Understanding Ocean and Coastal Acidification

Introduction

The amount of CO2 in the atmosphere is increasing, due to the burning of fossil fuels and other human activities. How do these changes, as well as other human activities, affect the chemistry of the ocean? In these activities, you will use real data to investigate long-term changes in ocean chemistry and the effect that these changes have on the organisms living in these areas.

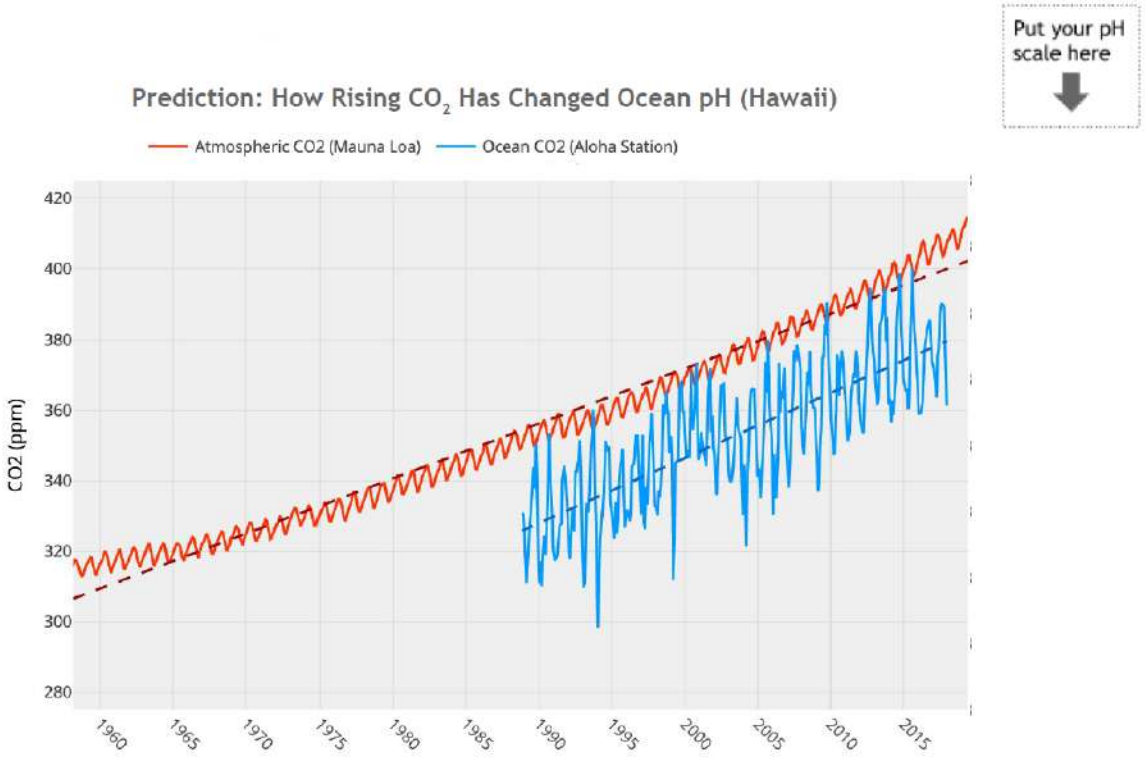
Procedure

- Use your internet browser to find the Data in the Classroom website. https://noaa.maps.arcgis.com/apps/MapSeries/index.html?appid=adec7620009d439c85109ab9aa1ea227
- Launch the Ocean & Coastal Acidification module, and click on 'Level 1'
- Work through the online activities.
- Stop and use this worksheet when instructed to do so.

Level 1

1. Predict the likely effect of rising CO 2 on ocean pH by completing all of the sentences below.
    a. I predict that the pH of the ocean has changed from 8.1 (1988) to …….. (today).
    b. This change in pH is likely the result of the following changes in atmospheric CO 2 and ocean CO2 :.....
    c. The primary chemical reaction(s) that may explain this change in pH are……..

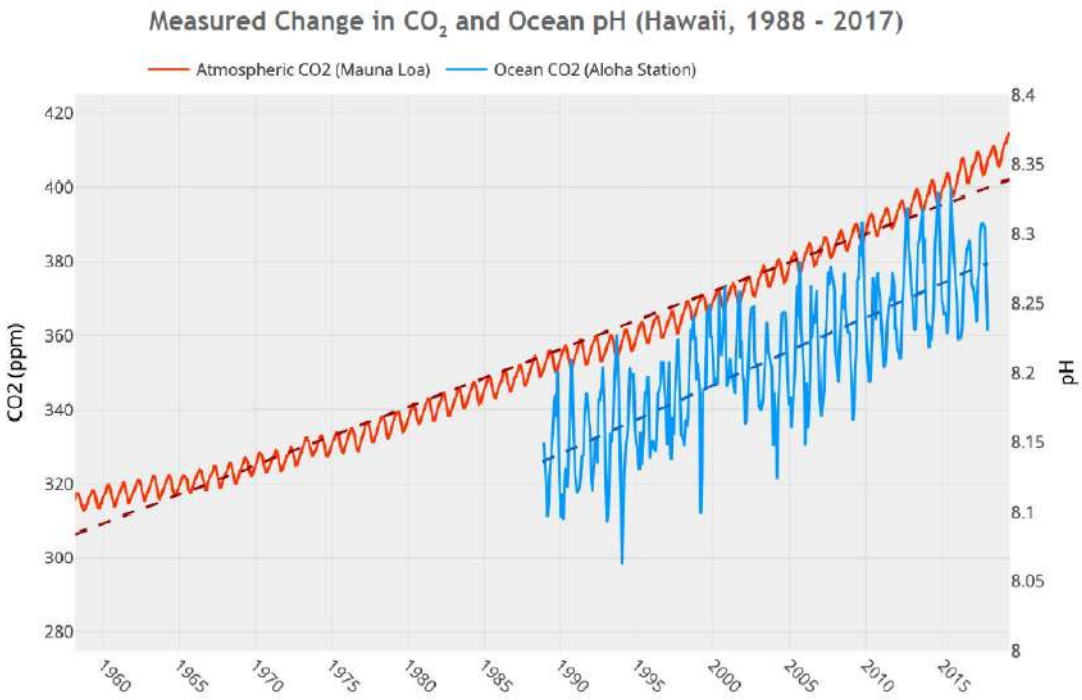
2. Make a line on the graph below to illustrate your prediction.
   Here's how.
    a. Add "Ocean pH" to the legend above the graph.
    b. Create a pH scale along the y-axis on the right side of the graph.
    c. Do NOT make your scale from 0 to 14. Keep it centered around your prediction.
    d. Find the year 1988 on the x-axis. Ocean pH was 8.1 in 1988. Place a dot at this location on the graph.
    e. Starting from the dot, create a line that shows your predicted change in ocean pH from 1988 to current.



LEVEL 2 – Measuring Changes in Ocean pH

3. After completing the online activities in Level 2, compare your predictions from Level 1 with the actual changes in ocean pH. Then, complete the sentences below.
    a. I predicted that pH would [increase / decrease] by ……..…... pH units.
    b. The data show that pH actually [increased / decreased] by ……..…... pH units.
    c. Because the pH scale is logarithmic, this change represents a …… percent [increase / decrease] in acidity.

4. Draw a line on the graph to show the actual change in ocean pH over time.
    a. Note: the pH scale along the y-axis is completed for you.
    b. Remember to add “Ocean pH” to the legend above the graph.
    c. Draw a dotted trend line through the pH data to show the long-term trend.



5. CO2 and pH both change in a predictable pattern from year to year.
    a. Describe the pattern…..
    b. What causes the pattern? Use the evidence from the graph in your answer….

6. What is ocean acidification? Define the term in your own words……

LEVEL 3 – Examining Acidification Along the Coast

7. Compare ocean pH at two locations, Hawaii and coastal Washington, between 2010 and 2017.

Location	**Highest pH value**	**Lowest pH value**	**Range (highest - lowest pH)**
Cha Ba (Washington)			
WHOTS (Hawaii)			

8. Explain:
    a. What are two major differences between ocean pH along the coast of Washington and ocean pH near Hawaii? Use the data in the above table to support your answer.
    The two major differences between ocean pH and coastal pH are...

b. In both locations, human-caused increases in CO 2 can cause acidification. What two OTHER biological process(es) might influence pH in coastal areas? Complete the table below.

Location	**What process causes a change in pH?**	**What is the effect on ocean pH?**	**Explanation**
Open ocean	Human-caused increases in atmospheric CO2	pH decreases	CO2 combines with water to form carbonic acid
Coastal ocean	Human-caused increases in atmospheric CO2	pH decreases	CO2 combines with water to form carbonic acid

9. How would you define coastal acidification? Use your answers in Question 8 to help form a definition, in your own words.
   Coastal Acidification is…..

LEVEL 4 – Acidification's Impact on Shell Building Animals

10. Changes in ocean chemistry reduce the ability of some animals to build their calcium carbonate (CaCO3) shells.
    a. Write the chemical reaction(s) below to illustrate this statement.
       …...
    b. Explain the reaction(s) in 1-2 sentences.
       …..

11. Aragonite saturation state (Ω) is a measurement that describes the tendency for calcium carbonate to form or to dissolve. What is the relationship between aragonite saturation state, CO 2 and pH? Choose increases or decreases in each case below.
    a. When CO 2 in the atmosphere increases, ocean CO2 [increases/decreases].
    b. When ocean CO 2 [increases/decreases], pH [increases/decreases].
    c. When pH [increases/decreases], aragonite saturation state (Ω) [increases/decreases].
12. Data: Complete the table below to show WHEN ocean conditions might negatively affect the growth and survival of larval Pacific oysters. For each month, write the % of observations that fall below the threshold (Ω < 1.5 and Ω < 2.0).

Aragonite saturation state (Ω)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Ω < 1.5 *lethal conditions*												
Ω < 2.0 *conditions not adequate for growth*												

13. Explain:
    a. Given the current conditions in WA, will larval oysters have enough aragonite to grow and build shells? Explain using the data above.
       …..
    b. In natural systems, oysters reproduce in the summer months. Will larval oysters be able to build their shells given the current summertime conditions?
       …..
    c. Could larval oysters experience lethal conditions at any point during the year? Explain using the data above.
       …..
    d. Complete the final section of Level 4. How do you think shell-building animals will be impacted, given the conditions predicted for 2100?
       …..

Optional:

LEVEL 5 – Designing Your Own Investigation

1. Develop Your Question: Write a draft of your question below. Make sure your question can be answered using the data available on Level 5 of the Ocean & Coastal Acidification module.

2. Make a Plan: Make a list below of the specific data you will need to answer the question. Other than the data listed above, what other information (if any) will you need to answer your question?

3. Get the data: Download (or take screenshots) of the data you will need from Level 5.

4. Interpret the data: What does your data show? Be specific and descriptive.

5. Draw a Conclusion : What is the answer to your question? Use evidence and data to support your conclusion.