Authentic Data Integration

Data: Atmospheric & Ocean CO_2 and pH
Source: NOAA Understanding Ocean and Coastal Acidification

- Both figures below can be modified/expanded and students can identify specific data points and values at: https://chart-studio.plotly.com/create/?fid=dvignoles:12#/ (linked from NOAA)

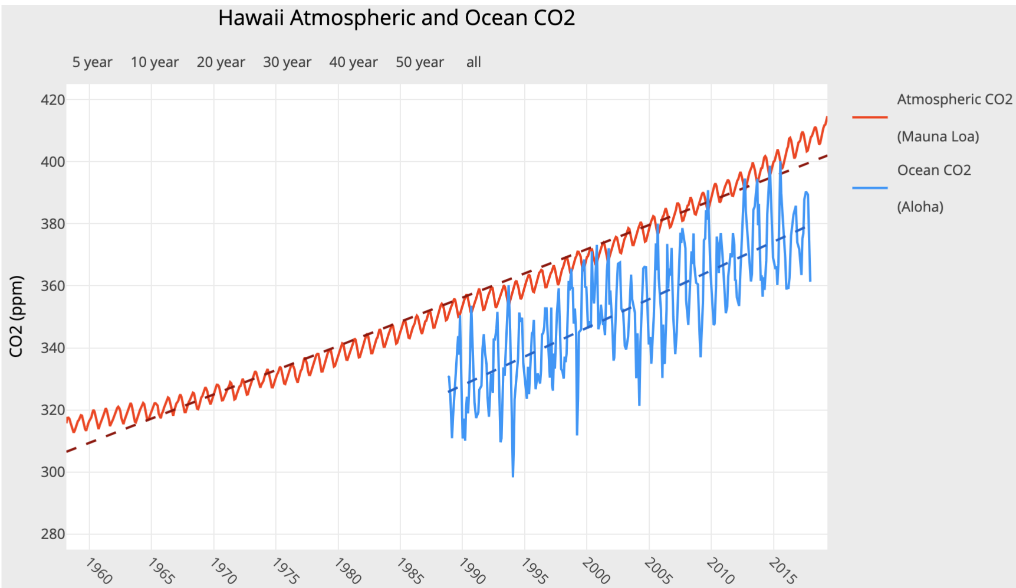

Figure 1. Atmospheric and oceanic CO_2 levels measured at Mauna Loa and Station ALOHA, respectively.

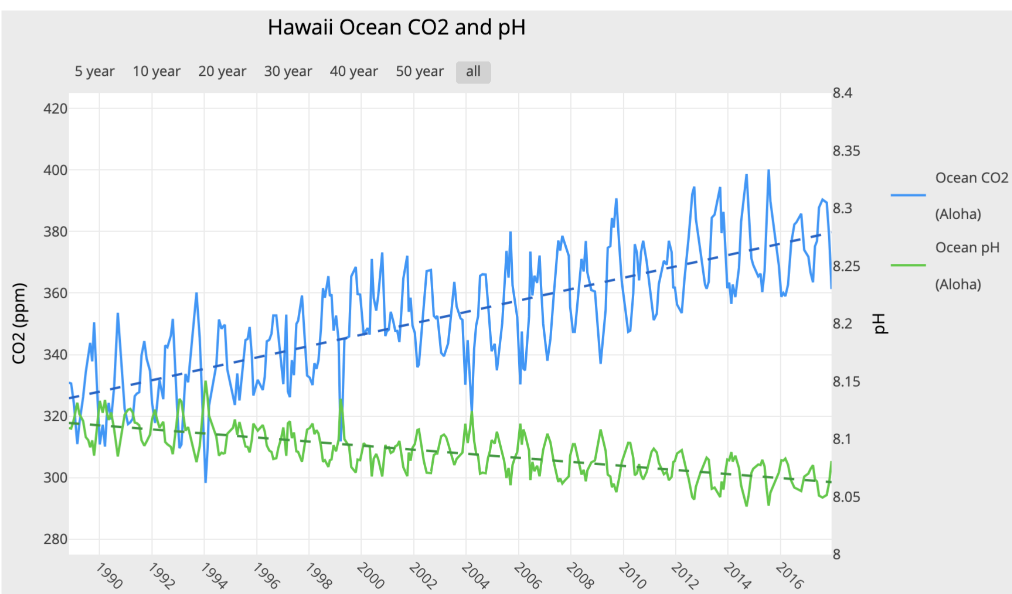

Figure 2. Oceanic CO_2 and pH levels measured at Station ALOHA.

Accompanying Standard

AP Environmental Science Topic 9.7: Explain the causes and effects of ocean acidification.
Essential knowledge:

- Ocean acidification is the decrease in pH of the oceans, primarily due to increased CO_2 concentrations in the atmosphere, and can be expressed as chemical equations.

- As more CO_2 is released into the atmosphere, the oceans, which absorb a large part of that CO_2, become more acidic.
- Anthropogenic activities that contribute to ocean acidification are those that lead to increased CO_2 concentrations in the atmosphere: burning of fossil fuels, vehicle emissions, and deforestation.
- Ocean acidification damages coral because acidification makes it difficult for them to form shells, due to the loss of calcium carbonate (College Board, 2020).

Lesson Enhancement

This data will serve as the launch point for students to begin thinking about and investigating the impact of and relationship between carbon dioxide, ocean pH/ocean acidification, and ocean chemistry with shell-building marine life. Using this introductory data, students will first examine the trends in atmospheric and ocean CO_2 levels (Fig. 1). Students will come to identify not only the rise in both atmospheric and ocean CO_2 levels, but also understand the reason for the seasonal oscillations in measured levels, due to changes in global photosynthetic activity (NASA, 2024). This data will allow students to actually quantify the relationship between rising CO_2 levels in the atmosphere and the ocean, rather than leaving it as a qualitative relationship.

Once students interpret the atmospheric and oceanic CO_2 data, they will then think about another layer of data by examining the change in oceanic CO_2 levels and pH levels. Students will be asked to identify the correlation between dissolved CO_2 levels and pH levels, again analyzing the oscillation in levels. This data will lead students to identify the correlation between increasing oceanic CO_2 levels and decreasing pH levels. And, students will be reminded that, because pH is a logarithmic scale, a small decrease in value translates to a great increase in acidity, by calculating the change in oceanic acidity. Ultimately, this data will launch a further investigation into more localized trends in oceanic CO_2 and pH levels, using further NOAA data accompanied with an investigation into the impacts of ocean acidification on shell-building marine life and the design of possible solutions and/or mitigation plans.

Beliefs about Data

I personally believe that, at any point possible, authentic data should be pulled in and incorporated into lessons with students. Use of data could be students generating their own datasets from a variety of investigations or manipulating and/or analyzing a given dataset. I think doing this accomplishes two important goals. First, the use of authentic data makes the science “real” - it’s not some hypothetical data set that a curriculum writer created on a fancy, nice looking graph for a section of the textbook. Real data - generated from real science - backs up what we are teaching and learning, makes it concrete for students that this thing or this concept does really happen out in the world, and exposes them to the messiness of real data and experimental results. Second, the use of authentic data adds rigor to students’ STEM experiences by developing their ability to analyze data and make claims based on evidence, furthering their scientific literacy and science skills. Data is all around us and students need to be able to think about how that data was generated, what story that data is trying to tell, and how that data is being used to accomplish a specific goal. Students will encounter numerous questions and claims out in the real world that involve data. For example, should they upgrade to a new phone/laptop which promises a longer lasting battery, what percent of election polls are for/against a particular idea, what are the best benefits/trade offs to a credit card or a savings account? Students need to be fluent in reading and analyzing data and by incorporating authentic data in the classroom, students are able to further their development of those skills in a collaborative and supportive environment.

Interdisciplinary Context

The dataset I have chosen ties together numerous scientific domains, including biology, environmental science, earth science, and chemistry. In order to understand the phenomenon, students need to explore relationships between the carbon cycle, anthropogenic and organic activities that release/remove carbon dioxide, atmospheric and marine systems, pH scale, and water and carbon dioxide chemistry. Additionally, to begin to understand the complex relationship presented by the data, students need to develop their mathematical skills, analyzing data trends presented on line graphs, trend lines and lines of best fit, and the logarithmic nature of the pH scale. Additionally, students will need to use the understanding of log scales to calculate how much of an increase in acidity is presented by the change in data from a pH of ~8.12 to ~8.06.

Furthermore, this data is intended to be a launching point for future student exploration. Students will start with understanding the global trend before diving deeper into specific, local real-time measurements of dissolved CO_2 and pH (from NOAA's various coastal moorings: https://www.pmel.noaa.gov/co2/story/Coastal+Moorings). Through this, students will understand that, although there is the global trend of increasing CO_2 and ocean acidification, the impacts of that trend look different in different locations across the globe, calling for localized investigation and mitigation plans. Students can conduct investigations to see the direct relationship between carbon dioxide and pH in specific locations and then read primary literature about the effects of increasing acidity on marine health and marine life, tying in scientific literacy and reading skills.

Additionally, it is envisioned towards the end of this learning segment to have students engage in the engineering practices by researching, evaluating, and proposing /designing models and solutions to help mitigate the impacts of ocean acidification on shell-building organisms like oysters and mussels or the impacts on coral reefs and reef restoration. Possible solutions to this global issue will develop students' engagement with the engineering practices as they think about the goals, problems, and real-life trade-offs inherent in any design to a complex problem. And, while doing so, students will need to furthermore tie in and connect chemistry concepts such as buffering and the relationships between acids and bases with biological concepts such as the flux in CO_2 from combustion/respiration and photosynthesis.

References

College Board. (2020). *AP environmental science course and exam description*. College Board.

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