An evaluation of potentiometric pH sensors in coastal monitoring applications

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An evaluation of potentiometric pH sensors in coastal monitoring applications

Abstract

A wealth of historical coastal water pH data has been collected using potentiometric glass electrodes, but the accuracy and stability of these sensors is poorly understood. Here we compared pH measurements from five potentiometric sensors incorporated into profiling Sea-Bird instrument packages and compared them to spectrophotometric measurements on discrete bottle samples collected at two to three depths associated with each cast. Differences ranged from −0.509 to +0.479 with a mean difference of −0.055 pH units. Ninety-two percent of the measurements were within ± 0.2 pH units, but 1% of the measurements had differences greater than 0.322. Sensor performance was affected by depth, but most of the difference

was associated with calibration shortcomings. Sensor drift within a day was negligible; moreover, differences between bottle samples and electrode measurements within a sampling day were smaller than differences across days. Bootstrap analysis indicated that conducting a daily in situ calibration would reduce the mean difference to 0.002 pH units and increase the number of samples within a 0.2 pH unit error to 98%.

Access full article: http://onlinelibrary.wiley.com/wol1/doi/10.1002/lom3.10191/full

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[Evaluation of marine pH sensors under controlled and natural conditions for the Wendy Schmidt Ocean Health XPRIZE]()

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Abstract

The annual anthropogenic ocean carbon uptake of 2.6 ± 0.5 Gt C is changing ocean composition (e.g., pH) at unprecedented rates, but our ability to track this trend effectively across various ocean ecosystems is limited by the availability of low-cost, high-quality autonomous pH sensors. The Wendy Schmidt Ocean Health XPRIZE was a year-long competition to address this scientific need by awarding $2 million to developers who could improve the performance and reduce the cost of pH sensors. Contestants' sensors were deployed in a series of trials designed to test their accuracy, repeatability, and stability in laboratory, coastal, and open-ocean settings. This report details the validation efforts behind the competition, which included designing the sensor evaluation trials, providing the conventional true pH values against which sensors were judged, and quantifying measurement uncertainty. Expanded uncertainty (coverage factor $k = 2$, corresponding to 95% confidence) of validation measurements throughout the competition was approximately 0.01 pH units. A custom tank was designed for the coastal trials to expose the sensors to natural conditions, including temporal variability and biofouling, in a spatially homogenous environment. The competition prioritized the performance metrics of accuracy, repeatability, and stability over specific applications such as high-frequency measurements. Although the XPRIZE competition focused on pH sensors, it highlights considerations for testing other marine sensors and measuring seawater carbonate chemistry.

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[Acidified ocean water widespread along North American West Coast]

June 1, 2017

An acidification sensor on the Oregon Coast. Credit: Oregon State University

A three-year survey of the California Current System along the West Coast of the United States found persistent, highly acidified water throughout this ecologically critical nearshore habitat, with "hotspots" of pH measurements as low as any oceanic surface waters in the world.

The researchers say that conditions will continue to worsen because the atmospheric carbon dioxide primarily to blame for this increase in acidification has been rising substantially in recent years.

One piece of good news came out of the study, which was published this week in *Scientific Reports*. There are “refuges” of more moderate pH environments that could become havens for some marine organisms to escape more highly acidified waters, and which could be used as a resource for ecosystem management.

“The threat of ocean acidification is global and though it sometimes seems far away, it is happening here right now on the West Coast of the United States and those waters are already hitting our beaches,” said Francis Chan, a marine ecologist at Oregon State University and lead author on the study.

“The West Coast is very vulnerable. Ten years ago, we were focusing on the tropics with their coral reefs as the place most likely affected by ocean acidification. But the California Current System is getting hit with acidification earlier and more drastically than other locations around the world.”

A team of researchers developed a network of sensors to measure ocean acidification over a three-year period along more than 600 miles of the West Coast. The team observed near-shore pH levels that fell well below the global mean pH of 8.1 for the surface ocean, and reached as low as 7.4 at the most acidified sites, which is among the lowest recorded values ever observed in surface waters.

The lower the pH level, the higher the acidity. Previous studies have documented a global decrease of 0.11 pH units in surface ocean waters since the beginning of the Industrial Revolution. Like the Richter scale, the pH scale in logarithmic, so that a 0.11 pH unit decrease represents an increase in acidity of approximately 30 percent.

Highly acidified ocean water is potentially dangerous because many organisms are very sensitive to changes in pH. Chan said negative impacts already are occurring in the California Current System, where planktonic pteropods – or small swimming snails – were documented with severe shell dissolution.

“This is about more than the loss of small snails,” said Richard Feely, senior scientist with the National Oceanic and Atmospheric Administration’s Pacific Marine Environmental Laboratory. “These pteropods are an important food source for herring, salmon and black cod, among other fish. They also may be the proverbial ‘canary in the coal mine’ signifying potential risk for other species, including Dungeness crabs, oysters, mussels, and many organisms that live in tidepools or other near-shore habitats.”

Tidepool organisms are threatened by acidification. Credit: Jane Lubchenco

Previous studies at OSU have chronicled the impact of acidified water on the Northwest oyster industry.

Chan said the team’s observations, which included a broad-scale ocean acidification survey via ship by NOAA, did not vary significantly over the three years – even with different conditions, including a moderate El Niño event.

"The highly acidified water was remarkably persistent over the three years," Chan said. "Hotspots stayed as hotspots, and refuges stayed as refuges. This highly acidified water is not in the middle of the Pacific Ocean; it is right off our shore. Fortunately, there are swaths of water that are more moderate in acidity and those should be our focus for developing adaptation strategies."

The researchers say there needs to be a focus on lowering stressors to the environment, such as maintaining healthy kelp beds and sea grasses, which many believe can partially mitigate the effects of increasing acidity.

Further, the moderately acidified refuge areas can be strategically used and managed, Chan pointed out.

"We probably have a hundred or more areas along the West Coast that are protected in one way or another, and we need to examine them more closely," he said. "If we know how many of them are in highly acidified areas and how many are in refuge sites, we can use that information to better manage the risks that ocean acidification poses."

Managing for resilience is a key, the researchers conclude.

"Even though we are seeing compromised chemistry in our ocean waters, we still have a comparably vibrant ecosystem," Chan said. "Our first goal should be to not make things worse. No new stresses. Then we need to safeguard and promote resilience. How do we do that? One way is to manage for diversity, from ensuring multiple-age populations to maintaining deep gene pools.

"The greater the diversity, the better chance of improving the adaptability of our marine species."

Chan, a faculty member in the College of Science at Oregon State University, was a member of the West Coast Ocean Acidification and Hypoxia Panel appointed by the governments of California, Oregon, Washington and British Columbia.

Explore further: International team reports ocean acidification spreading rapidly in Arctic Ocean

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https://phys.org/news/2017-05-acidified-ocean-widespread-north-american.html

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Persistent spatial structuring of coastal ocean acidification in the California Current System

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The near-term progression of ocean acidification (OA) is projected to bring about sharp changes in
the chemistry of coastal upwelling ecosystems. The

distribution of OA exposure across these earlyimpact systems, however, is highly uncertain and limits our understanding of whether and how
spatial management actions can be deployed to ameliorate future impacts. Through a novel coastal
OA observing network, we have uncovered a remarkably persistent spatial mosaic in the penetration
of acidified waters into ecologically-important nearshore habitats across 1,000 km of the California
Current Large Marine Ecosystem. In the most severe exposure hotspots, suboptimal conditions for
calcifying organisms encompassed up to 56% of the summer season, and were accompanied by some
of the lowest and most variable pH environments known for the surface ocean. Persistent refuge areas
were also found, highlighting new opportunities for local adaptation to address the global challenge of
OA in productive coastal systems.

[Persistent spatial structuring of coastal ocean acidification in the California Current System (PDF)]

[Ocean Acidification 2.0: Managing our Changing Coastal Ocean Chemistry]

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Ocean acidification (OA) is rapidly emerging as a significant problem for organisms, ecosystems, and human societies. Globally, addressing OA and its impacts requires international agreements to reduce rising atmospheric carbon dioxide concentrations. However, the complex suite of drivers of changing carbonate chemistry in coastal environments also requires regional policy analysis, mitigation, and adaptation responses. In order to fundamentally address the threat of OA, environmental managers need to know where, when, and by how much changes in coastal ocean carbonate chemistry will influence human livelihoods and what they can reasonably do about these effects. Here, we synthesize available biogeochemical and ecological information on the problem of coastal acidification and review actions managers have undertaken thus far. We then describe nine opportunities ripe for decisionmakers to mitigate—and, where necessary, to adapt to—ocean acidification at the spatial scales relevant to their authority.

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