Fact Sheet: The Ocean in a High CO_2 World

What is ocean acidification?

The burning of fossil fuels releases carbon dioxide (CO_2) to the atmosphere, leading to a warmer climate. But there is another direct impact of increasing CO_2 in the atmosphere. It is changing the chemistry of the ocean.

The ocean absorbs CO_2 from human activities at a rate of 22 million tons per day, thus removing 30% of CO_2 emitted to the atmosphere each year and mitigating the harmful impact of this "greenhouse gas" on our climate. This valuable service provided by the ocean, however, may have a high ecological cost.

When CO_2 dissolves in seawater, carbonic acid is formed. This phenomenon, called "ocean acidification", decreases the availability of carbonate, making it more difficult for many marine organisms to construct their hard parts out of calcium carbonate minerals. The combination of increased acidity and decreased carbonate concentration also has implications for the physiological functions of numerous marine organisms.

Why is ocean acidification an important concern?

Since the beginning of the Industrial Revolution, the ocean has become 30% more acidic. This change is three times greater and 100 times faster than any change in acidity experienced during the last 21 million years. How or if affected organisms and ocean ecosystems will adapt or evolve is unknown. Depending on the response of the marine ecosystem, ocean acidification could have significant ecological and economic impacts.

How will acidification affect marine ecosystems and fisheries?

Marine organisms that use calcium carbonate ($CaCO_3$) to construct their shells or skeletons—including corals, coccolithophores (calcareous phytoplankton), mussels, snails, and sea urchins—are the most vulnerable to acidification. As carbonate becomes scarcer, organisms will find it increasingly difficult to form their skeletal material.

For example, decreased calcification rates will slow the growth of coral reefs and make them more fragile and vulnerable to erosion. By the middle of this century, reef erosion may surpass reef-building.

In the case of calcareous phytoplankton, part of the marine food web, some organisms likely to be affected by acidification are important prey for those higher up the food chain, including commercially fished species. But it is not yet clear how impacts on individual organisms will propagate through marine ecosystems, or if marine food webs can reorganize themselves to make up for the loss of some key elements.

In certain invertebrates and some fish, CO_2 accumulation and lowered pH in animals' bodies may result in acidosis, a build up of carbonic acid in body fluids, leading to lowered immune response, metabolic depression and asphyxiation. Fish larvae may be particularly sensitive to acidification.

What are the possible socio-economic effects of ocean acidification?

Without a better understanding of acidification's effects on ecosystems, making meaningful predictions of socio-economic impacts is difficult. The potential scale of these effects, however, is cause for concern and an added incentive to increase our knowledge.

Acidification may affect marine food webs and lead to significant changes in commercial fish stocks, threatening food security for millions of people and a multi-billion dollar industry. Coral reefs generate billions of dollars annually in tourism, which may be at risk as reef area diminishes and corals become more prone to diseases. In addition, reefs will provide shorelines with less protection from erosion and flooding.

Ocean acidification, along with warming surface waters and changes in ocean mixing, may reduce the ability of the ocean to absorb CO_2, leaving more CO_2 in the atmosphere and worsening its impact on the climate. Such a reduction would make it more difficult, and more expensive, to stabilize atmospheric CO_2 concentrations.

What actions, policy and management responses are needed?

The primary way to protect the ocean from the threat of ocean acidification is to reduce CO_2 emissions. It appears impractical to chemically reverse acidification at the scale of the world ocean through engineering approaches, and there are unknown risks for marine ecosystems associated with such large-scale manipulations of ocean chemistry.

Better ecosystem management may reduce the vulnerability of some valuable species. For example, marine reserves are being established throughout much of the coastal oceans to preserve biodiversity and boost fishing stocks. Policies need to allow flexibility to shift the boundaries of these reserves as ocean chemistry and ecosystems change in response to acidification.

Coastal waters are suffering from human-induced assaults from land that may weaken the ability of marine life to survive the chemical changes from ocean acidification. There is even some evidence that some coastal pollution is exacerbating the acidification problem. Stronger and more aggressive national and international policies protecting coastal waters from nutrient and toxic waste runoff are urgently needed.

Given the likelihood that ocean acidification will negatively affect commercial fisheries, and with changing climate also affecting agriculture, global policies are essential to insure against extreme food shortages. Results from ocean acidification research, including modelling, must be incorporated into fish stock predictions to ensure that appropriate management practices are established before stocks are depleted. Using the information already available, we can carry out more effective risk assessments, similar to those of insurance companies.

An issue of this magnitude with such high uncertainties poses an enormous challenge to the world's decision-makers, already uncomfortable making decisions when there is uncertainty about unprecedented, long-term, intergenerational problems. A global effort is required to reduce these uncertainties and to allow meaningful ecological and economic projections. This effort will require globally coordinated research, including an effective method for setting priorities, standardization of experimental procedures, information and data sharing, and long-term funding.

Sponsors

The nongovernmental **Scientific Committee on Oceanic Research** (www.scor-int.org) was established by the International Council of Scientific Unions in 1957 to promote international cooperation in all areas of ocean science.

The **Intergovernmental Oceanographic Commission** (http://ioc-unesco.org/) was established under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1960 to provide Member States of the United Nations with an essential mechanism for global cooperation in the study of the ocean.

The **Marine Environment Laboratories (MEL) of the International Atomic Energy Agency** (http://www-naweb.iaea.org/naml/) promotes UN interagency efforts to protect the seas, and carries out research on ocean acidification by combining isotopes with manipulative experiments and by using numerical models to better understand and project how acidification may alter marine resources during the 21st century.

The **International Geosphere-Biosphere Programme** (http://www.igbp.net/) is an international scientific research programme that studies the interactions between biological, chemical and physical processes and human systems, and collaborates with other global environmental change programmes to develop and impart the understanding necessary to respond to global change.

For more information

- The Ocean Acidification Network (www.ocean-acidification.net)
- Ocean Acidification Information Outlet (http://oceanacidification.wordpress.com/)
- Eur-Oceans Fact Sheet: Ocean Acidification - The Other Half of the CO_2 Problem (http://ioc3.unesco.org/oanet/OAdocs/FS7_oceanacidification.pdf)
- The Pew Charitable Trust Science Brief: Carbon Dioxide and Our Ocean Legacy (http://www.pmel.noaa.gov/pubs/PDF/feel2899/feel2899.pdf)