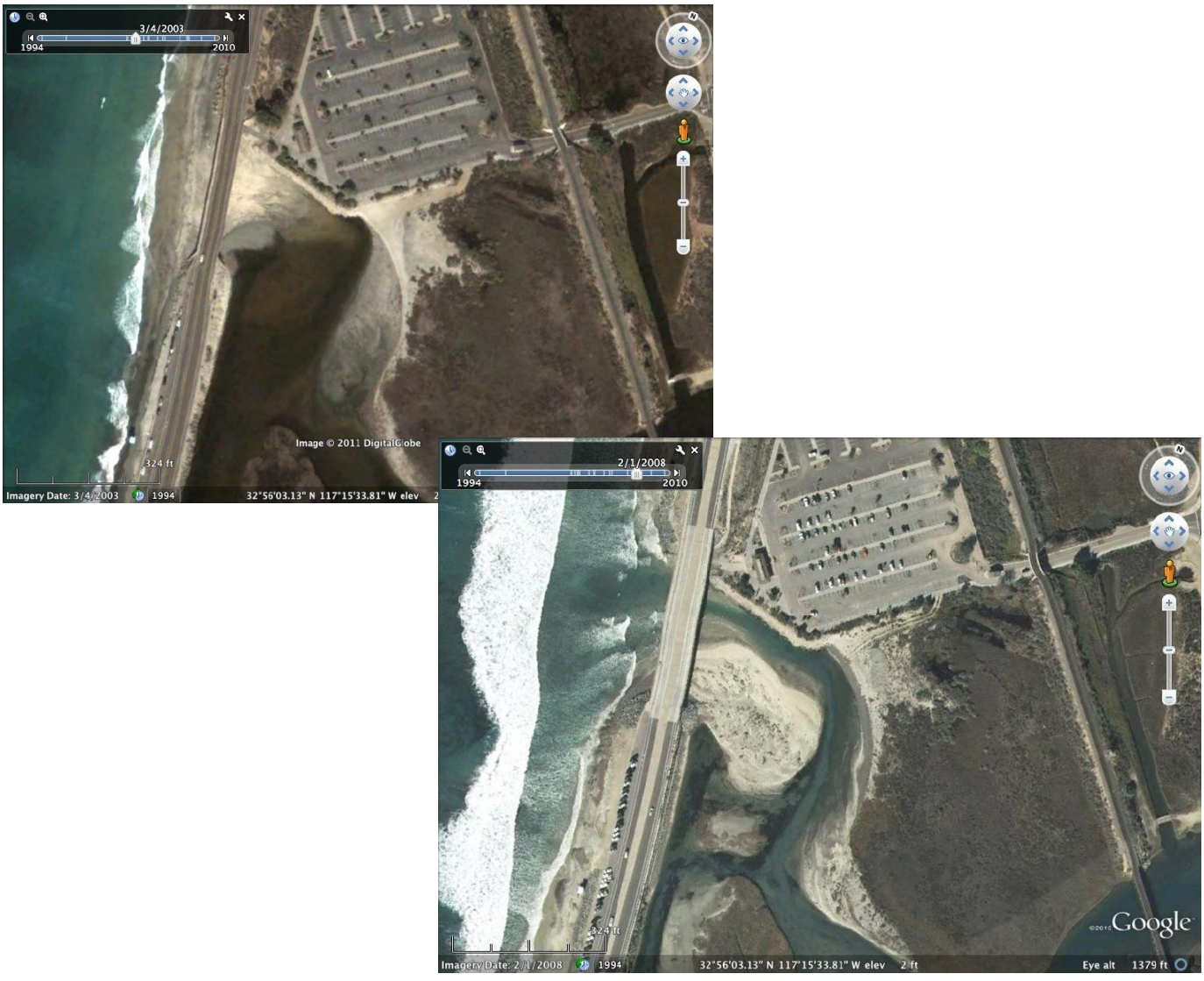
(Don’t) Shut Your Mouth

San Diego County - Los Peñasquitos Lagoon

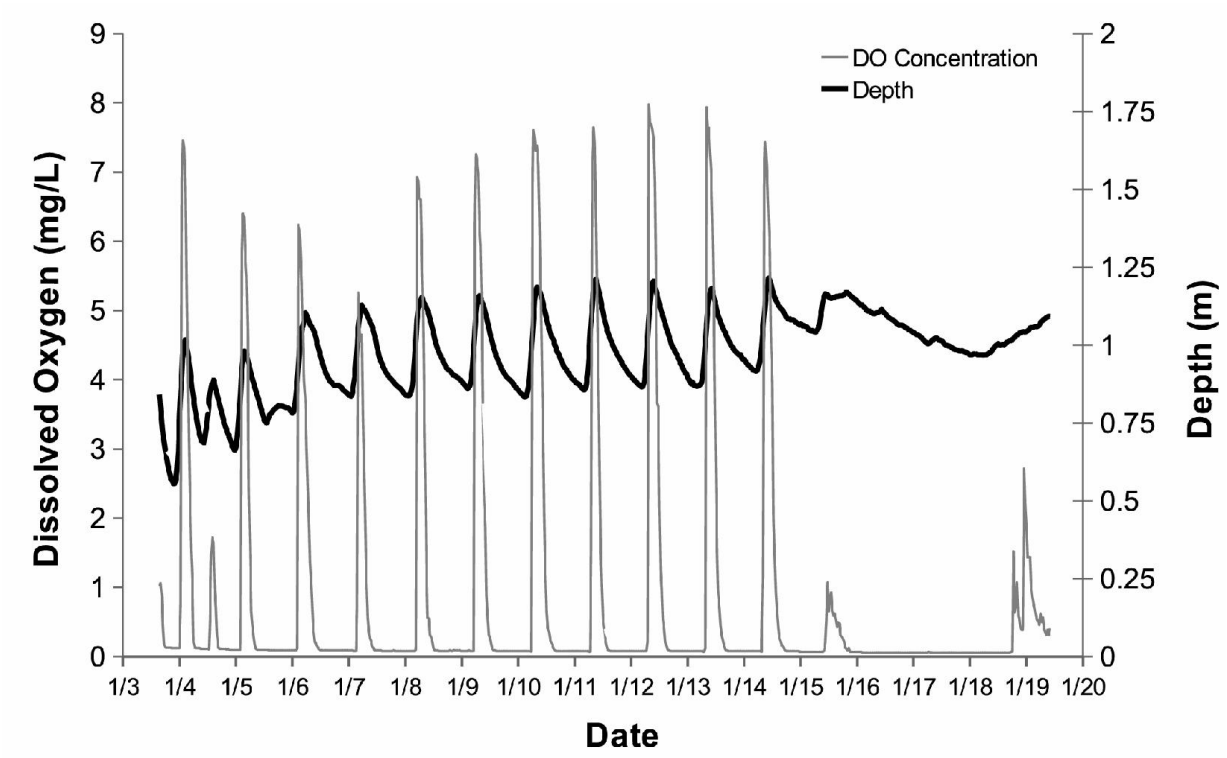
Los Peñasquitos Lagoon is a small estuarine ecosystem in San Diego, California. Human activity in the area of the lagoon has caused changes to the estuary system. For example, the construction of a railroad trestle causes the lagoon mouth to close more frequently than it would naturally. When these mouth closures occur, water from the ocean is less likely to reach the lagoon. With less water coming in from ocean, the overall health of the estuarine ecosystem suffers.

Los Peñasquitos Lagoon during closed and open conditions.



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:

Los Peñasquitos Lagoon During and Following a Mouth Closure



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? You may notice that the overall water level in the lagoon is gradually increasing. A sand bar is forming at the estuary mouth. Water is piling up in the lagoon behind this barrier. Now there is just one tidal exchange per day, indicating that only the higher tides make it into and out of the lagoon. 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. When well-oxygenated ocean water flows in the lagoon at high tide, oxygen shoots up. When tides begin to ebb, anoxic (low oxygen) water from the lagoon and watershed moves past the data logger. As the mouth becomes increasingly blocked, the tidal water exchange decreases and finally ceases. The water becomes anoxic, increasing the possibility of events such as large-scale fish kills.

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

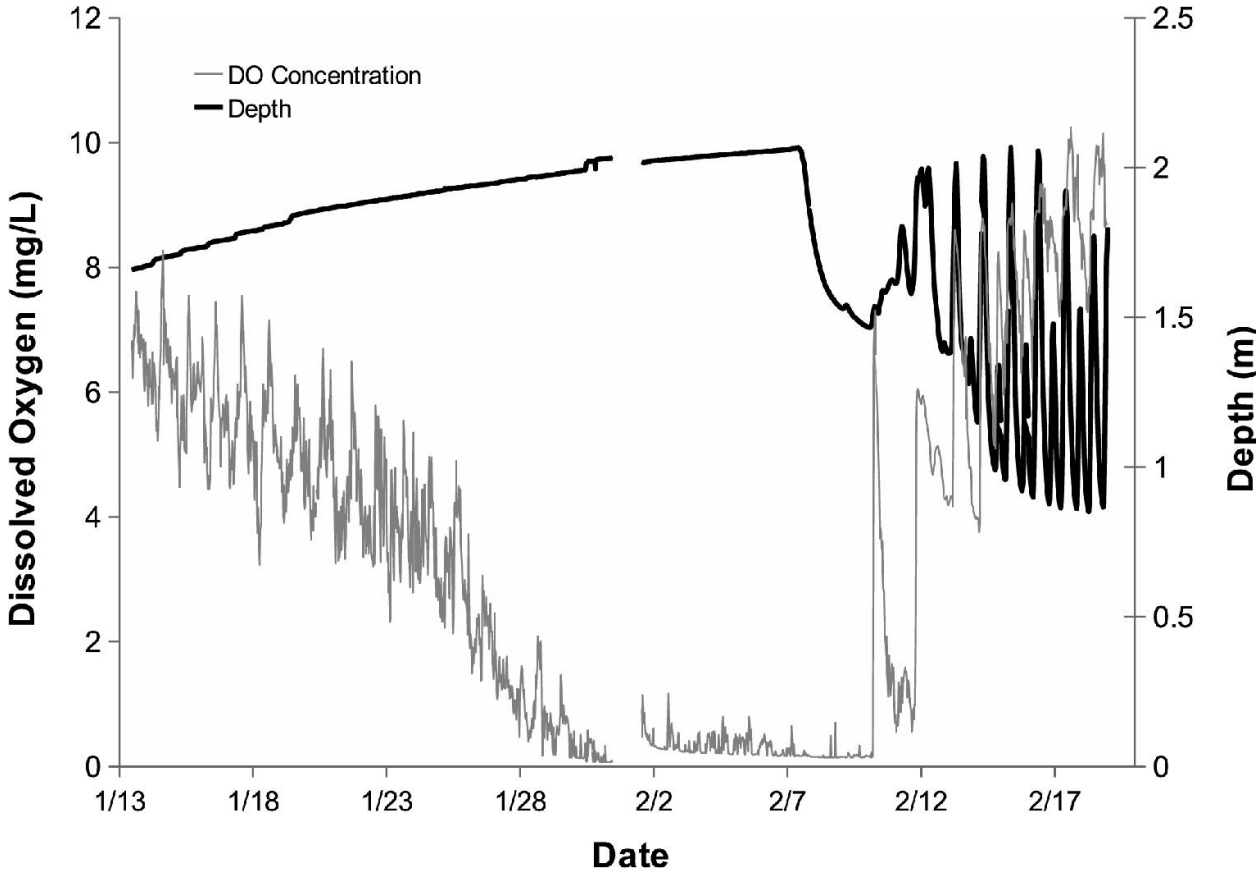
1. In San Diego County, there are normally two high tides and two low tides each day. Look at the graph. On what day did the mouth closure at Los Peñasquitos Lagoon make it "appear" that there was only one high tide and one low tide?

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 hypoxic (less than 2 mg/L)? How long did the water remain hypoxic?

What happens to the estuary if the mouth doesn't get reopened? The graph below shows dissolved oxygen levels and water depth at Los Peñasquitos Lagoon during a mouth closure event:

Los Peñasquitos Lagoon During a Mouth Closure and After Opening



During the 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 decreased and eventually stayed near zero. Clearly, aquatic life within the estuary was suffering at this point. On February 8, workers dredged open the estuary mouth, allowing the hypoxic water within the estuary to flow out and restoring natural flow of ocean water into the estuary via the tides. Dissolved oxygen levels quickly recovered.

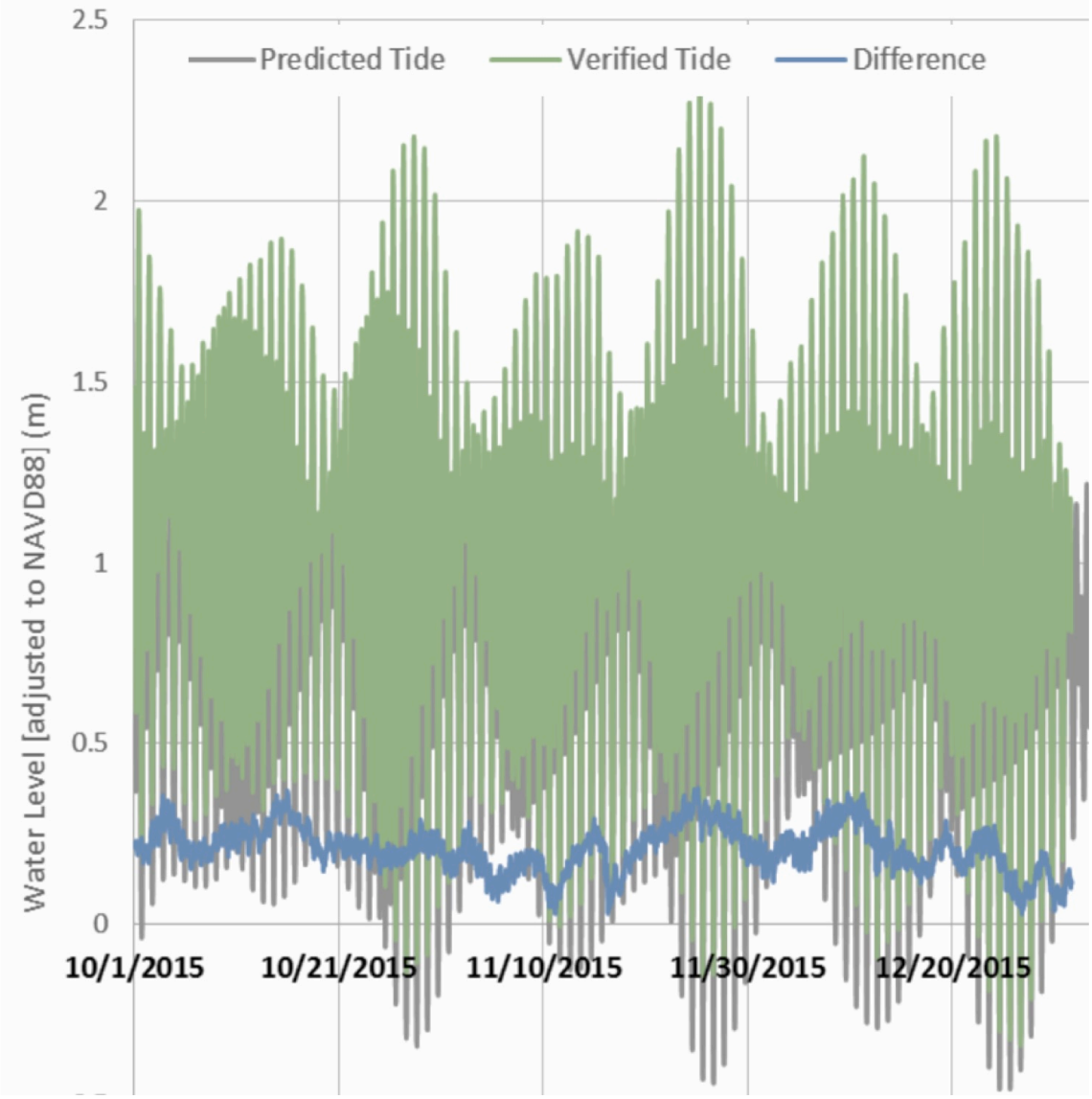
San Diego County - Tijuana River Reserve

About 30 miles south of Los Peñasquitos Lagoon is the Tijuana River NERR, 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 be two periods of reported closure during the last 170 years. Both of these occurred during El Niño events, periods of warm water and altered weather patterns that develop along 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

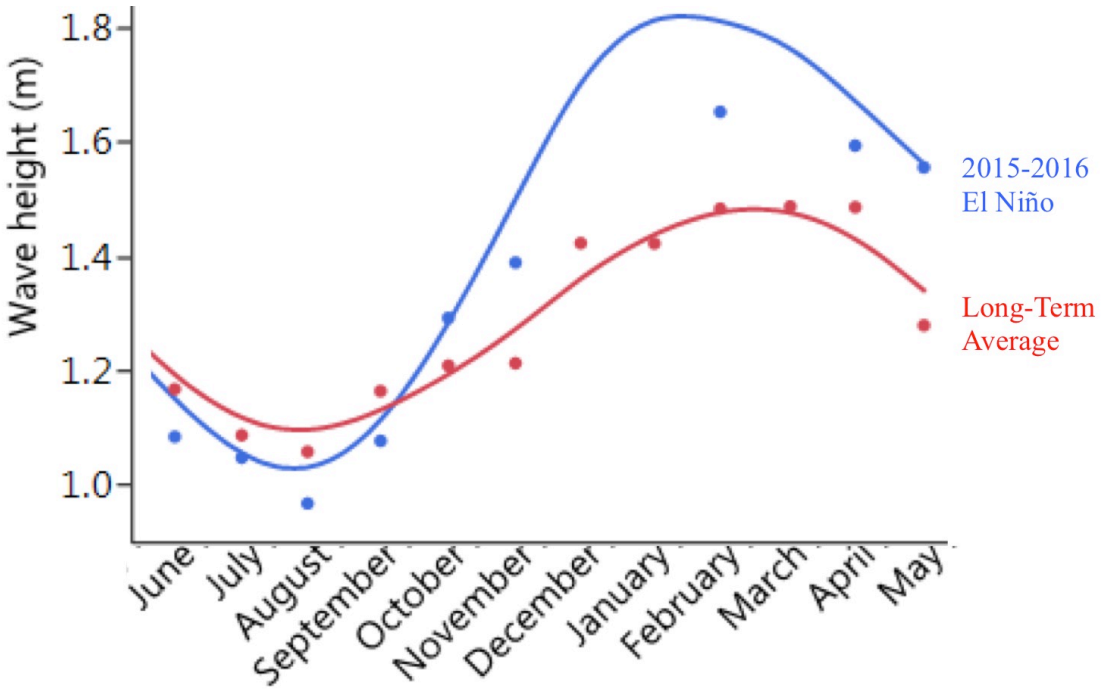
During strong El Niños, local sea levels are higher than during other times, due to changing ocean currents and the fact that warm water expands and pushes higher up the shore. This can be observed by comparing predicted tides, such as those you would see on a tide chart or tide calendar, to the actual (also called verified) tidal levels measured at the Scripps Institution of Oceanography Pier in La Jolla (in between the Tijuana River Reserve 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 (in Green) and Observed, Verified Tides (in Gray), Showing Local Sea Level Rise Due to El Niño (in Blue)



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.

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

4. How much was sea level elevated during late 2015?

5. 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?

6. How can extreme events like El Nino be used to preview potential impacts of climate change?

Old Woman Creek

Now let's look at another estuary that experiences mouth closures. Compare these pictures of Old Woman Creek estuary when the estuary mouth is open and when it is closed.

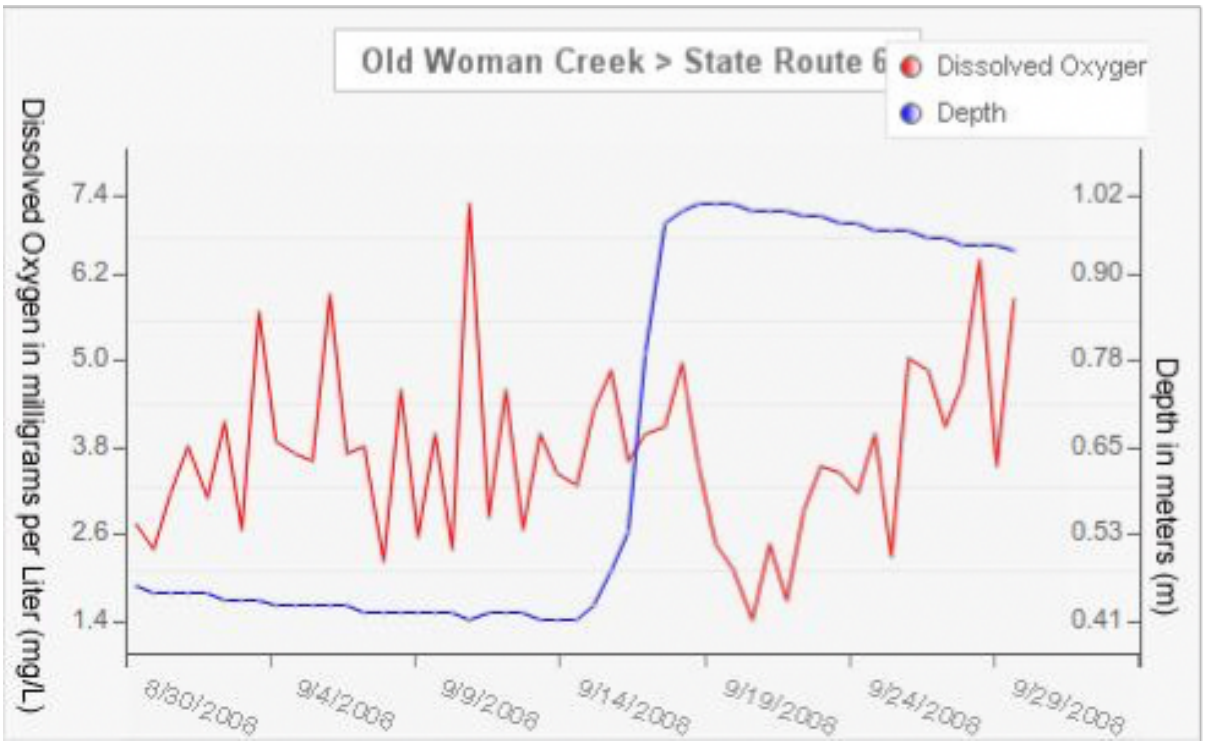
Old Woman Creek estuary after runoff from a heavy Old Woman Creek estuary when the mouth has been rain has cut through the barrier beach, leaving estuary closed off from Lake Erie by a barrier beach.
mouth open to Lake Erie.

Water levels in the Old Woman Creek estuary rise and fall dependent on whether or not the estuary mouth is closed. When the barrier beach closes the mouth of the Old Woman Creek estuary, the barrier beach blocks the flow of water from the lake into the estuary, as well as the flow of water from the estuary out into the lake. The estuary mouth will remain closed until waters from significant rains upstream in the Old Woman Creek watershed create enough water pressure to break through the barrier beach and reopen the mouth. This natural process can occur at any of the Great Lakes estuaries.

At Old Woman Creek, mouth openings and closures occur frequently throughout the year. The barrier beach that closes the estuary mouth at Old Woman Creek is formed from sand moved by currents and wind-driven waves. The wind blowing across Lake Erie sets up the phenomenon called a seiche (pronounced SAYSH). In a seiche, wind- driven water gets pushed down on one end of the lake, piles up on the other end of the lake, and then sloshes back and forth from end to end until water levels return to equilibrium.

When the Old Woman Creek estuary mouth is closed, phytoplankton tend to build up within the estuary. The phytoplankton rapidly produce large amounts of oxygen in the water. In a typical freshwater estuary mouth closure, the dissolved oxygen levels within the estuary drop at first due to the absence of water entering the estuary form the lake. However, because of the phytoplankton, the dissolved oxygen levels usually increase over time.

Open and Closed Mouth Conditions at Old Woman Creek



Old Woman Creek, State Route 6

Examine the graph above, and answer the following questions:

7. When did the mouth close at Old Woman Creek estuary? How do you know?

8. Hypoxia is when there isn't enough dissolved oxygen in the water for aquatic creatures to live. What day did the water get hypoxic (DO less than 2 mg/L)?

9. After the mouth closed, there was an abrupt drop in dissolved oxygen. Then the levels of dissolved oxygen began to rise again. What biological process may explain this recovery in DO levels?

10. Before the mouth closed, dissolved oxygen levels experienced a large number of highs and lows. After the mouth closed, oxygen levels show fewer numbers of these same fluctuations. Why?

11. Think about the estuaries you've looked at in this exercise. How do tides, wind, geology, and site characteristics directly impact the estuaries?