Ocean Acidification
Demonstration
(the addition of carbon dioxide makes water more acidic)

NOTE: It is highly recommended that this be done as a demonstration, rather than a hands-on activity because of the potential for injury (frostbite) from the dry ice.

Introduction:
Ocean acidification is a current and future problem for our ocean. The average coastal ocean pH is 8.2 in southern California, but it is changing because of the addition of carbon dioxide to the atmosphere and the subsequent absorption of that carbon dioxide into the ocean. The lower the number on the pH scale the more acidic the solution is. About 30% of the carbon dioxide produced daily is absorbed by the ocean. The pH of the ocean has decreased 0.1 in the last century; it is becoming more acidic/less basic. Some of the organisms at greatest risk include larva and shell-forming animals at the base of the food web that provide food for larger species. Organisms faced with the stress of ocean acidification can migrate, acclimate or go extinct. Additional stressors that increase the impact include temperature increase and habitat loss. The increase in ocean acidification is both an environmental and economic concern.

National Science Standards: A, B, C, D, E, F, G
Ocean Literacy Principles and Concepts: 1,3,4,5,6
Education in the Environment Initiative Principles and Concepts: Ib, c, IIa, c, IIIa, c, IVa, c

Background information sources:
Information about pH:
Talking about pH: http://www.usc.edu/org/cosee-west/Feb08Resources/TalkingAboutpH.doc
The pH scale: http://www.usc.edu/org/cosee-west/Feb08Resources/ThepHscale.xls

Ocean Acidification Information:
Chemistry: http://www.usc.edu/org/cosee-west/forinformalscienceeducators/I%27Melting.pdf
NOAA: http://www.pmel.noaa.gov/co2/OA/

Materials:
- clear glass container that can handle cold temperatures (water with dry ice) – can be a pyrex beaker or a vase at least 6 inches tall and 4 inch opening
- water – seawater or freshwater or do one container of each – enough to fill your glass container about 1/3 full, about 3 to 4 inches
- pH indicator paper or pH meter
- red cabbage juice indicator (red cabbage is a natural pH indicator. The pigment flavin is the source of this. Create by chopping ½ a red cabbage and simmering it in water in a non-reactive pot until the cabbage loses its color. Cool and then strain cabbage water into a glass jar. Store in refrigerator until ready to use. Acidic solutions: red = pH 2, purple = pH 4, neutral solutions: violet = pH 6, blue = pH 8, basic solutions: blue-green = pH 10 and greenish yellow = pH 12)

- dry ice – purchase as close to time of use as possible and keep wrapped tightly. **Do not allow it to touch skin.**
- gloves, goggles, tongs, or pot holder to handle dry ice safely
- hammer and screw driver to chip off pieces of ice
- ice chest or cooler to store dry ice

optional materials:

- digital camera
- carbon dioxide meter

Procedures:

1. Pour enough water (salt or fresh) to fill the container ½ full.

2. Use pH strip or meter to test the pH of the water.

3. Add a very small amount of cabbage juice to the water (this should make the water a bit bluish-purple)

4. Test the pH again (it should be the same or similar pH as before the cabbage juice was added)

5. Optional: If you have a digital camera, take a photo of the color of the water with the cabbage juice for comparison later. Alternatively you can set up a control container where you don't add the dry ice and see if there is any change over the same time period.

6. Add a small piece of dry ice (utilizing all your safety equipment). Add enough so that as it sublimates, it fills the top of the container with carbon dioxide. It is heavier than air so it does not rise far above the water.

7. Admire the chemistry for awhile (the dry ice should be bubbling and the bubbles should be releasing white smoke-looking gas into the container above the layer of water.) While observing, below are some guiding questions the presenter may use to start discussion with the audience:

- *What is dry ice?* It is the solid form of carbon dioxide; there is no water in dry ice.

- *Why do you need all that safety equipment to handle dry ice?* It is much, much colder than ice made from water and can cause frostbite; to keep carbon dioxide in its solid form, you have to have a freezer that is -109.3°F or -78.5°C!

- *What's happening to the dry ice in the water?* It is changing straight from a solid to a gas, which is called <u>sublimation</u>.

- *Why does the carbon dioxide gas stay in the container rather than floating upward and going away?* Carbon dioxide is heavier than air (which is composed primarily of nitrogen and oxygen). You can also gently blow or wave your hand to waft some of the carbon dioxide out of the container and watch it come out of the container and then fall downward. You may want to hold up the container while you do this so that everyone can see.

- *Why do people use dry ice?* It can chill items for transport without producing a water byproduct.

- *Why is dry ice sold under lock and key?* It can be dangerous if swallowed or inhaled as it sublimates, if it comes in contact with skin it can cause frostbite, or when combined with other substances can explode.

8. Optional: to help convince your audience that dry ice is carbon dioxide, take your carbon dioxide meter and point it away from your experiment to get a reading, then slowly put the probe into the carbon dioxide gas and show the change in the carbon dioxide reading.

9. Optional: After watching the dry ice sublimate for a while, if you have a camera, take another photograph.

10. Call participants attention to the color of the water/cabbage juice indicator/dry ice mixture. Has it changed? It should be more purplish on its way to pink or maybe it is already pink if you've added enough dry ice and have let it sit for long enough.

Time to relate this to the ocean:

If you used salt water, it's just that much easier to make the connection, but it doesn't really matter if you used fresh or salt water. When you add carbon dioxide to water, it makes it more acidic/less basic. This is what is happening to the ocean. Humans add carbon dioxide to the atmosphere by burning fossil fuels (driving cars, creating electricity), deforestation, and in many other ways. The ocean then absorbs some of what gets emitted into the atmosphere, sometimes we say that the ocean acts as a "sink" for carbon dioxide. This changes the chemical make up of the ocean's water. The ocean finds a new equilibrium with the added carbon dioxide and it is a more acidic/less basic ocean.

The chemical composition of the ocean acts as a buffer absorbing more carbon dioxide than freshwater can without a change in pH. The levels of pH released are more than the ocean can compensate for so we are seeing changes in which organisms can survive in an area and which cannot. Nutrients, temperature and food availability have an impact that can result in reaching a tipping point.