SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY

Press Release

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Halting Ocean Acidification Calls for Steep Carbon Cuts

Honolulu, HI – 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—the so-called cradle of life on Earth.

Coral reef community at Rapture Reef, Northwestern Hawaiian Islands.
Photo: James Watt, www.wattstock.com

The ecological and economic consequences are difficult to predict but possibly calamitous, say a team of chemical oceanographers led by Richard Zeebe from the School of Ocean and Earth Science and Technology at the University of Hawaii at Manoa. In the July 4 issue of Science, the researchers warn that halting the changes already underway will likely require even steeper cuts in carbon emissions than those currently proposed to curb climate change.

The oceans have absorbed about 40% of the carbon dioxide (CO_2) emitted by humans over the past two centuries. This equates to roughly 500 billion metric tons of carbon dioxide, equivalent in weight to about 28 inches of water (~70 cm) across the whole State of Texas.

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 decline by about 0.1 unit from pre-industrial levels – a 25% increase in hydrogen-ion concentration. Small changes in the pH value can make a big difference because pH is measured on a logarithmic scale – analogous to the Richter scale, which measures the strength of Earthquakes. For example, a drop by one pH unit means a ten-fold increase in acidity.

Depending on the rate and magnitude of future emissions, the ocean's pH could drop by as much as 0.35 units – more than twice as many hydrogen ions – by the mid-21st century. The increase in the amount of hydrogen ions in the oceans has been labeled "Ocean Acidification" and is cause for concern because it 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 and the Hawaiian Islands Coral Reef Reserve.

Most marine organisms live in the ocean's sunlit surface waters, which are also the waters most vulnerable to CO_2-induced acidification over the next century as emissions continue. To prevent the pH of surface waters from declining by 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.

Predicting changes in ocean chemistry over the next few centuries is not terribly difficult; it's much easier, for example, than predicting climate. The main reason is that the chemistry of CO_2 in seawater is well known. In other words, forecasting changes in surface ocean pH is quite reliable for a given rate of CO_2 emissions.

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

“If we continue with business as usual and don’t cut carbon dioxide emissions, carbonate reefs will ultimately start to dissolve. This is basic chemistry.” says Zeebe. “The biology is a bit trickier. Most lab and field experiments show that calcifying organisms struggle under high-CO_2 conditions but it’s very difficult to predict their long-term reaction, let alone responses of entire marine ecosystems.” Reduced calcification will surely hurt shellfish such as oysters and mussels, with big effects on commercial aquaculture. 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. Once standards for future ocean pH changes have been implemented, their results will help to establish carbon dioxide emissions targets.

“Putting carbon dioxide in the atmosphere at a scale and pace at which we do it not only has substantial consequences for climate but also for ocean chemistry and we need to consider this when talking about reducing emissions.” says Zeebe. “Drastic emission cuts at some point in the future might be an option in terms of climate change but it could be too late for coral reefs and other marine organisms.”

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