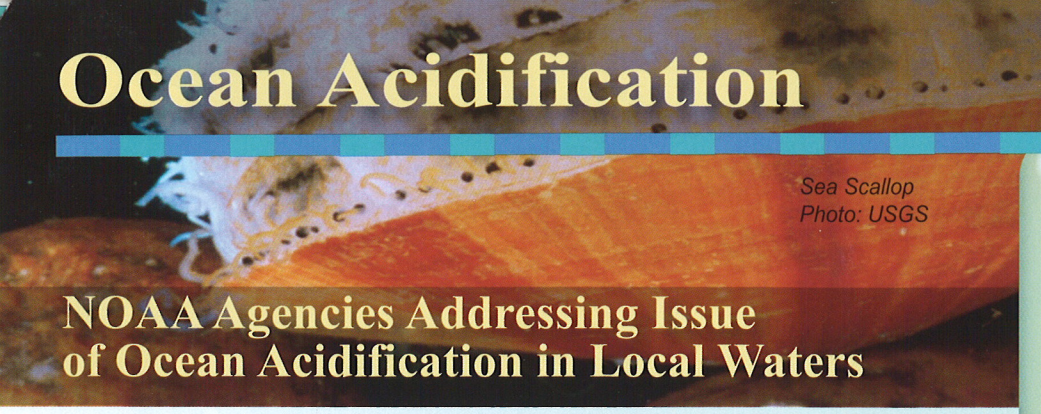
Ocean Acidification



Sea Scallop
Photo: USGS

NOAA Agencies Addressing Issue of Ocean Acidification in Local Waters

You've probably heard about the issue of global warming, but do you know about the other carbon problem?

The steadily increasing volume of carbon dioxide (CO_2) emissions is not only exacerbating the greenhouse effect and raising global temperatures, but it's also increasing ocean acidity. This change in the acidity of seawater may have far-reaching effects on life in the ocean – and by extension, the entire planet.

To better understand what is happening in our waters, Congress passed the Federal Oceanic Acidification Research and Monitoring Act in early 2009. Three agencies have been tasked with implementing this act – NOAA , NASA, and the National Science Foundation (NSF). NOAA's role is to: 1. establish a long-term monitoring program, 2. develop strategies to adapt to these changes, 3. provide education and outreach programs, and 4. support research that studies ocean acidification effects on ecosystems and the impacts these changes will have on society and the economy. The major idea is that if we can expect certain changes, we can prepare for them and not be blind-sided. If an ecosystem becomes more acidic, perhaps other stressors, like extra nutrients or pollution can be reduced to help ease the impact. If acidity levels vary over time and space, human uses, such as shellfish farming, may have to accommodate these new natural cycles.

The sanctuary is now working with NOAA's Fisheries Service northeast office in the development of a regional plan. One key element for the sanctuary is the establishment of Stellwagen Bank as a sentinel site in the monitoring program.

NOAA's Ocean Acidification Concerns

- Reduced calcification rates
- Significant shifts in key nutrients and trace elements
- Shift in phytoplankton diversity
- Reduced growth, production and life span of adults, juveniles and larvae
- Reduced tolerance to other environmental fluctuations
- Changes to fitness and survival
- Changes to species biogeography
- Changes to key biogeochemical cycles
- Changes to food webs
- Reduced sound absorption
- Reduced homing ability
- Reduced recruitment and settlement
- Changes to ecosystems and their services

Acid Test: The Movie

A visually stunning documentary on ocean acidification has been released by the Natural Resources Defense Council. The 20-minute show can be viewed at the NRDC Web site at: http://www.nrdc.org.

Ocean Literacy Fast Facts

Phytoplankton use CO_2 and H_2O to produce oxygen and sugar in a process called photosynthesis. Most of the oxygen we breathe was created at sea. Photosynthesis and the process of respiration also move CO_2 into deep water.

Ocean Chemistry 101

There's an old chemistry class adage that says, *"Do as you ought'a, add acid to water."* That slogan was intended to keep students safe from splashes and acid burns. Today the slogan could be revised to fit a new global safety issue – *"Do as we ought'a, reduce CO_2 in seawater."* This reduction is necessary to slow the process of ocean acidification.

Ocean Acidification Chemical Reactions

CO_2 *(atmos)* $\leftrightarrow CO_2$ *(aqueous)*

H_2O *(water)* + CO_2 *(carbon dioxide)* $\leftrightarrow H_2CO_3$ *(carbonic acid)*

$H_2CO_3 \leftrightarrow H^+ + HCO_3^-$ *(bicarbonate)*

$H^+ + HCO_3^- \leftrightarrow 2H^+ + CO_3^{-2}$ *(carbonate)*

$Ca^{+2} + CO_3^{-2} \leftrightarrow CaCO_3$ *(calcium carbonate)*

Over the past century and a half, a vast amount of carbon dioxide (CO_2) from the atmosphere has entered the ocean. On average, the ocean absorbs about 25% of all the carbon dioxide we emit from the burning of fossil fuels and land use changes, such as burning and decay. A recent article in the journal *Nature* claims 2.3 billion tons of CO_2 were absorbed in 2008 alone. The chemical reaction that CO_2 undergoes in the ocean is detailed above.

Carbon dioxide moves from the atmosphere into the water at the ocean's surface. As the CO_2 concentration increases in seawater, it reacts quickly with water to form carbonic acid. The acid dissociates to form a hydrogen ion and a bicarbonate ion. Most of the resulting hydrogen ions react with carbonate ions to produce more bicarbonate ions. As a result, more CO_2 in the water increases the amount of hydrogen ions, thereby increasing acidity and decreasing the number of carbonate ions. Scientific measurements show that since the mid-1800s (the start of the Industrial Revolution) ocean acidity has increased by 30%. Recent changes are even more rapid. This rate of change in ocean acidity is many times faster than any changes discovered over the last 55 million years.

The reduction in carbonate ions can have detrimental effects for many animals, such as clams, mussels and oysters and many forms of zooplankton and phytoplankton. The calcium carbonate that makes up the shells and skeletons is formed by a reaction of calcium and carbonate ions. Delicate coral reefs, now under so many pressures, ranging from warming waters to pollution, would be at significant risk. These harmful effects can be likened to a marine version of osteoporosis. Not only would shells not grow, but with increasing acidity some may start to dissolve.

The ramifications of more acidic ocean water in the Stellwagen Bank sanctuary are still unknown. The projected change in pH (acidity) is a big question. Researchers believe that ocean acidification may be heightened in the higher latitudes – the polar regions – and upwelling areas, some of the areas with the most productive fisheries. Denser, colder water is more efficient at absorbing carbon dioxide. More acidic waters may show changes in sound transmission, thereby affecting whales and other vocalizing animals, or it may affect the ways predators find their prey. The only given is that ocean acidification is presently happening and the marine science community is very concerned.

How Acidic is the Ocean?

Scientists use the pH scale to measure how acid or basic a solution is - 7 is neutral, more than 7 is basic and less than 7 is acidic. It may seem counter-intuitive, but if more hydrogen ions are in solution, the pH goes down and the solution is more acidic. Since the pH scale is logarithmic, a one point drop means a 10-fold increase in acidity.

The ocean is basically basic (pH 8.0-8.3). Ocean acidity varies from place to place depending on upwelling and other inputs. Fresh water is neutral at 7. The more acidic a solution is the lower its number, e.g., milk (6), tomato (4), lemon juice (2), battery acid (0). In reverse, the more basic an item, the higher its number, e.g., baking soda (9), ammonia (11), oven cleaner (13), and sodium hydroxide (14). Historically, ocean water has been slightly basic, but relatively constant over millions of years. Monitoring has shown that seawater pH has gotten more acidic since the start of the industrial revolution