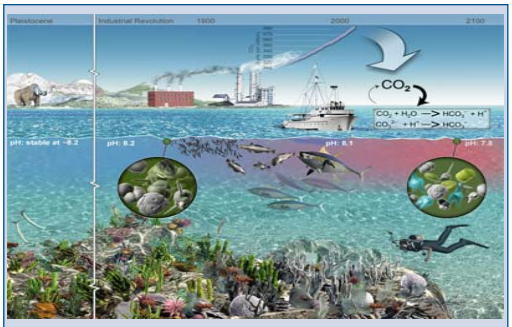
Ocean Acidification: Plotting the Dangers



Grade Level

- Grades 6 - 8

Timeframe

- 90 minutes

Materials

- Cups
- Straws
- Bromothymol blue
- Safety goggles
- Rulers
- Student Activity Sheet (p. 4)
- Graph paper (p. 5)

Key Words

- Ocean Acidification
- Carbon Dioxide
- Line of Best Fit
- Scatter Plot

Activity Summary

The rise of carbon dioxide levels that leads to ocean acidification is the focus of the lesson. Students will discover how carbon dioxide makes the ocean more acidic; while, discussing the effects on marine ecosystems. Students will apply graphing techniques to explore the rise of carbon dioxide levels in the ocean. Students will discuss methods of reducing carbon dioxide levels to prevent ocean acidification.

Learning Objectives

Students will be able to:

- Identify sources of carbon dioxide and describe how too much carbon dioxide in the atmosphere leads to ocean acidification.
- Demonstrate graphing techniques such as plotting points from data, scaling, and line of best fit.
- Make conclusions and predictions about the increase of carbon dioxide over time, including the time it will take to reach the limit of 500ppm carbon dioxide concentration.

Background Information

As part of Earth's natural carbon cycle, the ocean absorbs approx. 30% of the carbon dioxide in the atmosphere. Therefore, as the amount of CO_2 in the atmosphere increases, so does the amount in the ocean.

When CO_2 mixes with the water in the ocean, a chemical reaction occurs resulting in *Ocean Acidification*. This reaction is detrimental to several marine organisms including coral, *pteropods*, and shellfish. The increase in CO_2 reduces the amount of calcium carbonate available to many marine species in the construction of their shells.

Since the Industrial Revolution, the concentration of CO_2 in the atmosphere has continued to increase. The United States Environmental Protection Agency (EPA) has put a limit of *500ppm* on CO_2 concentration in the atmosphere. The current concentration is 392ppm. Organizations are currently trying to lower the level to 350ppm.

See Resources section for additional information.

Vocabulary

OCEAN ACIDIFICATION – When CO_2 reacts with water, carbonic acid is created. Too much CO_2 leads to a lower pH and a more acidic ocean.

PTEROPOD – A mollusk at the base of the marine food-chain.

500ppm – 500 parts per million: concentration of CO_2 that will decrease the oceans pH by 0.2.

BROMOTHYMOL BLUE – pH indicator that changes from blue to green or yellow indicating a change from neutral to acid.

Preparation

- Gather the materials.
- 10-15 minutes before the experiment, add a few drops of bromothymol blue to cups of water.

Procedure

Instructor should provide some background information about atmospheric CO_2: sources (factories, car emissions, etc.) and the rise in concentration levels.

Activity 1: CO_2 and H_2O

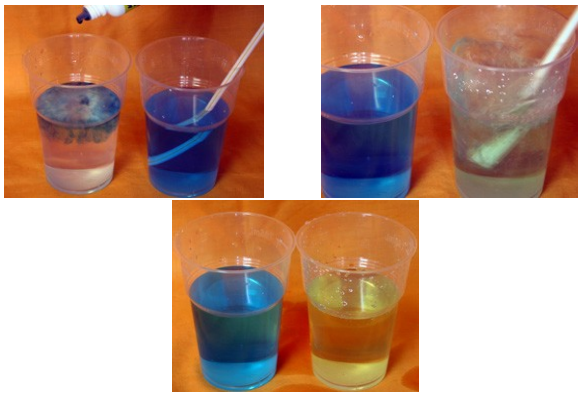
1. Each student/pair/group receives a cup half full of water with a few drops of bromothymol blue added, a straw, and safety goggles.
2. Instruct the students to
   a. Put on their goggles
   b. Hold the cup in one hand (on the table)
   c. Put the straw in the cup and hold it in other hand
   d. Blow into the straw

Discussion Questions:

1. What are you breathing into the straw?
2. What does the color change indicate about the water?
3. From this example, what can be inferred about industrial CO_2 emissions' effect on the ocean?

Extensions:

- Wait about 30 minutes for the color to change back and ask what it indicates. Refer to the earth's natural carbon cycle.



Instructor should provide some background information about atmospheric CO_2: the upper limit put forth by the EPA (500ppm), the current level (392ppm), and the goal level (350ppm).

Career Link: Scientists set up measuring tools to monitor changes in temperature, pH, salinity, etc. in order to make predictions about the future of our environment.

Activity 2: Plotting CO_2 Levels

1. Each student/pair/group receives a ruler, graph paper, and Student Activity Sheet – Plotting CO_2 Levels.
2. Students will complete the activity sheet.

Discussion Questions:

1. Why has CO_2 concentration increased over the last 50 years?
2. What can you do to help decrease atmospheric CO_2 levels?

Extensions:

- Plot seasonal or monthly data for the last 10 years; observe trends.
- Compare data between different locations in the world.

Education Standards

National Education Standards	Math 6-8: Algebra, Connections, Representation, Data Analysis Science 6-8: Earth and Space Science, Science in Personal and Social Perspectives Geography: Environment and Society (14)
Ocean Literacy Principles	3 – The ocean is a major influence on weather and climate (e) 6 – the ocean and humans are inextricably interconnected (g)
Climate Literacy Principles	2 – Climate is regulated by complex interactions among components of the earth system (d) 5 – Our understanding of the climate system is improved through observations, theoretical studies, and modeling (c, e) 6 – Human activities are impacting the climate system (b) 7 – Climate change will have consequences for the earth system and human lives (d)

Resources

Channel Islands Report on Ocean Acidification.
Ocean Acidification and the Channel Islands National Marine Sanctuary: Cause, effect and response. September 19, 2008.
https://nmschannelislands.blob.core.windows.net/channelislands-prod/media/archive/sac/pdfs/cwg-oar.pdf

Data Page of yearly/monthly atmospheric CO_2 levels.
https://www.esrl.noaa.gov/gmd/ccgg/trends/

Centers for Ocean Sciences Education Excellence
"Role of the COSEE Network is to create catalytic, multi-faceted collaborations to integrate ongoing research in the ocean sciences with K-12 education and outreach." http://www.cosee.net/

Integrated Ocean Observing System (IOOS)
Observation systems, data, and educational resources. "U.S. IOOS is a vital tool for tracking, predicting, managing, and adapting to changes in our ocean, coastal and Great Lakes environment."
https://ioos.noaa.gov/

350.org
Site devoted to the reduction of atmospheric CO_2 levels through public awareness.
https://350.org/

NOAA Ocean Explorer
"The NOAA Ocean Exploration program provides a variety of learning and teaching tools designed to engage broad audiences and enhance America's environmental literacy through the excitement of ocean discovery."
https://oceanexplorer.noaa.gov/edu/welcome.html

Acknowledgement
This lesson was developed by NOAA's Monitor National Marine Sanctuary.

Name:_____

Date: _____

Plotting CO_2 Levels

Student Activity Sheet

Our country and our world are growing. More people have cars and access to electricity. Buildings are getting taller. The population is growing exponentially larger. Farming is becoming more industrialized to keep up with demand. Factories are able to produce a lot of many different materials from food to tools. All of these advancements have improved day to day life. However, it comes with a cost. More industry requires more energy.

Most of this energy is obtained from coal and oil. When burned, emissions are produced in the form of carbon dioxide (CO_2). The ocean absorbs a third of the CO_2 from the atmosphere. Too much can result in Ocean Acidification (when the ocean becomes less basic and more acidic). Ocean acidification causes harmful effects on the marine ecosystem.

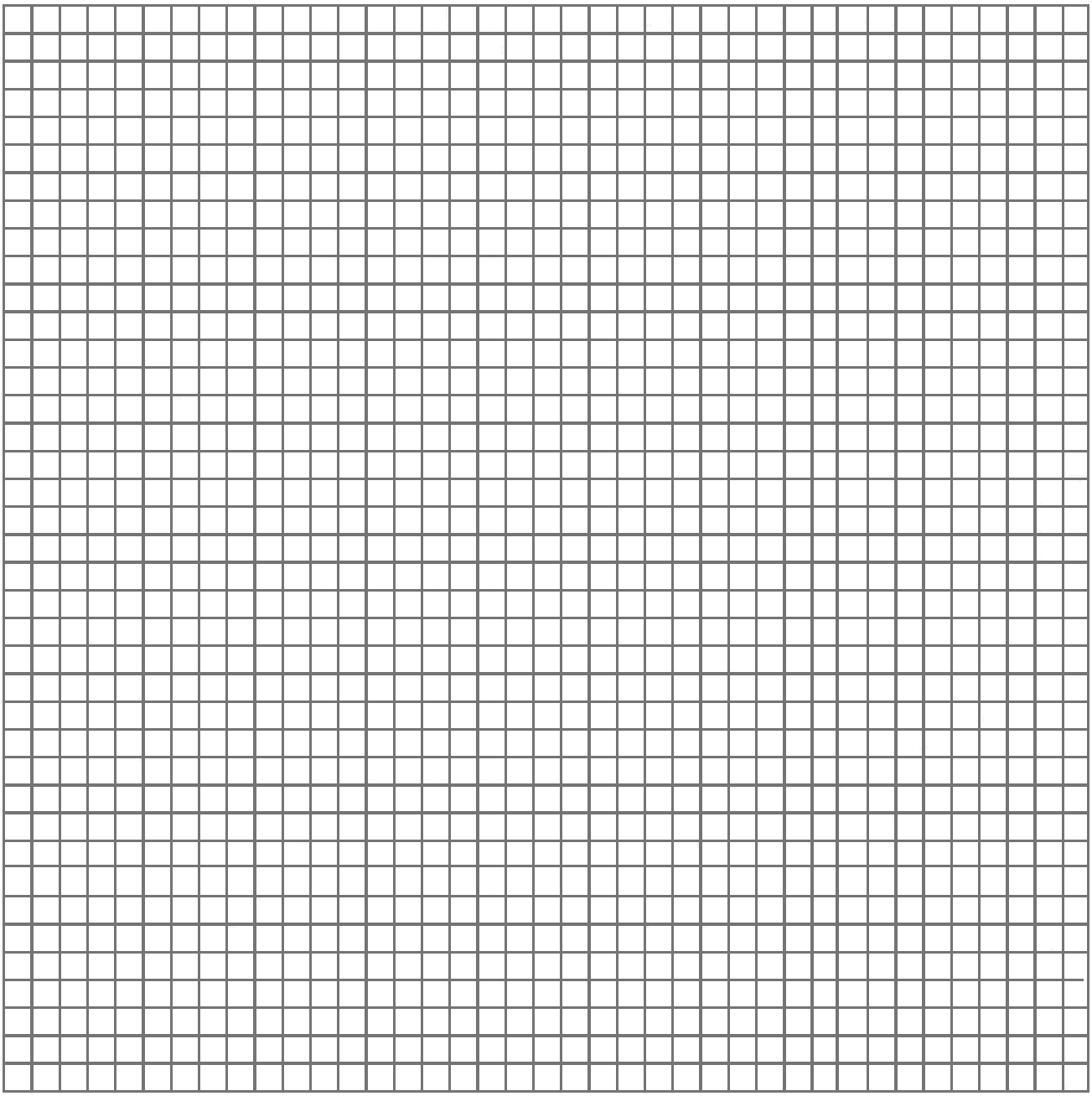
Scientists around the world are monitoring Earth's atmosphere and ocean, keeping track of changes and trends that could have repercussions for the environment. Below is a set of data from Mauna Loa, Hawaii, recording atmospheric CO_2 levels over the last 50 years. The levels are given in "ppm" – parts per million.

Year	Annual Average CO_2 Level (ppm)
1960	317
1970	326
1980	339
1990	354
2000	369
2010	392
2020	411

Your job is to

1) Plot the data on graph paper as a Scatter Plot
    a. Label the x-axis and y-axis
    b. Use scaling
2) Draw the Line of Best Fit
    a. Use your ruler to draw a straight line that best represents the data
3) Find the Equation for the line of best fit
    a. Choose two points on your line of best fit
    b. Find the slope of the line: $m = \frac{y_2 - y_1}{x_2 - x_1}$
    c. Find the equation of the line $(y - y_1) = m(x - x_1)$
4) Using the equation, predict how many years it will take for the CO_2 level to reach 500ppm.

Annual Atmospheric CO_2 Levels in Mauna Loa, Hawaii



Student Answer Sheet

1. Plotting the data
    a. On graph
2. Drawing the line
    a. On graph
3. Finding the equation
    a. Point 1:_____ Point 2: _____
    b. Slope:

    c. Equation of the line of best fit:

4. Predicting the future: Use the equation to determine the year CO_2 levels reach 500ppm

Discussion Questions

Why has CO_2 concentration increased over the last 50 years?

What can you do to help decrease atmospheric CO_2 levels?