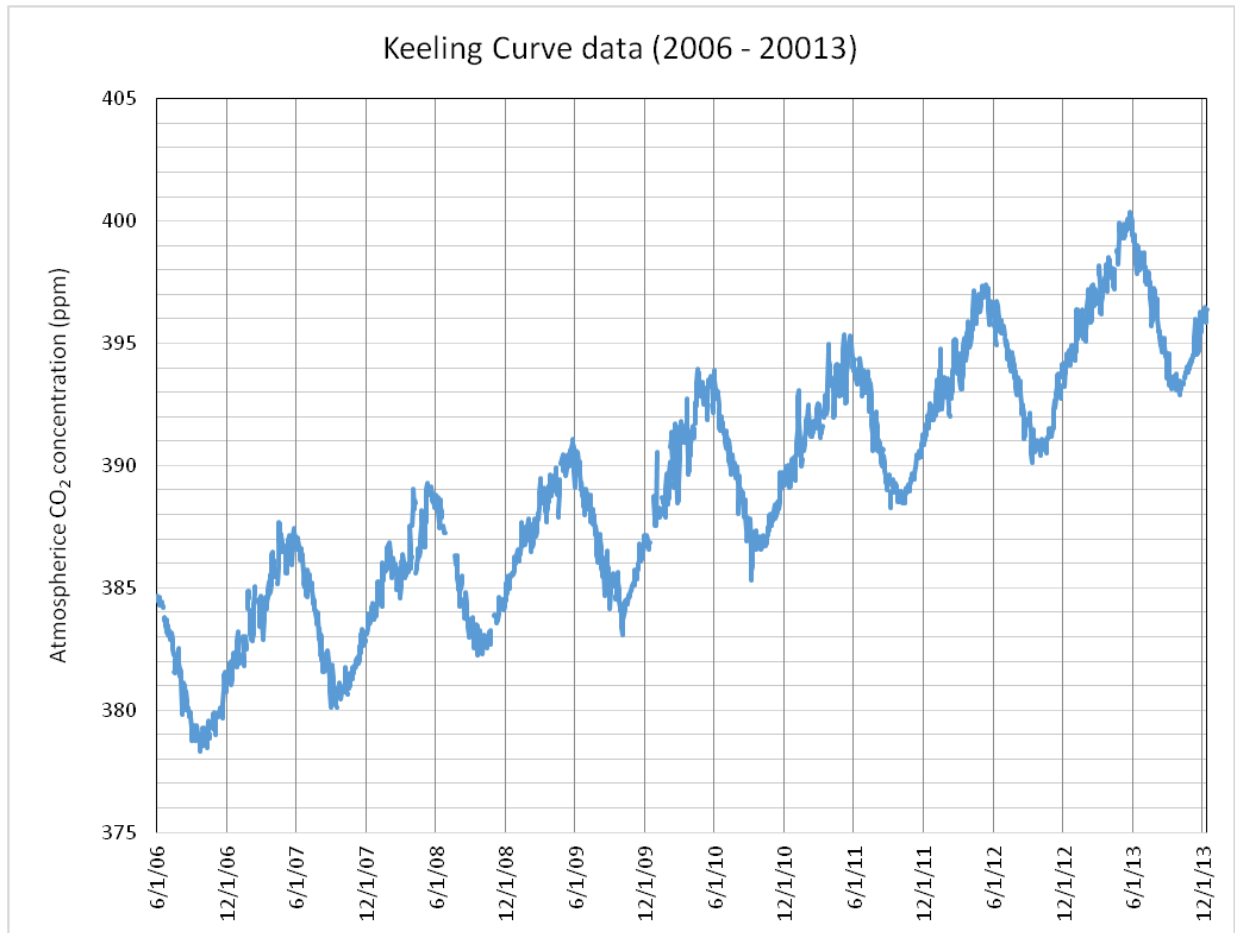


Using Environmental Data to Investigate Ocean Acidification Session 9

Part 1: Using global data to track recent changes in atmospheric CO₂ concentrations.

In this activity you will use recent atmospheric CO₂ concentrations data collected at the Mauna Loa observatory in Hawaii (see below) to estimate the rate of change of global atmospheric CO₂ concentrations over roughly the past decade.

Question: How much have global atmospheric CO₂ concentrations changed over recent years? How does the concentration of atmospheric CO₂ change throughout the year?



Using the graph above, answer the following questions about atmospheric CO₂ concentrations.

1. What time of the year do the lowest concentrations of carbon dioxide occur? [*late summer, early fall*]
2. Visually estimate the lowest CO₂ concentration in 2006 [*approx. 378 ppm*]
3. Visually estimate the lowest CO₂ concentration in 2013. [*approx. 393 ppm*]
4. What is the difference in these CO₂ concentration values between 2006 and 2013? [*15 ppm*]
5. Draw a line connecting the lowest values for each year in the graph above. Estimate the **annual** rate of change in CO₂ over this seven year period. Use units of “ppm per year”. [*2.14ppm per year*]
6. How does your estimate compare to the rate of increase of 2.07 per year reported by NOAA? [*very close*]

When you are done with the questions above, please proceed to the next page

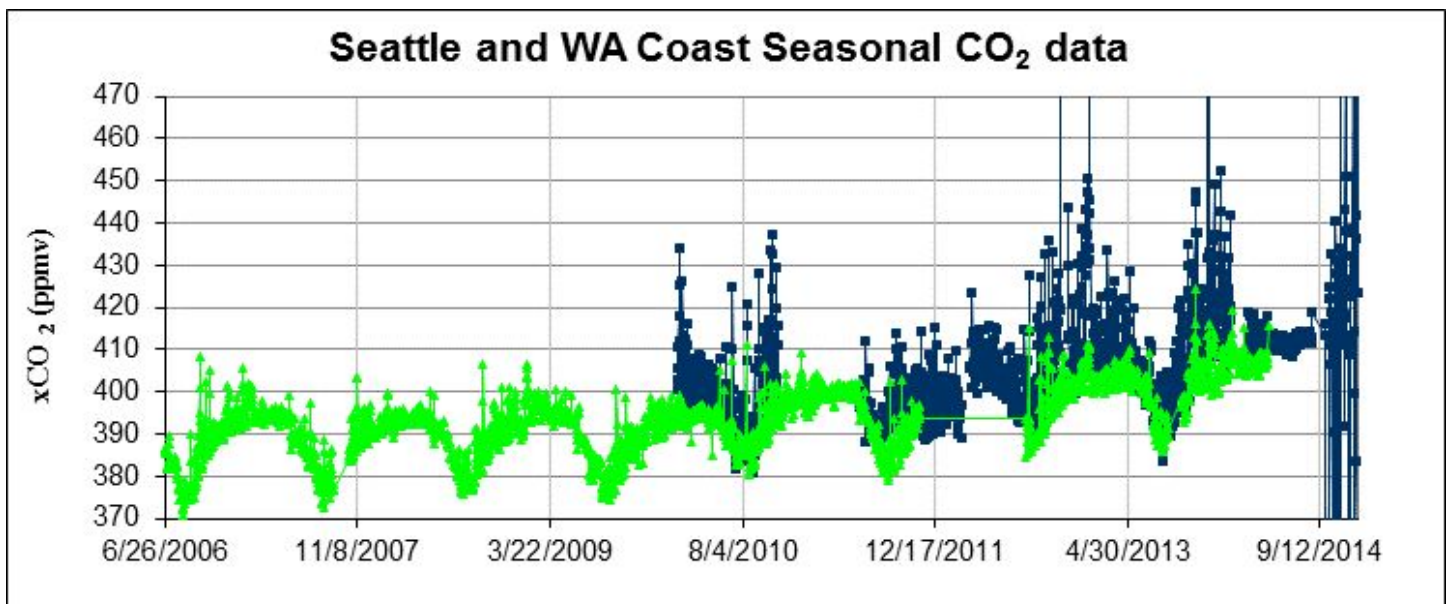
Part 2: Using local data to evaluate regional changes in atmospheric CO₂ concentrations.

In this section, you will use 8 years of data from a CO₂ sensor placed on an offshore buoy on the outer coast of Washington State to estimate the change in atmospheric CO₂ concentrations.

Question: How much have atmospheric CO₂ concentrations changed over almost the past decade in Washington State? How do patterns in regional CO₂ concentration increases compare to global predictions/estimates?

Data collection: You will collect atmospheric CO₂ data reported on NOAA's Pacific Marine Environmental Laboratory (PMEL) carbon website.

- 1) Go to the PMEL Space Needle website at <http://www.pmel.noaa.gov/co2/story/Space+Needle>
- 2) Click the "Seasonal" tab above the display of atmospheric CO₂ data.
- 3) Look at the graph of CO₂ data and estimate the lowest CO₂ concentration in 2006. Do the same for 2013. This will give you a baseline for comparing CO₂ concentrations during this time period.
 - a. What was the lowest CO₂ concentration value in 2006? [*370 ppm*]
 - b. What was the lowest CO₂ concentration value in 2013? [*385 ppm*]
 - c. What is the difference in these CO₂ concentration values between 2006 and 2013? [*15 ppm*]
 - d. Estimate the annual rate of change in CO₂ over this period. [*2.14 ppm per year*]
 - e. How does this estimate of the change in CO₂ concentration off the coast of Washington compare to the annual rate of increase you estimated for data collected in Hawaii. [*They are similar*]
- 4) Discuss the following questions in your small group:
 - a. What explanation can you offer for the difference/similarity in patterns of CO₂ concentrations collected in Hawaii and Washington over the past 10 years? [*Both are influenced by the Pacific ocean and season patterns*]
 - b. What does a comparison of CO₂ concentration data from Hawaii and Washington suggest about changes that are taking place in other parts of the world? What additional evidence would you need to support your conclusion? [*It suggests that these are global not local patterns. Finding a similar pattern in another part of the world would support this conclusion*].



When you are done with the questions above, please proceed to the next page

Part 3. Tracking changes in surface water pH in local waters (Padilla Bay estuary)

Overview: You have observed changes in atmospheric CO₂ over a recent seven year period using data from the PMEL Carbon Study program. You will now consider how the pH of coastal waters in the same region has changed over the same period of time and reflect on the consequences for marine organisms.

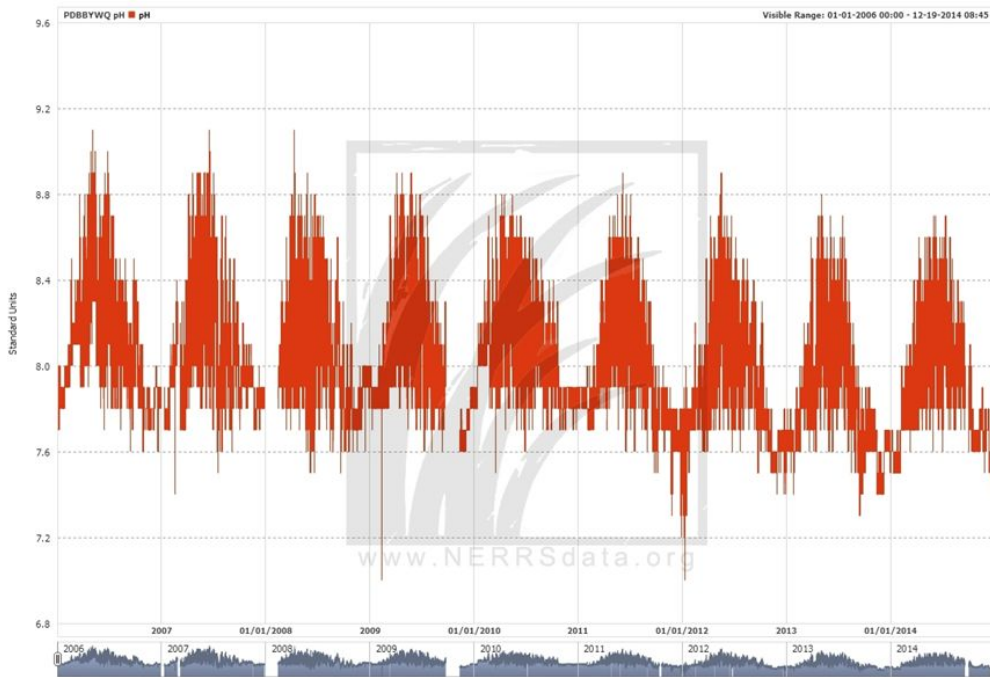
Question: How has ocean pH changed during the same period that increases in atmospheric CO₂ have been observed? Is there a similarity in the annual pattern of ocean pH and atmospheric CO₂ concentrations?

Review: Discuss the following questions with classmates before answering. Provide a brief explanation for your answer.

1. What will happen to global atmospheric CO₂ concentrations with continued combustion of fossil fuels? [*It will increase, because burning fossil fuels produces carbon dioxide*]
2. If global CO₂ concentrations increase, what do you predict will happen to CO₂ concentrations in the surface waters of the oceans? What activity in a previous session demonstrated this relationship? [*Ocean CO₂ concentrations will also increase, because the CO₂ is being absorbed by the ocean from the atmosphere. The Tracking Carbon Flows through the Ocean Reservoir where they had multiple jars with BTB and conducted different experiments with them to track CO₂.*]
3. As CO₂ concentrations increase in the water, what will happen to the amount of carbonic acid in the water? [*As CO₂ concentrations increase in the water, the amount of carbonic acid in the water will increase.*]
4. As carbonic acid concentrations increase in the water, what will happen to the pH of that water? [*The pH of the water will drop and become more acidic.*]

Data collection: You will collect data on surface water pH from the monitoring systems at the Padilla Bay National Estuarine Research Reserve (NERR).

- 1) Go to the NERR data export website at <http://cdmo.baruch.sc.edu/get/export.cfm>
- 2) Using the interactive map, click on the button for “Padilla Bay, WA”.
- 3) Select the “Bayview Channel” water quality station from the list of stations that appears. Click “Proceed with this Station”
- 4) This page displays real-time data being collected from the sensors at this station, along with a series of options for viewing or downloading data. Click the radio button next to “Graph Data”
- 5) You are going to analyze pH data from an nine year period. To access these data, enter “01/01/2006” as a start date and “12/31/14” as an end date. Choose “pH” as the 1st parameter in the dropdown menu.
- 6) Click the “Graph!” button. This will generate a graph of all your pH data. (*This may take up to a minute.*)
- 7) Once your graph has been displayed, complete the “Exploring patterns in your data” prompts below. If you want to print your graph, right click on the image. Or you can save your graph by clicking “save this graph as an image”.



Exploring patterns in your data: How has pH changed over the past nine years in Padilla Bay? How does this compare to patterns in atmospheric CO₂ concentrations?

- 1) Estimate the highest pH values for 2006 and 2014. To do this, use the sliders at the bottom of the page, or select “1Y” from the preset zoom buttons at the bottom left. Move the cursor over the graph to get values.
 - a. What is the highest pH value in 2006? [9.1]
 - b. What was the highest pH in 2014? [8.7]
 - c. What is the difference in these pH values between 2006 and 2014? [0.4]
 - d. What is the annual rate of change in the pH in Padilla Bay? [-0.4 over 8 years, or -0.05 per year]

When you are done with the questions above, please wait to complete the final page.

Exploring best fit lines in your data:

1. Draw a small circle around the highest pH measurement each year.
2. Fill in each circle.
3. Make a dashed line that connects the dots from every year.
4. Use a ruler to draw a single “best fit” line that goes through the middle of the area all of the dots from each year.

What do you notice about the trend of these data points?

