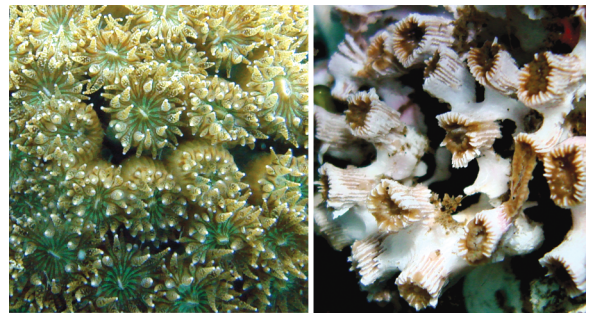
Is regulation on ocean acidification on the horizon?

With mounting evidence that ocean waters worldwide are turning more acidic, scientists have issued ever more urgent pleas for policy makers to recognize that this phenomenon is a direct and real consequence of rising levels of atmospheric CO_2. Researchers warn that as ocean pH falls, the capacities of calcifying marine organisms to build shells and skeletons will be severely reduced, in all likelihood causing widespread impacts on marine ecosystems. In June 2009, a statement endorsed by 70 national science academies emphasized that the issue must be on the agenda at the upcoming global climate talks in Copenhagen. "To avoid substantial damage to ocean ecosystems, deep and rapid reductions of global CO_2 emissions by at least 50% by 2050, and much more thereafter, are needed," the statement warned.

On the U.S. domestic policy front, the Federal Ocean Acidification Research and Monitoring Act was signed into law in March 2009 to fortify funding for research on ocean acidification, which is dubbed "global warming's evil twin". Otherwise, the issue has garnered little attention from the government. However, that may be about to change.

On May 14, the nonprofit Center for Biological Diversity filed the first federal lawsuit on ocean acidification, charging that the U.S. Environmental Protection Agency (EPA) failed to comply with its mandate under the Clean Water Act (CWA) to protect Washington State's ocean waters from pollutants such as excessive CO_2. The lawsuit follows the Center's 2007 petition to EPA to update water-quality criteria for marine pH under CWA. On April 15, EPA responded to that petition by initiating a public process to collect information about ocean acidification, in order to review the current criterion for marine pH and determine if a revision is warranted.



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(Left) In an in situ experiment, researchers transplanted *Cladocora caespitosa* coral to acidified waters near hydrothermal vents. (Right) After four months, the coral skeletons were dissolved and the polyps collapsed.

CWA and pH

Section 303(d) of CWA requires states to identify water bodies under their jurisdiction that fail to meet standards set by the states in accordance with EPA guidelines. States are obliged to review their listings of such "impaired" waters biennially and submit them for approval to EPA, which has the authority to amend the lists if the agency determines that degraded water bodies have been omitted. "Once a water body is listed, either the states or EPA must address the impairment, establishing limits for identified contaminants that the waters can receive and still meet water-quality standards," Center attorney Miyoko Sakashita explains. CWA recognizes pH as a conventional pollutant, and EPA's current recommended criterion, drafted in 1976 and adopted by most states, specifies a "pH range of 6.5 to 8.5 for marine aquatic life (but not varying more than 0.2 units outside of the normally occurring range)."

During 2007, the Center sent petitions to 10 coastal states (Alaska, Washington, California, Oregon, Hawaii, New York, New Jersey, Maine, Delaware, and Florida) urging that they list their ocean waters as impaired "due to decreases in pH resulting from anthropogenic CO_2 emissions." When the Washington State Department of Ecology began its public water-quality assessment process as part of its effort to update its list, the Center submitted a 13-page letter presenting scientific findings on ocean acidification. Without remedial action, the letter stated, "Ocean acidification will have significant negative impacts on the survival of calcifying organisms as well as fish and other marine species. Commercial and recreational uses will be harmed as a result, which will particularly affect the shellfish and fishing industries that are so important to Washington citizens." Citing studies showing that the pH of global ocean surface waters has already declined by approximately 0.1 units (turning seawater 30% more acidic), the Center alleged that the department was ignoring state policy requiring corrective action in response to changes of 0.1 pH units or greater.

Nevertheless, the Department of Ecology's list, forwarded to EPA in June 2008, did not include marine waters. The reason, according to spokesperson Sandy Howard, was: "State law requires [that] actual data for specific water bodies be used for 303(d) listing purposes, rather than broader studies and assumptions about the status of waters." She adds, "We acknowledge that acidification is happening, but listing ocean waters is not the way to address it. How can you say where the CO_2 originates? What's needed is an international protocol on global emissions."

The Center's input to EPA during its review of Washington's list was likewise shrugged off, and in

10.1021/es901664n

Published on Web 06/24/2009

January 2009 the agency approved the list without additions. "At the same time, EPA informed us of its intention to consider reviewing pH criteria and to develop biological assessment methods and other technical guidance relating to evaluation of the health of coral reefs, which are particularly threatened," Sakashita says.

To date, most of the other states petitioned have yet to finalize their lists, Sakashita notes. The legal complaint against EPA essentially mirrors the arguments that the Center made while Washington was drawing up its list. "Our goal is to get EPA and the states to list acidified waters and ultimately enact CO_2-reduction measures." She adds, "Greenhouse gas emissions affecting U.S. coastal waters may well originate from other countries, but that doesn't weaken the need to reduce them state by state, or set regional reduction targets."

Because litigation is pending, an EPA spokesman says, the agency is unable to comment on the lawsuit.

The scientific case

Two major studies published during 2008 did in fact demonstrate reduced pH levels in Washington waters. In the first, shipboard sampling conducted during spring 2007 revealed that coastal waters from British Columbia to Baja California were considerably more acidic and lower in carbonate than expected. "The effects were especially pronounced for Washington," notes oceanographer and lead author Richard Feely of the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory.

The second paper reported results from about 25,000 acidity readings made by University of Chicago ecologist Timothy Wootton and colleagues from 2000 to 2008 in waters bathed by a major current off northwestern Washington. "The results showed that overall pH has fallen by more than 0.2 units since 2000, and detrimental impacts on calcifying species are already detectable," Wootton says. "Ocean acidification is apparently progressing faster in our study area than predicted."

However, the pH of seawater is known to fluctuate significantly, depending on a host of factors, such as temperature, phytoplankton abundance, seasonal upwelling of CO_2-rich water from the depths, and other drivers still being worked out. "Coastal waters generally range from 7.4 to 9.0," Feely explains, "and the open ocean has seasonal as well as diurnal cycles, with pH ranging from about 7.9 to 8.5."

Ocean acidification is well established theoretically, based on fundamental physics and chemistry and modeling informed by vast datasets assembled from large-scale research programs; the first of these programs was the U.S. Joint Global Ocean Flux Study in the 1980s. Moreover, laboratory studies on a wide variety of taxa, from calcifying plankton and corals to mollusks and fish, have revealed a range of harmful physiological effects from acidified seawater. However, Feely says, "Reliable long-term measurements of pH have been limited to a small number of instrumented ocean stations. Very few direct time-series measurements of pH in U.S. coastal waters exist for defining natural variability in given areas. [Yet] new criteria and any possible regulatory mechanisms would have to take variability into account," he says.

Legal hurdles

Even if EPA redefines its pH criterion, the agency may not have the authority under CWA to compel states to enforce new programs for curbing the CO_2 emissions that are responsible for decreased pH, says Holly Doremus, a professor of environmental law at the University of California Berkeley. "Also, where the science is uncertain, states can deviate from EPA criteria if they can make plausible arguments to do so." Furthermore, she points out, "Nonpoint pollution sources don't require discharge permits under CWA, so there's no easy hook for addressing enforcement. And atmospheric CO_2 is the ultimate nonpoint pollution source."

However, Sakashita contends, "EPA has created regional pollution-reduction targets for mercury, another pollutant deposited from dispersed atmospheric sources, including international ones. We have the tools to do this for CO_2 also under the CWA."

It remains to be seen whether the Center's lawsuit succeeds in enlisting CWA to play a role in addressing one of the most ominous aspects of climate change. Meanwhile, EPA is winning kudos for its willingness to revisit its marine pH standard. "It's very appropriate that we do this now," says marine biologist Vicky Fabry of California State University San Marcos, who has lobbied long for more ocean monitoring. "It's essential information for a better understanding of ocean acidification and its effects on marine ecosystems," she says.

Sakashita is also encouraged. "It's the first time EPA has acknowledged the reach of CWA to ocean acidification, and we hope it will provide states with new standards based on the best science available," she says.

—NOREEN PARKS