BACK BAY SCIENCE CENTER

Ocean Acidification Module

Activity – Testing Impact on Shells

CALIFORNIA STATE CONTENT STANDARDS

Grades 6 – 8

6th Gr. Science:
Ecology - 5b, e

7th Gr Science:
Physical Principles in Living Systems - 6d
Investigation and Experimentation - 7a
8th Gr Science:
Reactions – 5a,
History/Social Science: 8.3.6; 8.12.5

Grades 9 – 12

Science:
Biology/Life Sciences - Ecology 6a, b

AP Science - Science Practices SP1.1, 1.2
Earth Science: ES 5.3
Life Science LS 3.1, 3.2

History/Social Science:
11th Grade: 11.11.5
12th Grade: 12.3.2

EEI P and C: Ic; IVb, c
Ocean Literacy Principles: 1g, h; 4a; 5f, h; 6e, g; 7c, d
Climate Literacy Principles: 2c, d; 3c; 4f, g; 6c, d; 7d

BACKGROUND INFORMATION

While most of us are aware of the Greenhouse Effect, fewer have considered the impact that increased levels of carbon dioxide is having on our Oceans. In the last few years, there has been proliferating research on the acidification of our oceans and its cause. This increased acidity is moderating the global biodiversity of our ocean habitats. Entire groups of marine species are being jeopardized. While this phenomenon is seen in all of our ocean basins, local spikes are seen due to compounding human factors. In the face of such a serious situation, what can we do?

Ocean acidification is sometimes referred to as the “hidden” side of the world’s carbon crisis. Research globally is pretty conclusive: the increased levels of carbon dioxide from fossil fuel emissions are lowering the pH in our oceans. About 30-50% of the carbon dioxide released from burning of fossil fuels have been absorbed by our oceans. As a result, it has increased acidity up to about 30% since the beginning of the Industrial Age. Scientists at NOAA, Woods Hole and various universities have been tracking this increase found in hydrogen ions in water. If humans don't take any steps to reduce emissions, it is projected that atmospheric carbon dioxide concentrations will have a three-fold increase over present levels. Until the economic downturn in 2008 when many commuting practices changed, actual emissions were on track to exceed this: reaching a five-fold increase in acidification by 2100. A threshold (tipping-point) increase in temperature of 2 degrees Celsius during this century is considered by many to be the point at which we can avoid dangerous human impact. This increase results in about a 10% decrease in carbon uptake in surface waters and may also impact ocean circulation, further reducing the ocean's capacity to absorb atmospheric carbon dioxide and thus increasing acidification. It should be noted, that while water from melting ice caps dilutes concentrations of various components of the carbonate system (conversion of carbon dioxide, in the presence of water into carbonic acid and then the acidic ions of bicarbonate and carbonate) in sea water, including total alkalinity and salinity, it actually increases acidity because the seawater and atmosphere are then out of equilibrium and so the seawater absorbs more carbon dioxide until equilibrium is reached.

Increased ocean acidity has already had an impact on several of our ocean ecosystems. Coral Reefs, Rocky Intertidal, and Polar Regions are showing signs of being degraded. Coral Reefs harbor a tremendous biodiversity of life in our oceans, but a growing number of studies are showing that their coral calcification rate decreases when carbon dioxide levels increase, lessening their ability to build their skeletons. The loss of Coral Reefs has been likened to losing our rainforests. The protection they offer coastal communities against storm surges as well as the economic and recreational impact on fishing and tourism will hit hard. This impacts Rocky Intertidal habitats as well, where the local acid levels are often accentuated by pollutants transported from the watershed communities. While many have attributed the melting of our polar regions to increased water temperature, it's now acknowledged that the aciidity of the waters is becoming increasingly corrosive, hastening the dissolution.

Increased acidity in their habitat has had a destructive effect on several aquatic species. Organisms with calcium in their systems, such as mollusks, tube worms, and carbonate-forming algae are vulnerable. According to NOAA, mollusk populations of oysters and clams along the West Coast are declining. Crustaceans such as lobsters are also being studied. Although they're still able to produce their shells, the extra energetic cost under acidic conditions and the toll this takes on the animal's growth, hunting and reproduction needs is being researched. A decline in any of these populations has ripple effects throughout the food-web: Birds and marine mammals that rely on them for food are also jeopardized, as are human sport and commercial harvests. Although phytoplankton processes carbon dioxide as part of photosynthesis, there have been several studies that arrive at the same conclusion: the current aquatic food-web will alter as ocean acidification increases. Newly dominant phytoplankton species that are better adapted to the more acidic waters, will likely be non-native species and so less able to support the productive food-chains that currently support marine ecosystems and fishery resources.

Research has tied increased acidification to fossil-fuel emissions world-wide. Calcifying organisms in every ocean from the equator to the poles has been effected. Although not nearly to the extent of atmospheric carbon dioxide-driven acidification, coastal communities have localized spikes due to other compounding human factors. Perhaps the most prevalent and persistent problem is that of excess nutrients, mostly Nitrogen, that result from garden and agricultural fertilizers as well as animal waste and sewage that find their way into the storm drains and waters. The increase of nutrients causes algal blooms in both inland and coastal waters. As the algae die, the proliferating bacteria which decompose them use up much of the oxygen in the water, increasing the carbon dioxide levels. Massive fish die-offs make the news, but the increased acidification usually does not. Besides fertilizers, localized acid rains, residues from cigarette butts and acidic products washed into the waters also lower pH.

The global impact of ocean acidification is daunting. There is enough research to show that it is possible to slow the process. There is even research showing that the acidification could possibly be stopped, if stronger actions are taken. It is also clear that if we do nothing, and continue utilizing fossil-fuel as our main energy source, the process will actually accelerate. Counter-acting global warming at the same time is a bonus. The shipping industry is the sixth largest global producer of greenhouse gas emissions, and has started to downshift to a slow streaming rate. While this saves money for the companies and makes a substantial dent in their carbon dioxide production, this policy is currently voluntary and unregulated. Research has shown that establishing Marine Protected Areas and stopping destructive fishing practices increases the resiliency of marine ecosystems and helps them withstand acidification. After several years of advocating and lobbying, California established a system of coastal Marine Protected Areas going into effect January 2012. On a federal level, the Omnibus Land Act of 2009 ties the health of our aquatic ecosystems to terrestrial behaviors and establishes a system of monitoring and development grant opportunities.

It is clear that to address this issue we need to be vigilant personally and in our communities to make a difference. Our efforts need to be personal, community-based and global. A personal assessment of how much energy we use can help us make wiser choices (clustering errands, driving more slowly, walking, carpooling, turning off lights, turning surge-protectors off). We can also look at our gardening, pets and boating practices. As consumers, we can use our buying power to demand that our products be energy efficient, and made in energy efficient factories. We can ask our local businesses and governments to be more energy efficient as well, with energy providers (often government-regulated) using a balanced array of sources instead of relying solely on fossil-fuels. Many are finding that in doing this, they are also saving money.

RESOURCES:
http://act.oceanconservancy.org/
http://www.whoi.edu/OCB-OA/FAQs/
http://www.nrdc.org/oceans/acidification/
http://www.nodc.noaa.gov/
http://www.nrdc.org/oceans/acidification/aboutthefilm.asp - 20 minute You Tube video
http://www.nrdc.org/globalWarming/solutions/default.asp
http://www.nrdc.org/oceans/acidification/science.asp
http://www.energystar.gov/
http://greenliving.nationalgeographic.com/carbon-footprints/
http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/global-personal-energy-meter/

EXTENSIONS:

Conduct an Energy Inventory at home to figure out your Carbon footprint. Do this on your own or involve friends and family.

Look at ways you can decrease your use of acid-producing products. Do this on your own or with friends and family.

Have a family discussion on ways to lessen the use of energy based burning of fossil-fuels – including carpooling, clustering errands so fewer trips taken, driving more slowly to consume less fuel, using surge protectors and turning them off when appliances aren't in use to diminish drain of phantom energy, purchasing energy-efficient appliances, save money, too.

TEACHER GUIDE – Ocean Acidification Module

ACTIVITY: Testing Impact on Shells

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OBJECTIVES:

Students will be able to –

1. Verbalize that Ocean waters are becoming more acidic.
2. Name 3-5 ways that increased acidification impacts aquatic habitats.
3. Identify 2-4 species that are vulnerable to increased acidity in oceans.
4. Explain how change in species distribution will alter the ocean ecosystems.
5. List 3-5 ways humans can decrease ocean acidification by their own actions.

KEY TERMS:

Alkaline Biodiversity Carbonate ion Carbonic acid Coral Reef Corrosive Crustacean Ecosystem Fossil-fuel emissions Greenhouse Effect Mollusk Native species Ocean Acidification Omnibus Public Land Management Act Organism pH Photosynthesis Phytoplankton Rock Intertidal Threshhold Watershed

MATERIALS:

Observation Worksheets and Analysis Questions
Pencils
Non-latex gloves
Straw
Glass
Tap Water
pH paper
Large pH scale
Grease pencil
Vinegar
4 eggs, 2 of which have been hard-boiled and labelled H with a grease pencil
4 beakers - 2 labelled V for vinegar, 2 labelled W for Tap Water

Sealed samples of sea shells: 1 in air, no water, showing overall size and shape
1 in plain ocean water
1 after 1 day in pH 7, or lower for effect
1 after 1 week in pH 7, or lower for effect
1 after 1 month in pH 7, or lower for effect