

Coral Sand and Vinegar: Investigating Ocean Acidification

Background & Key Concepts

In Activity 2 (Drowning Island), we learned that increased levels of carbon dioxide (CO_2) in the atmosphere are causing the Earth's climate to warm and sea levels to rise. Global climate change is a serious problem, but it's not the only problem caused by excess CO_2 . When human activities put excess CO_2 in the atmosphere, some of this CO_2 gets absorbed in the ocean. In the ocean, CO_2 combines with water (H_2O) to form carbonic acid (H_2CO_3). This causes the ocean to become more acidic (that is, have a lower pH). This process is called ocean acidification, and is a huge problem for marine ecosystems. For example, many marine organisms (such as coral) have calcium carbonate shells, which dissolve in acid.

How do we know this?

Since October 1988, scientists from the Hawai'i Ocean Time-series (HOT) program have been making measurements of seawater about once per month at a location 60 miles north of O'ahu called Station ALOHA. These data allow us to track how ocean chemistry has changed over time. The graphs below (Fig. 5.1), which are explained in detail on the following page, show that the ocean's CO_2 has increased and its pH has decreased since the HOT program began collecting data.

The Station ALOHA Curve

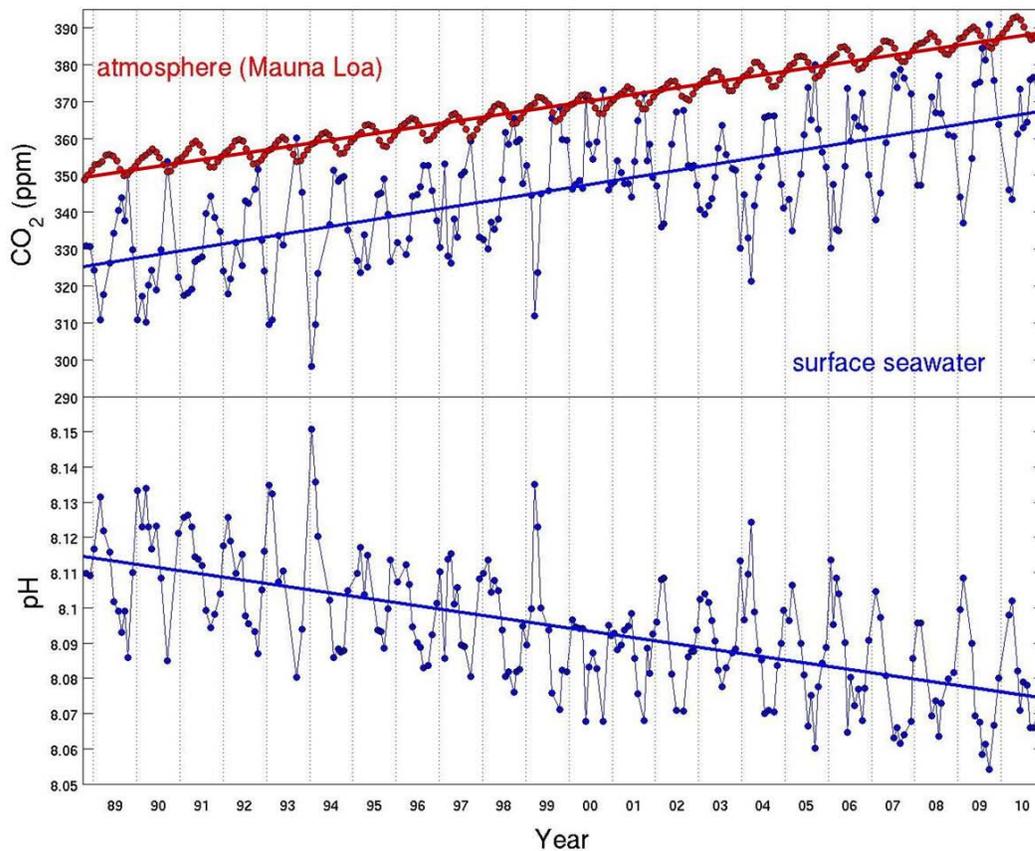
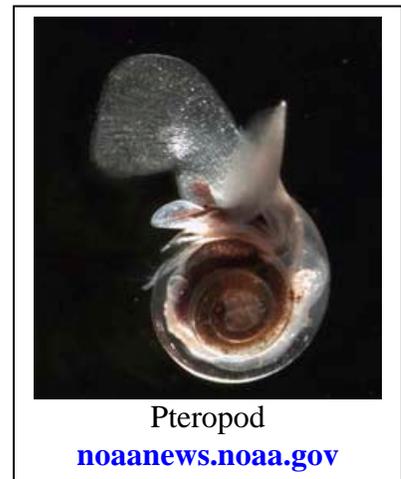


Figure 5.1 Time series of atmospheric CO_2 (red dots) and oceanic CO_2 and pH (blue dots). Atmospheric data were collected at the Mauna Loa Observatory, and oceanic data were collected at Station ALOHA, located 60 miles north of O'ahu.

The graphs in Figure 5.1 are called time series, meaning they show changes over time. The horizontal x-axis, given in years, runs from late 1988 through 2007. The top graph shows that CO₂ has increased in both the atmosphere and the ocean since 1988. The atmospheric data (red dots) were collected from Mauna Loa Observatory under the supervision of Charles Keeling; they form the “Keeling Curve”. Note the annual seasonal cycles, due to varying amounts of photosynthesis and respiration, as well as a general increase in CO₂ with time. The oceanic data (blue dots) were collected by the HOT program under the supervision of Drs. David Karl and Matthew Church and are called the “Station ALOHA curve”. The blue line is a “best fit” to the oceanic data. Like the atmospheric data, the oceanic data show intra-annual cycles and a general increase in CO₂ since 1988. For more information, go to: <http://hahana.soest.hawaii.edu/hot/>

Why is this important?

Ocean acidification affects the ability of calcifying organisms, such as corals and certain types of plankton, to create their calcium carbonate shells. Without these protective structures, these organisms cannot grow properly and defend themselves. Ocean acidification therefore threatens their survival. Because calcifying organisms like corals and plankton provide shelter or food for countless other creatures, their disappearance will have severe and widespread consequences. For example, pteropods are small, planktonic snails that swim near the ocean’s surface. These currently abundant organisms are eaten by a wide variety of fishes, and even by some marine mammals such as whales. If ocean acidification prevents pteropods from growing, the entire food web will be disrupted, and the impacts on marine ecosystems could be catastrophic.



Hawai‘i Content & Performance Standards (HCPS III)

The following standards and benchmarks can be addressed using this lesson:

Science Standard 1: The Scientific Process: SCIENTIFIC INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process.

Grade 5 Benchmarks for Science:

Benchmark SC.5.1.2 Formulate and defend conclusions based on evidence.

Science Standard 2: The Scientific Process: NATURE OF SCIENCE: Understand that science, technology, and society are interrelated.

Grade 5 Benchmarks for Science:

Benchmark SC.5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

Science Standard 4: Life and Environmental Sciences: STRUCTURE AND FUNCTION IN ORGANISMS: Understand the structures and functions of living organisms and how organisms can be compared scientifically.

Grade 3 Benchmarks for Science:

Benchmark SC.3.4.1 Compare distinct structures of living things that help them to survive.

Science Standard 5: Life and Environmental Sciences: DIVERSITY, GENETICS, AND EVOLUTION: Understand genetics and biological evolution and their impact on the unity and diversity of organisms.

Grade 3 Benchmarks for Science:

Benchmark SC.3.5.1 Describe the relationship between structure and function in organisms.

Grade 4 Benchmarks for Science:

Benchmark SC.4.5.3 Describe how different organisms need specific environmental conditions to survive.

Social Studies Standard 7: Geography: WORLD IN SPATIAL TERMS-Use geographic representations to organize, analyze, and present information on people, places, and environments and understand the nature and interaction of geographic regions and societies around the world.

Grade 3 Benchmarks for Social Studies:

Benchmark SS.3.7.4 Examine the ways in which people modify the physical environment and the effects of these changes.

Materials

- Coral sand
- Vinegar
- Small dish
- Medicine dropper or plastic pipette

All materials are included in the C-MORE Science Kit on Ocean Acidification, which can be borrowed by Hawai'i's teachers free of charge. Request a kit at:

http://cmore.soest.hawaii.edu/education/teachers/science_kits.htm

Procedure

- 1) Put a small amount of sand into the small dish.
- 2) Use the dropper to place a few drops of vinegar on the sand.
- 3) Watch what happens!



Explanation

This activity allows you to see first-hand the effects of ocean acidification on calcifying organisms. Most sand in Hawai'i is composed of tiny pieces of shells, corals, and other calcifying organisms. When exposed to vinegar, which is an acid, the calcium carbonate-containing sand produces CO₂ bubbles as it dissolves. Since the shells and skeletons of live calcifying organisms will be similarly affected as the ocean acidifies, these organisms will not be able to grow properly, and all of the organisms that depend on them will also be impacted.

Extension

Try the same experiment with basalt sand, which is composed of eroded bits of lava. What do you think will happen?

References Cited

Hawai'i Ocean Time-series (HOT): <http://hahana.soest.hawaii.edu/hot/>

Additional References

Doney, S.C. 2006. The dangers of ocean acidification. *Scientific American* March: 58-65.

Special Issue: Ocean Acidification-from Ecological Impacts to Policy Opportunities. 2009. *Current: The Journal of Marine Education* 25(1): 1-45.

Acid Test: The Global Challenge of Ocean Acidification (20 minute movie on ocean acidification):

<http://www.nrdc.org/oceans/acidification/aboutthefilm.asp>

The Ocean in a High CO₂ World: <http://www.ocean-acidification.net/>

Pacific Marine Environmental Laboratory ocean acidification home page:

<http://www.pmel.noaa.gov/co2/story/Ocean+Acidification>

European Project on Ocean Acidification page: <http://oceanacidification.wordpress.com/>