to close more frequently than it would naturally. When these mouth closures occur, water from the ocean is less likely to reach the lagoon. With less water coming in from the ocean, the overall health of the estuarine ecosystem suffers. Ecosystem health is monitored with

water quality dataloggers, which track the "vital signs" of the lagoon.

San Diego County – Tijuana River Reserve

About 30 miles south of Los Peñasquitos Lagoon is the Tijuana River National Estuarine Research Reserve, which lies immediately north of US - Mexico border. This is one of the larger estuaries in the region, and it tends to have a mouth that is consistently open to the ocean. In fact, there have only been two periods of reported closure during the last 170 years. Both of these occurred during El Niño events, periods of warm water and altered ocean currents that develop along the west coast. This indicates that something about El Niños can lead to closures, even in systems that are typically open.

Teacher Preparation

1. Read about the NERRS Systemwide Water Quality Monitoring Program (SWMP).

2. Read the Teacher Background above to familiarize yourself with the study sites. Explore the web link in the Teacher Background to understand the NERRS System-wide Monitoring Program, specifically water quality and the importance of phytoplankton, dissolved oxygen, and water flow in estuaries.

3. Look at the graphs found on the Student Master: Don't Shut Your Mouth. You will need to help your students read these graphs that have two dissimilar vertical axes and scales.

4. Make copies of Student Master: Don't Shut Your Mouth

Procedure or Activity Steps

1. Divide your class into teams of two students.
2. Distribute copies of Student Master: Don't Shut Your Mouth.
3. Have your students look at the Student Master. Review with your students how to read the two Dissolved Oxygen and Water Depth graphs on the Student Master. As each graph is actually displaying two separate sets of data, students need to be able to tell which data line goes with which vertical axis and scale.
4. Once students have completed work on the Student Master, discuss their answers to the questions in class.

Materials Needed

- Student Master: Don't Shut Your Mouth
- Teacher Master: Don't Shut Your Mouth

TEACHER MASTER

Don't Shut Your Mouth

1. In San Diego County, there are normally two high tides and two low tides each day. Look at the graph. On what day did the mouth closure at Los Peñasquitos Lagoon make it appear that there was only one high tide and one low tide? Did ocean tides change on this day as well?

   POTENTIAL ANSWERS: Around January 6th. No, ocean tides did not change, only the tides making it into the lagoon.

2. While the mouth is open, why do you think the high-water levels occur at the same time as the spikes in dissolved oxygen?

   POTENTIAL ANSWERS: When ocean water, which is well-oxygenated, flows in the lagoon at high tide, oxygen shoots up. When tides begin to reverse and flow out of the estuary, anoxic (low oxygen) water from the lagoon and watershed moves past the data logger.

3. Hypoxia is when there isn't enough oxygen in the water for aquatic creatures to live. On which day did the water in Los Peñasquitos Lagoon become consistently hypoxic (less than 2 mg/L)?

   POTENTIAL ANSWERS: Around January 15th

4. What are some of the potential consequences of hypoxia?

   POTENTIAL ANSWERS: Stressful conditions and potential die-off of aquatic organisms. Bad smells.

5. How can this information be used to guide management?

   POTENTIAL ANSWERS: Tracking conditions as measured with the datalogger can alert managers to development of hypoxic conditions. This can be used to decide when to open the mouth with heavy construction equipment.

6. During this closure, what do you think caused the daily cycles in oxygen levels?

   POTENTIAL ANSWERS: Day/Night cycles in photosynthesis and respiration.

7. When do you think the mouth management occurred? How soon did the system recover?

   POTENTIAL ANSWERS: February 7th. Conditions recovered relatively rapidly, within two or three days (when incoming tides refreshed oxygen in the lagoon).

8. How much was sea level elevated during late 2015? What might have caused water levels to rise during El Niños?

   POTENTIAL ANSWERS: Up to 1 foot. Thermal expansion and currents that pile water up on our coast.

9. During what season do the largest waves tend to hit the San Diego coast? How much bigger were the waves during the El Niño, compared to the long-term average?

   POTENTIAL ANSWERS: Winter and up to 0.5 m

10. How can this El Niño be used to preview potential impacts of climate change?

    POTENTIAL ANSWERS: With sea level rise, the extreme events now will be everyday occurrences in a few decades.

11. You can explore a variety of conditions at the Tijuana River Reserve, Los Peñasquitos Lagoon, and Scripps Pier. How do things look now?

    POTENTIAL ANSWERS: Answers will vary here. Closures at Los Peñasquitos more likely in the winter and spring.

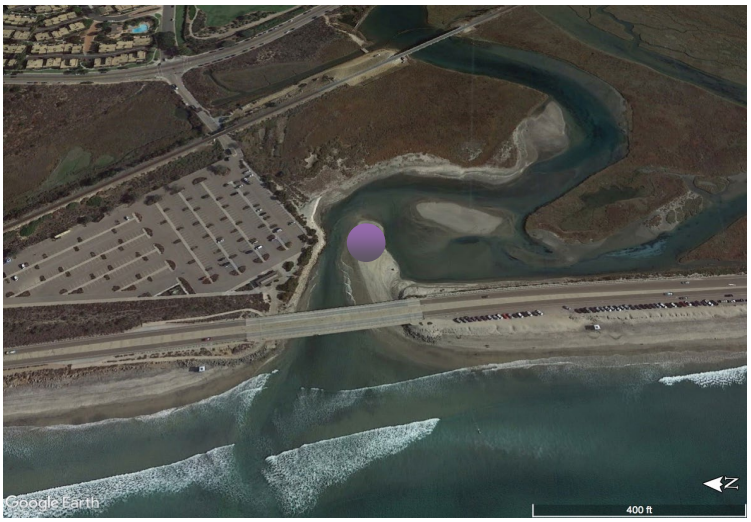
STUDENT MASTER

Don’t Shut Your Mouth

San Diego County - Los Peñasquitos Lagoon

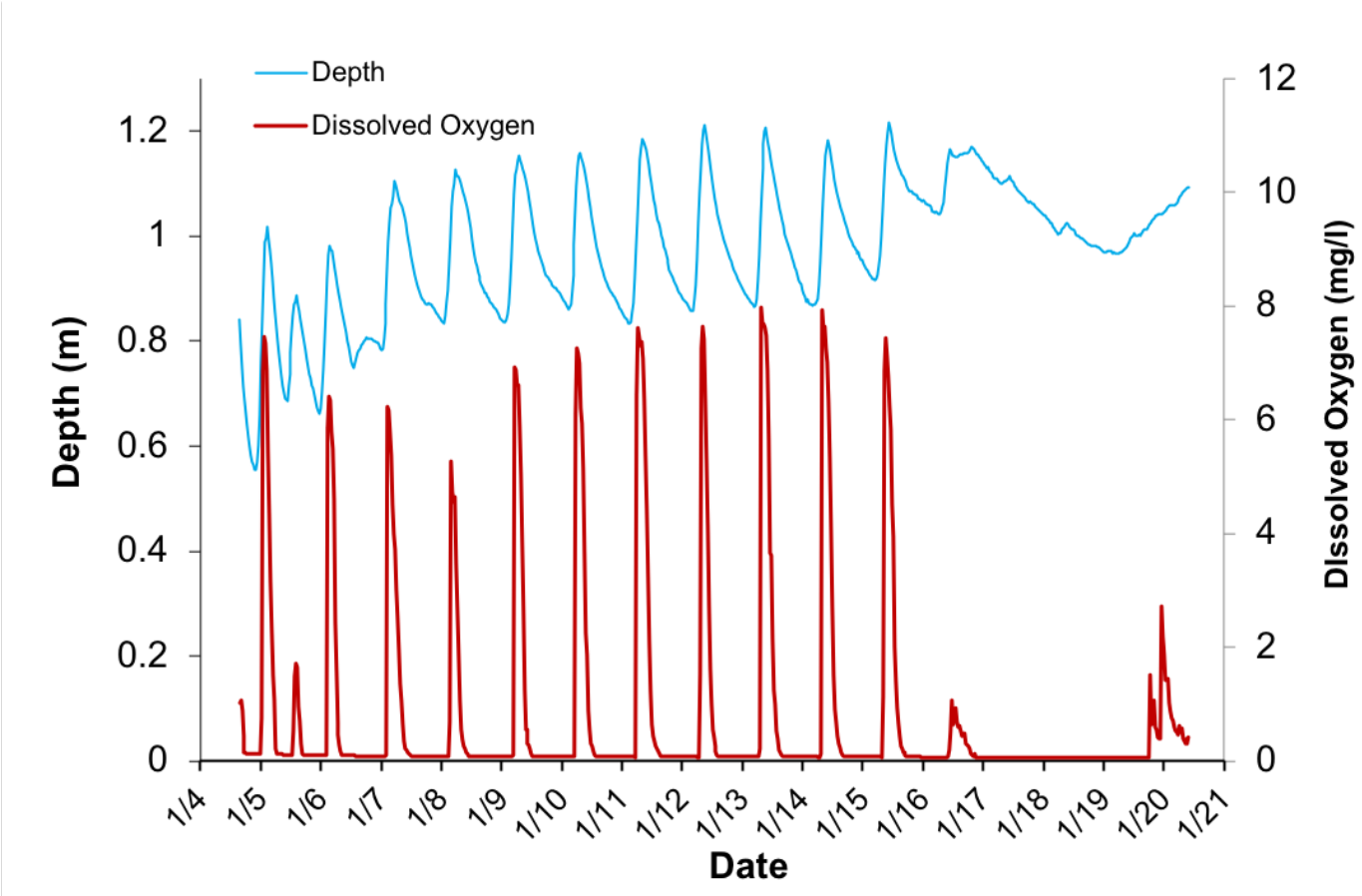
Los Peñasquitos Lagoon is a small estuary in San Diego, California. Human activity in the area of the lagoon has caused changes to this sensitive ecosystem. The construction of a railroad trestle, highway, and parking lot all interfere with the lagoon mouth (the place where the estuary drains and ocean water comes and goes with the tides). This causes the lagoon mouth to close more frequently than it would naturally. When these mouth closures occur, water from the ocean is less likely to reach the lagoon. With less water coming in from the ocean, the overall health of the estuarine ecosystem suffers. Ecosystem health is monitored with water quality dataloggers, which track the “vital signs” of the lagoon.

Los Peñasquitos Lagoon during open (left, December 2017) and closed conditions (right, March 2016). Red dots show datalogger location.



Let's look at how a mouth closure affects Los Peñasquitos Lagoon. The graph below shows dissolved oxygen and water depth (samples taken every 15 minutes) during a 17-day period when a mouth closure event occurred:

Water Depth and Dissolved Oxygen in Los Peñasquitos Lagoon Prior to a Mouth Closure Event (2003)



The estuary's mouth wasn't fully closed during the first two weeks shown on the graph. On January 5, the mouth is open. You can see two high tides and two low tides. This is the normal semi-diurnal tide characteristic of the region. However, over the next couple of days, the two high tide spikes seem to become one. The tides haven't changed. So, what happened? A sand bar is forming at the estuary mouth, only allowing one high tide to reach into the system daily. During the last week, you see no tidal water exchange on the graph. The mouth of the estuary is fully closed.

Looking at dissolved oxygen, you can see a very clear relationship with the tidal exchange. As the mouth becomes increasingly blocked, the tidal water exchange decreases and finally ceases. The water becomes *hypoxic*, which means it contains very little oxygen, increasing the possibility of events such as large-scale fish kills.

Examine the graph on the previous page for Los Peñasquitos Examine the graph on the previous page for Los Peñasquitos Lagoon to answer the following questions:

1. In San Diego County, there are normally two high tides and two low tides each day. Look at the graph. On what day did the mouth closure at Los Peñasquitos Lagoon make it appear that there was only one high tide and one low tide? Did ocean tides change on this day as well?

2. While the mouth is open, why do you think the high-water levels occur at the same time as the spikes in dissolved oxygen?

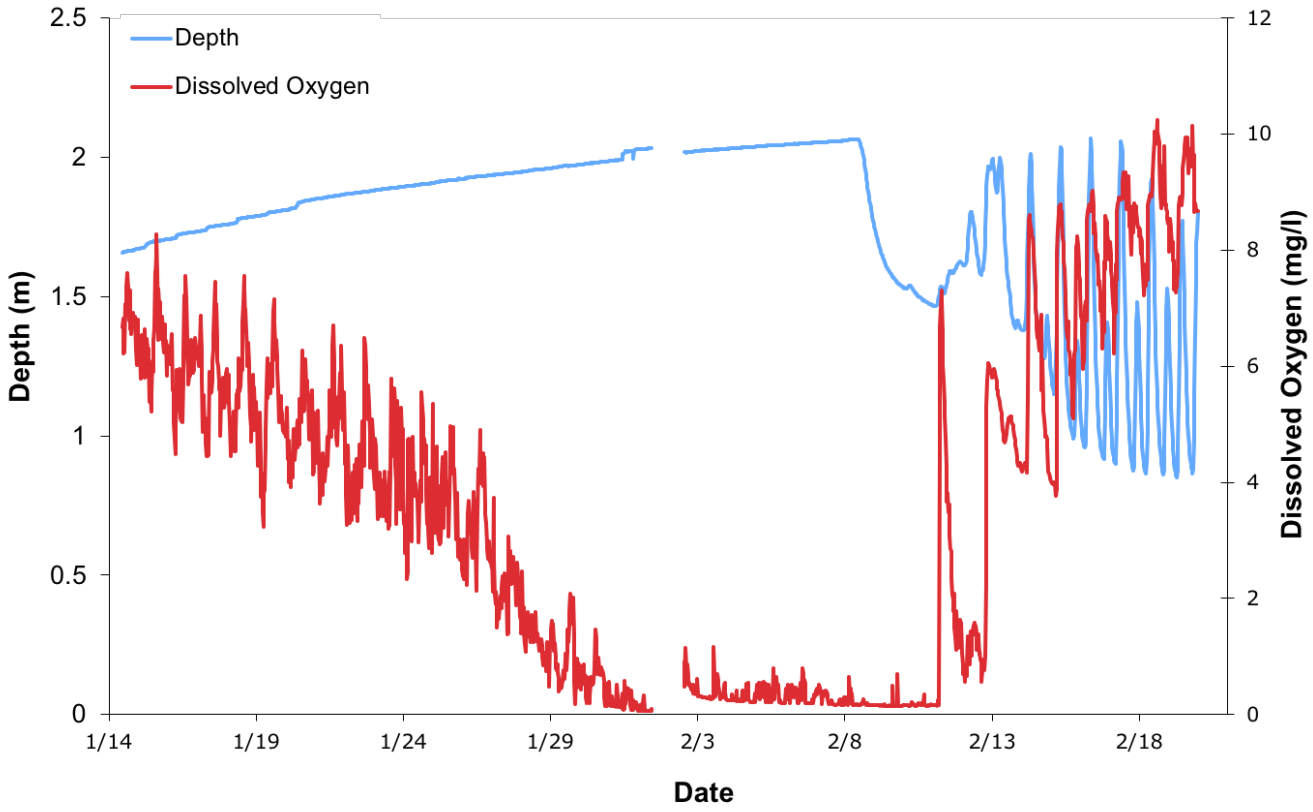
3. Hypoxia is when there isn't enough oxygen in the water for aquatic creatures to live. On which day did the water in Los Peñasquitos Lagoon become consistently hypoxic (less than 2 mg/L)?

4. What are some of the potential consequences of hypoxia?

5. How can this information be used to guide management?

The graph below shows dissolved oxygen levels and water depth at Los Peñasquitos Lagoon during a different mouth closure event:

Los Peñasquitos Lagoon During a Mouth Closure and After Opening (2006)



During this mouth closure, water from the watershed piled up in the lagoon behind the sand bar that formed at the estuary mouth. The water level slowly, steadily rose. At the same time, the dissolved oxygen levels go up and down daily, but decrease over the period of closure and eventually stay near zero. Clearly, aquatic life within the estuary was suffering at this point, and management action was taken to dredge open the estuary mouth.

6. During this closure, what do you think caused the daily cycles in oxygen levels?

7. When do you think the mouth management occurred? How soon did the system recover?

Mechanical Mouth Opening at Los Peñasquitos Lagoon
(May, 2019; photos by Mike Hastings, Los Peñasquitos Lagoon Foundation)

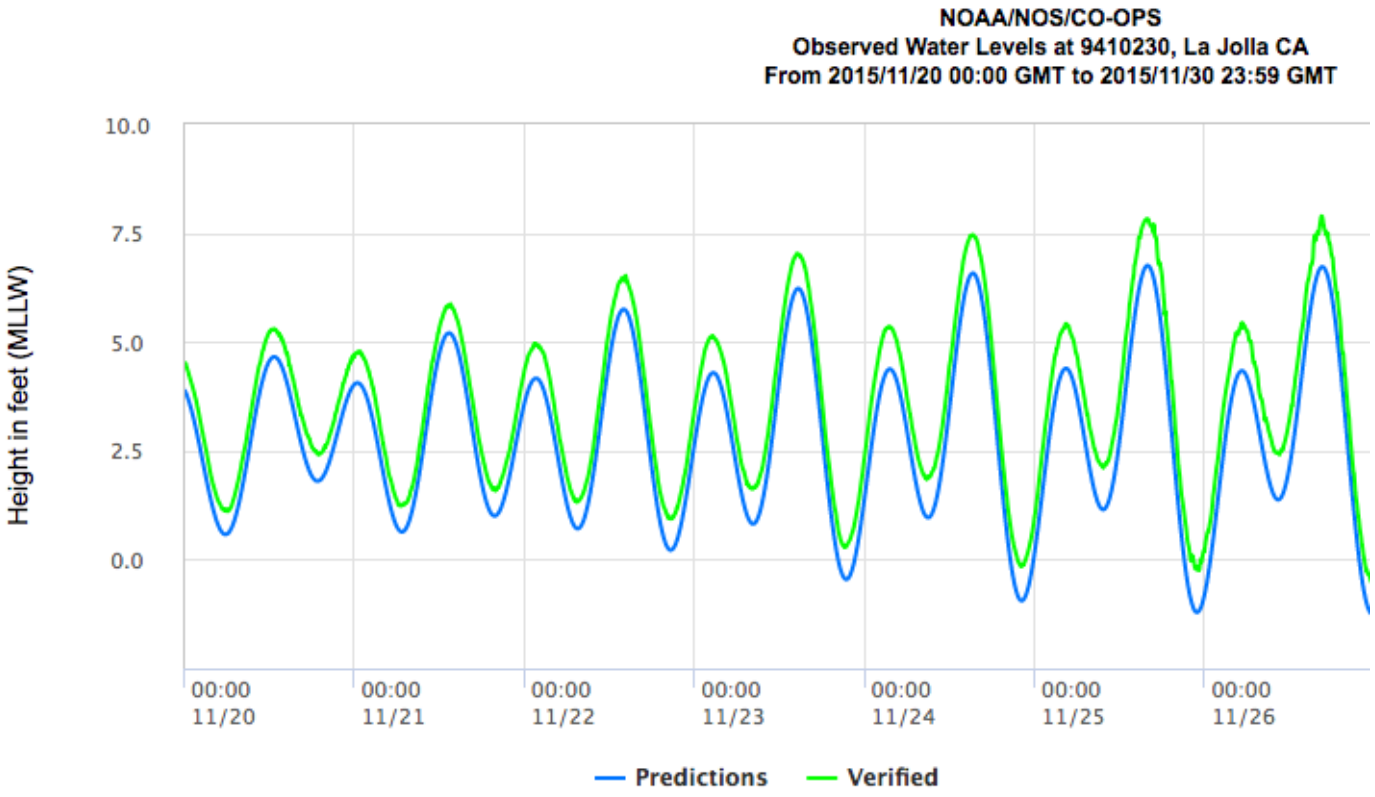
San Diego County – Tijuana Reserve

About 30 miles south of Los Peñasquitos Lagoon is the Tijuana River National Estuarine Research Reserve, which lies immediately north of US - Mexico border. This is one of the larger estuaries in the region, and it tends to have a mouth that is consistently open to the ocean. In fact, there have only been two periods of reported closure during the last 170 years. Both of these occurred during El Niño events, periods of warm water and altered ocean currents that develop along the west coast. This indicates that something about El Niños can lead to closures, even in systems that are typically open.

Mouth Closure at the Tijuana River Reserve (2016)

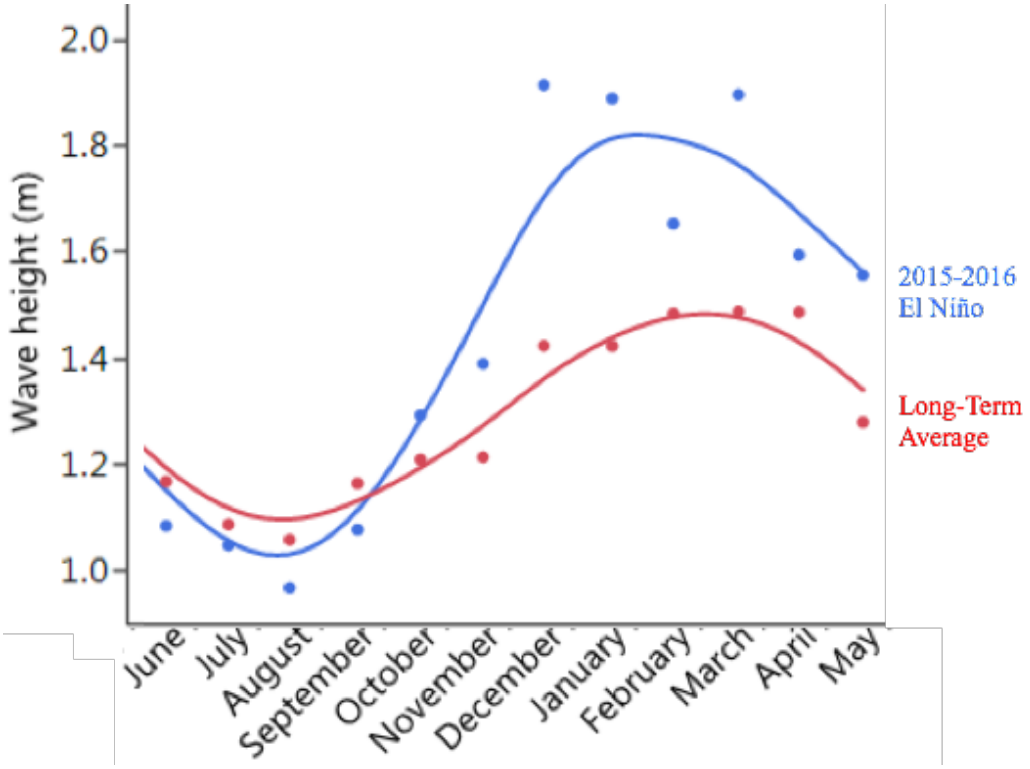
During strong El Niños, local sea levels are higher than during other times. This can be observed by comparing predicted tides, such as those you would see on a tide chart or tide calendar, to the actual (also called verified) tidal levels measured at the Scripps Institution of Oceanography Pier in La Jolla (in between the Tijuana River NERR and Los Peñasquitos). The difference between expected and observed is the amount of local, temporary sea level rise due to El Niño.

Difference Between Predicted Tides and Observed (Verified) Tides at Scripps



Large waves from powerful storms often accompany El Niños. Scripps also maintains offshore buoys that measure the height of passing waves before they start to break on the shore. The graph below compares measured waves during the 2015-2016 El Niño to the long-term average of waves measured at the buoy, on a monthly basis.

Measured Wave Heights at Point Loma (San Diego) Buoy



It is not immediately obvious that high water levels and big waves would necessarily cause mouth closures, but two El Niño events now indicate that this is what can happen. What do we think is happening? Mouth closure is likely caused by large waves, riding on top of a higher ocean, pushing sand into lagoon entrances and rapidly building up large sand bars. This blocks tidal action and closes the mouth. Like Los Peñasquitos Lagoon to the north, the Tijuana River Reserve mouth had to be mechanically opened to restore tidal flushing. In this case, however, hypoxia developed very rapidly, and there were fish kills (including leopard sharks) in the estuary.

TJ river mouth reopened after flooding, shark deaths

El Niño conditions pushed enough sand into the mouth of the Tijuana River south of Imperial Beach to close off the flow of the river to the ocean. With the weekend rains water from the closed off estuary was backing up into Imperial Beach streets, forcing an emergency opening of the river mouth with heavy equipment Monday afternoon. After the water receded it became apparent that the oxygen depleted waters had been fatal to many leopard sharks, mollusks and other species that inhabit the area.

Examine the graphs for tidal levels and waves in coastal San Diego.

8. How much was sea level elevated during late 2015? What might cause water levels to rise during El Niños?

9. During what season do the largest waves tend to hit the San Diego coast? How much bigger were the waves during the El Niño, compared to the long-term average?

10. How can this El Niño be used to preview potential impacts of climate change?

11. You can explore a variety of conditions at the Tijuana River Reserve, Los Peñasquitos Lagoon, and Scripps Pier. How do things look now?

    Tijuana River Reserve

    Los Peñasquitos Lagoon

    Scripps Pier