Acidifying oceans add urgency to CO2 cuts

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It's not just about climate change anymore. Besides loading the atmosphere with heat-trapping greenhouse gases, human emissions of carbon dioxide have also begun to alter the chemistry of the ocean—often called the cradle of life on Earth. The ecological and economic consequences are difficult to predict but possibly calamitous, warn a team of chemical oceanographers in the July 4 issue of *Science,* and halting the changes already underway will likely require even steeper cuts in carbon emissions than those currently proposed to curb climate change.

Ken Caldeira of the Carnegie Institution's Department of Global Ecology, writing with lead author Richard Zeebe of the University of Hawaii and two co-authors*, note that the oceans have absorbed about 40% of the carbon dioxide (CO2) emitted by humans over the past two centuries. This has slowed global warming, but at a serious cost: the extra carbon dioxide has caused the ocean's average surface pH (a measure of water's acidity) to shift by about 0.1 unit from pre-industrial levels. Depending on the rate and magnitude of future emissions, the ocean's pH could drop by as much as 0.35 units by the mid-21st century.

This acidification can damage marine organisms. Experiments have shown that changes of as little as 0.2-0.3 units can hamper the ability of key marine organisms such as corals and some plankton to calcify their skeletons, which are built from pH-sensitive carbonate minerals. Large areas of the ocean are in danger of exceeding these levels of pH change by mid-century, including reef habitats such as Australia's Great Barrier Reef.

Most marine organisms live in the ocean's sunlit surface waters, which are also the waters most vulnerable to CO2-induced acidification over the next century as emissions continue. To prevent the pH of surface waters from declining more than 0.2 units, the current limit set by the U.S. Environmental Protection Agency in 1976, carbon dioxide emissions would have to be reduced immediately.

"In contrast to climate model predictions, such future ocean chemistry projections are largely model-independent on a time scale of a few centuries," the authors write, "mainly because the chemistry of CO2 in seawater is well known and changes in surface ocean carbonate chemistry closely track changes in atmospheric CO2."

Although the ocean's chemical response to higher carbon dioxide levels is relatively predictable, the biological response is more uncertain. The ocean's pH and carbonate chemistry has been remarkably stable for millions of years—much more stable than temperature.

"We know that ocean acidification will damage corals and other organisms, but there's just no experimental data on how most species might be affected," says Caldeira. "Most experiments have been done in the lab with just a few individuals. While the results are alarming, it's nearly impossible to predict how this unprecedented acidification will affect entire ecosystems." Reduced calcification will surely hurt shellfish such as oysters and mussels, with big effects on commercial fisheries. Other organisms may flourish in the new conditions, but this may include undesirable "weedy" species or disease organisms.

Though most of the scientific and public focus has been on the climate impacts of human carbon emissions, ocean acidification is as imminent and potentially severe a crisis, the authors argue.

"We need to consider ocean chemistry effects, and not just the climate effects, of CO_2 emissions. That means we need to work much harder to decrease CO_2 emissions," says Caldeira. "While a doubling of atmospheric CO_2 may seem a realistic target for climate goals, such a level may mean the end of coral reefs and other valuable marine resources."

Source: Carnegie Institution

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