Comprehensive study makes key findings of ocean pH variations

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A group of 19 scientists from five research organizations have conducted the broadest field study of ocean acidification to date using sensors developed at Scripps Institution of Oceanography, UC San Diego.

The study, "High-Frequency Dynamics of Ocean pH: A Multi-Ecosystem Comparison," is reported in the Dec. 19 issue of the journal PLoS One. It is an important step toward understanding how specific ecosystems are responding to the change in seawater chemistry that is being caused as the oceans take up extra carbon dioxide produced by human greenhouse gas emissions, said its authors.

"These data represent a critical step in understanding the consequences of ocean change: the linkage of present-day pH exposures to organismal tolerance and how this translates into ecological change in marine ecosystems," the authors wrote. "These pH time series create a compelling argument for the collection of more continuous data of this kind."

Ocean acidification research is a relatively new study topic as scientists have only appreciated the potential extent of acidification within the last decade. As greenhouse gas emissions have accelerated in the past century, the oceans have taken up about a third of the carbon dioxide produced by human activities. That excess beyond natural levels increases amounts of carbonic acid in seawater. Acidification also limits the amount of carbonate forms that are needed by marine invertebrates such as coral and shelled organisms to form their skeletons.

Though many lab simulations of this effect have been performed recently, including at a new acidification laboratory in development at Scripps, there have been few comparable field studies. Using sensors recently developed at Scripps, the researchers surveyed marine ecosystems ranging from coral reefs in the South Pacific Ocean to volcanic CO2 vent communities in the Mediterranean Sea.

They found that in some places, such as Antarctica and the Line Islands of the south Pacific, the range of pH variance is much more limited than in areas of the California coast subject to large vertical movements of water known as upwellings. In some of their study areas, they found that the decrease in seawater pH being caused by greenhouse gas emissions is still within the bounds of natural pH fluctuation. Some areas already experience daily acidity levels that scientists had expected would only be reached at the end of the 21st Century.

This study is important for identifying the complexity of the ocean acidification problem around the globe. Our data show such huge variability in seawater pH both within and across marine ecosystems making global predictions of the impacts of ocean acidification a big challenge. Some ecosystems such as coral reefs experience a daily range in pH that exceeds the predicted increase in pH over the next century. While these data suggest that marine organisms may be more adapted to fluctuations in pH than previously thought much more research is needed to determine how individual species will respond over time. Importantly, these new sensors allow us continuously and autonomously monitor pH from remote parts of the world and thus provide us with important baselines from which we can monitor future changes caused by ocean acidification.

Because many in the marine chemistry community have expressed concerns that ocean acidification could happen too rapidly for some organisms to adapt, the researchers said that this finding is an important step toward identifying the mechanisms some marine organisms have developed in order to cope. They also said that knowledge of actual pH ranges in various ecosystems should improve assumptions about future pH levels that can only rely on broad generalizations about seawater chemistry. Furthermore it could guide future lab and field studies that investigate the limits of resistance and resilience in various marine communities.

The researchers used "SeaFET" sensors developed at Scripps by marine chemistry researcher Todd Martz. The sensors can measure pH and temperature in the top 70 meters (230 feet) of the ocean. Since 2009, Martz's team has constructed 52 SeaFETs, which have been used by 13 different research groups to study individual ecosystems.

"This collaboration was not planned; it just naturally formed as several of my colleagues requested replicates of a pH sensor that I built while working as a postdoc in Ken Johnson's group at MBARI," said Martz. "When I arrived at Scripps, we re-engineered my prototype design and since then I have not been able to keep up with all of the requests for sensors. Because every sensor used in this study was built at Scripps, I was in a unique position to assimilate a number of datasets, collected independently by researchers that otherwise would not have been in communication with each other. Each time someone deployed a sensor, they would send me the data and eventually it became clear that a synthesis should be done to cross-compare this diverse collection of measurements."

Deployed in the ocean over the course of months or years, the sensors are also able to record important data about how pH fluctuates over time. As data accumulates, the researchers suggested that the field data could identify ocean regions especially vulnerable to the effects of ocean acidification or areas that provide natural protections to organisms at risk.

"Such knowledge could enable protection, management, and remediation of critical marine habitats and populations in the future," wrote the authors.

Despite surveying 15 different ocean regions, the authors noted that they only made observations on coastal surface oceans and that more study is needed in deeper ocean regions farther away from land. Martz noted that large-scale programs like Argo, in which a network of more than 3,000 floats distributed throughout the oceans, measure fundamental data.

"The Honeywell DuraFET pH sensor used in the SeaFET has been a great tool for characterizing shallow sites from moorings and for use in shipboard underway systems," Martz said. "The next challenge will be observing the pH of the entire ocean from top to bottom without using ships. I am really excited about the prospect of adding these sensors to mobile autonomous platforms like profiling floats, gliders, and drifters. In fact we continue to work with Ken Johnson and MBARI to make this a reality. I think you can expect to see a pH sensor sending back data from an Argo-type profiling float at some point in 2012."

Provided by University of California - San Diego

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