Lesson 3.2 Ocean Acidification

Introduction

In last weeks lesson we learned about CO_2 and how it cycles through the earth, atmosphere and oceans. In this lesson we are going to look at a hot topic in ocean science, ocean acidification. Through some background information and an activity we will look at what may happen with an increase in CO_2 in the worlds oceans.

Background

Ocean Acidification is a topic of great import due to the far-reaching effects that a decrease in ocean pH can have. Ocean Acidification is the process in which CO_2 from the air is absorbed into the ocean. This absorption is a natural process of the carbon cycle. The issue comes when the amount of CO_2 in the atmosphere increases and therefore more CO_2 is absorbed by the ocean. This process is explained in this short video from NOAA.
https://www.youtube.com/watch?v=9EaLRcVdTbM&feature=channel_video_title

The following links provide a lot of background information on what ocean acidification is and some of its potential effects.
http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

http://cmore.soest.hawaii.edu/education/teachers/science_kits/materials/Ocean_Acidification/Articles/The_Dangers_of_Ocean_Acidification_Article.pdf

http://cmore.soest.hawaii.edu/education/teachers/science_kits/materials/Ocean_Acidification/Articles/Current-Ocean_Acidification_Issue.pdf

http://www.pmel.noaa.gov/co2/story/OA+Educational+Tools

Activity

This activity has been adapted, with permission, from a lesson created by Science North (www.sciencenorth.ca). Please visit their site for more information.
There is an excellent virtual lab activity that parallels this lab if you find this lab to be too complex. http://virtualurchin.stanford.edu/AcidOcean/AcidOcean.htm

Materials

- vinegar or 5-10% acetic acid solution
- 2-100mL beaker

- eyedropper bottle containing phenol red
- 2-500 mL flask
- water
- sea salt (instant ocean in baggie)
- straw
- eyedropper
- chalk (use chalk that contains at least 95% calcium carbonate and test the chalk you intend to use as some have additives that inhibit the chemical reaction)
- Sea creatures (piece of crab shell, clam shell, sea star, snail shell, or pictures of animals that use calcium carbonate)

Procedure

- Discuss the Carbon Cycle and the chemical reaction that occurs when an additional CO_2 is absorbed by the ocean.

-Have students pour sea salt into one flask full of water. Have students pour 50mL of freshwater into one beaker and 50mL of sea water into the other beaker. Have students add 3 drops of phenol red to each. What color is each? Phenol red is a pH indicator. When something is neutral, it is orange, pink when basic and yellow when acidic. What color is each? Ocean water is slightly alkaline (usually a pH of around 8). Show data points collected from the *JRH* (Image 1).

-Have students predict what will happen when we add CO_2 into the water.

- Now let's measure the level of CO_2 in the water. Using the titration kits, measure CO_2 in water. When you have an increase in H+ ions, its indicative of an acid.

-Have students use the straw and gently blow bubbles into the seawater. What color is it now? *It is now yellow as we have changed the pH from alkaline to acidic.*

This is what happens: (see image 2)

$$CO_2 + H_2O \Leftrightarrow H_2CO_3 \Leftrightarrow H^+ + HCO_3^- \Leftrightarrow H^+ + H^+ + CO_3^{2-}$$

carbon dioxide | water | carbonic acid | Hydrogen ion | Bicarbonate ion | Hydrogen ion | Hydrogen ion | Carbonate ion

Although this is a very incomplete picture of what happens in the ocean as there are a lot of other things like salts that are dissolved inside, calcium for example. Calcium can bind with CO_3^- and it will create $CaCO_3$, or calcium carbonate. This is a very important molecule for some animals that live in the ocean. These are the animals we are going to look at. See image 3 for a depiction of how CO_3^- becomes less available for the production of Calcium Carbonate.

-Show examples (either physical or pictures) of sea creatures that use calcium carbonate. Explain that all of these creatures use calcium carbonate from sea water to build the hard parts of their bodies. There are smaller creatures that do this too. These creatures are called coccolithophores (image 4). They are a type of marine plankton. Plankton are the basis of the food chain for marine ecosystems. These coccolithophores are a marine algae that have hard plates on the outside of them. They are extremely important food source in the ocean. They can produce huge blooms like this one seen off the coast of Newfoundland (image 5). Many other species of phytoplankton and zooplankton also have shells of calcium carbonate.

-Have students discuss and hypothesize what would happen to these creatures if the acidity of the ocean increased?
-Explain that chalk is made up of calcium carbonate. Fill one of your beakers with vinegar. Drop the piece of chalk into the vinegar and agitate.
-Discuss what happens. One of the things that scientists believe will happen from an increase in carbon dioxide in the air is that the oceans will become more acidic. This would result in an increase in Hydrogen ions and a decrease in available Calcium Carbonate, which could prevent animals from building up calcium carbonate shells. There are currently studies going on all over the world to help us learn and discover about what the affects of ocean acidification might be.
-In a recently published article (discussed here [http://www.antarctica.ac.uk/press/press_releases/press_release.php?id=1976] with visuals) pteropods, a type of marine snail with a calcium carbonate shell, were found to have dissolving shells due to ocean acidification.
Pteropods are important parts of the food web and without this important food source, the food web could be severely affected.

Action Points
-The current rate of ocean acidification and its future magnitude will threaten some marine ecosystems in coming decades - so we need to increase our knowledge of what these are and when they will occur.
-Effects of and adaptations to ocean acidification will differ across different marine ecosystems and cannot be determined at present with certainty. It is therefore important to reduce our uncertainty through further interdisciplinary research. We need additional observational, experimental and modeling research to assess the consequences of ocean acidification, including better understanding of changes in ocean carbonate chemistry, responses of ocean biology and socio-economic consequences.
-Despite uncertainties, policy-makers must begin to act immediately if they hope to reduce CO_2 emissions and thus stabilize atmospheric CO_2 at a level that will avoid large-scale consequences to ocean ecosystems.

Image 1

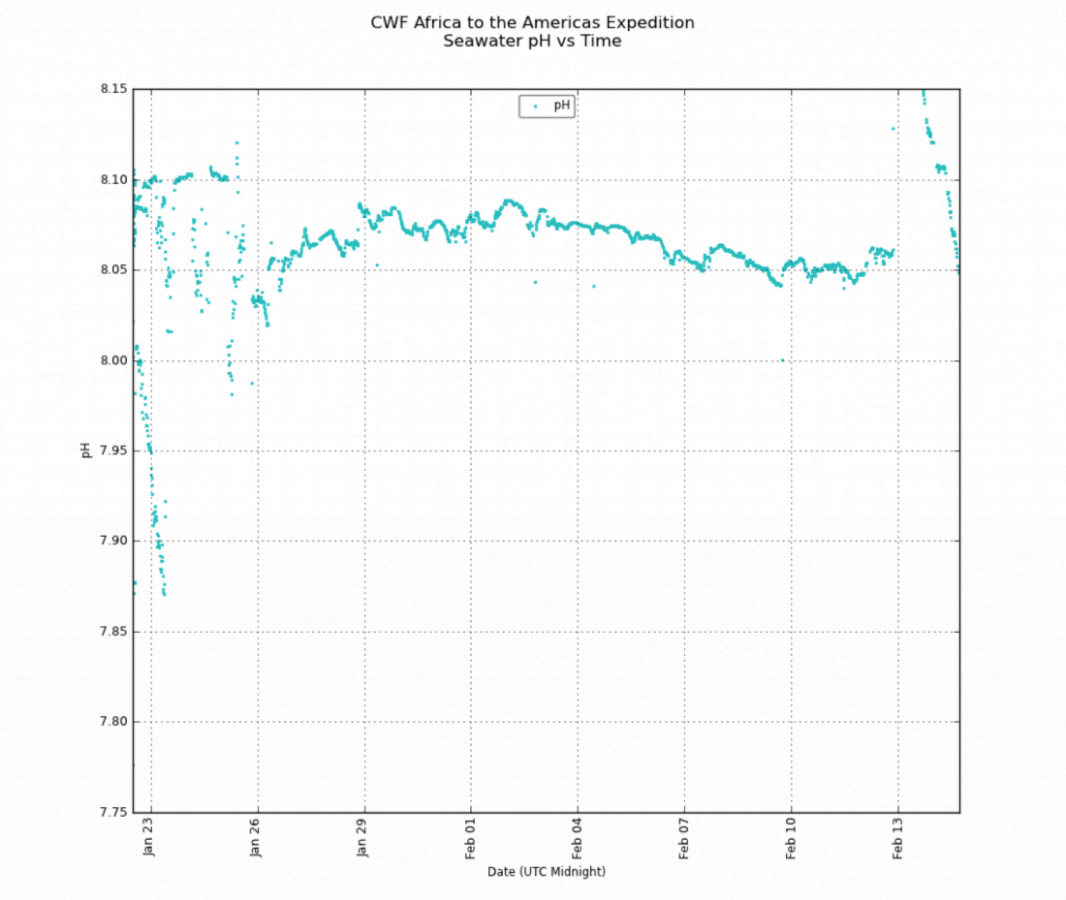
CWF Africa to the Americas Expedition
Seawater pH vs Time
pH
8.15
8.10
8.05
8.00
7.95
7.90
7.85
7.80
7.75
Jan 23
Jan 26
Jan 29
Feb 01
Feb 04
Feb 07
Feb 10
Feb 13
Date (UTC Midnight)

Image 2

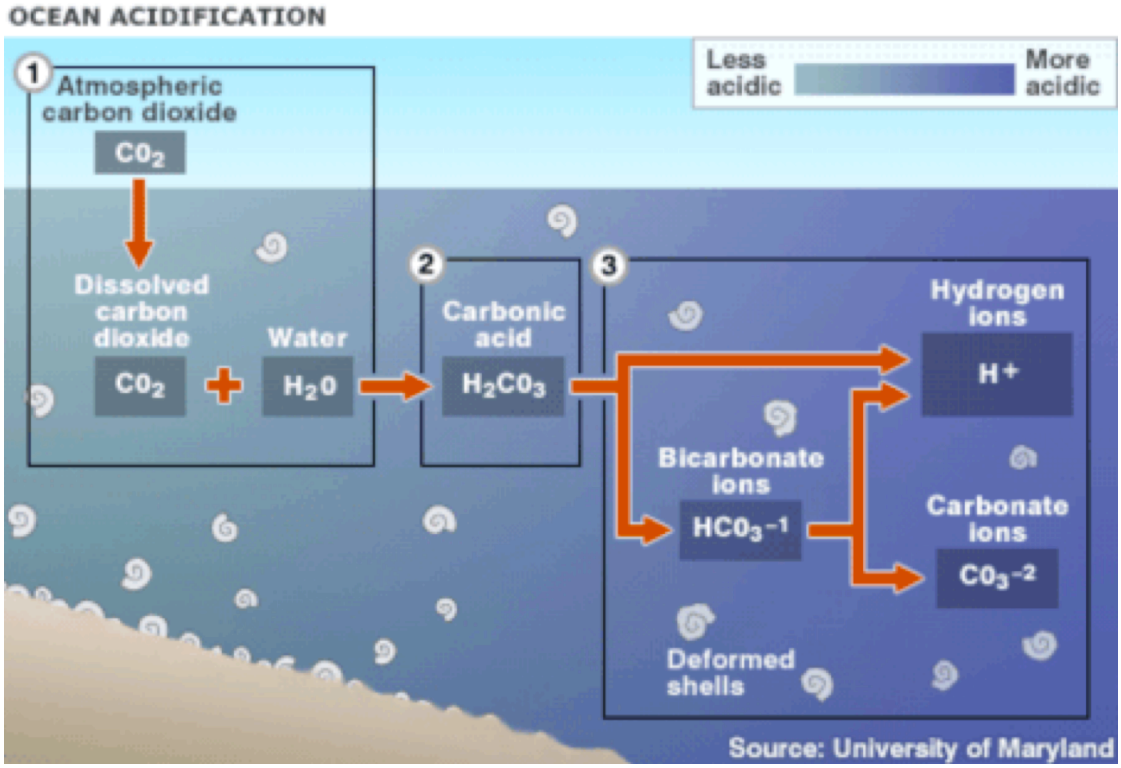
OCEAN ACIDIFICATION
Less acidic
More acidic
1
Atmospheric carbon dioxide
CO_2
Dissolved carbon dioxide
CO_2
Water
H_2O
2
Carbonic acid
H_2CO_3
3
Hydrogen ions
H^+
Bicarbonate ions
HCO_3^{-1}
Carbonate ions
CO_3^{-2}
Deformed shells
Source: University of Maryland

Image 3

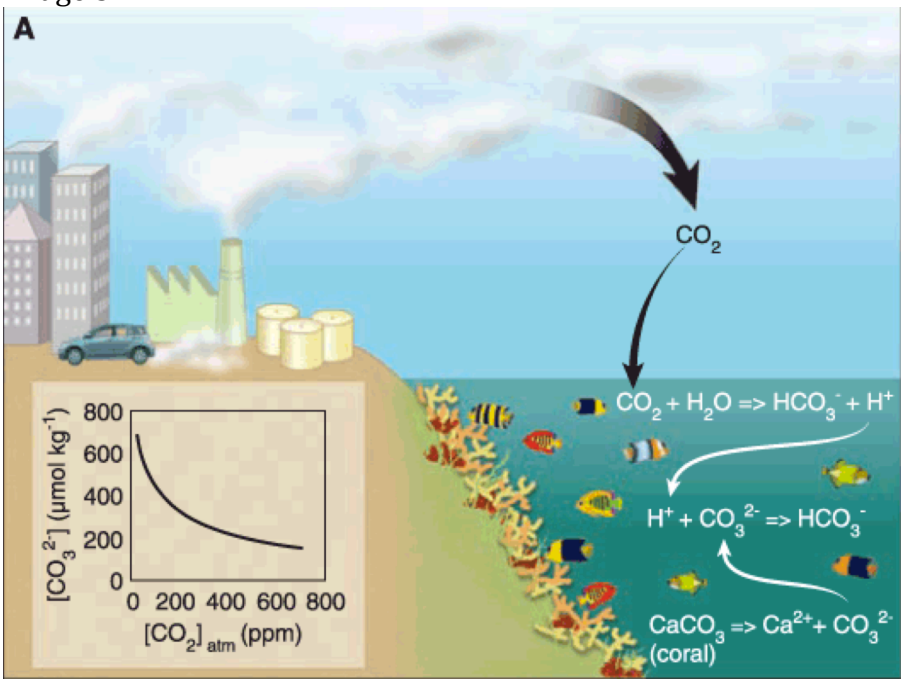

Image 4

Image 5