MPA news

International News and Analysis on Marine Protected Areas

Vol. 10, No. 6
December 2008/ January 2009

Ocean Acidification: What It Could Mean for MPAs

When scientists and policy-makers gathered in Poland this month for the United Nations Climate Change Conference, significant attention was paid to the effects of increased greenhouse gases on the oceans. The threats of sea level rise and warming sea temperatures, including the latter's impact on coral reefs by causing bleaching, received a major focus.

A lesser-known impact of the rise in carbon dioxide levels will be "ocean acidification", a term coined just five years ago. Early evidence suggests acidification could have as great an impact on ocean ecosystems — and, by extension, MPAs — as the other threats. Disconcertingly, a recent study on the northwest coast of the U.S. showed ocean acidification may be occurring much faster than expected. This month, *MPA News* examines ocean acidification and its potential impacts, as well as how MPA practitioners can plan ahead.

What is ocean acidification?

Earth's oceans absorb carbon dioxide, or CO_2 — the most common greenhouse gas, created by the burning of fossil fuels. Since the Industrial Revolution, which marked the start of the current rise in atmospheric greenhouse gas levels, the oceans have absorbed approximately half of the CO_2 emitted by human activities. Without this long-term storage, the greenhouse gas concentration in the atmosphere would be much higher, and the planet much warmer. However, absorbing the CO_2 causes changes in ocean chemistry, namely lowering the pH of seawater and decreasing the concentration of carbonate ions.

What is pH?

The acidity or alkalinity of a liquid is measured on a scale of 0 to 14. This measurement is called pH for "power of hydrogen", since it measures the activity of hydrogen ions in the liquid. A pH below 7.0 is acidic, while a pH above 7.0 is alkaline (also called basic). Since pH is a logarithmic scale, a difference of one pH unit is equivalent to a ten-fold difference in hydrogen ion concentration. In other words, a solution of pH 5.0 is ten times more acidic than a solution of pH 6.0.

It works like this: When the CO_2 is absorbed, it reacts with the water to form carbonic acid, which then releases hydrogen ions. These freed hydrogen ions reduce the water's pH — in other words, the water becomes more acidic. (For an explanation of pH, see the box "What is pH?".) Normally seawater is slightly alkaline, with a pH of 8.06. As seawater moves toward the acid end of the pH scale, its pH measurement will decline. Under scenarios from the Intergovernmental Panel on Climate Change, ocean pH by the year 2100 could drop as low as 7.76. That would represent a 30% increase in acidity, as the pH scale is logarithmic.

Some of the hydrogen ions released by carbonic acid also bind to carbonate ions in the water, making them unavailable for use by species that need them. Less carbonate makes it more difficult for many marine organisms — including corals, calcareous phytoplankton, mussels, snails, and sea urchins — to form calcium carbonate, their major mineral building block. To make matters worse, when carbonate concentrations fall too low, calcium carbonate that has already formed starts to dissolve. As a result, marine organisms have a harder time either creating new, or maintaining old, skeletal material. (Some people have compared ocean acidification to osteoporosis, the disease of reduced bone density in humans.)

The effects of decreased calcification rates have been studied most with coral reefs. Coral skeletons are made of calcium carbonate, and ocean acidification poses a direct threat to the foundation of reef ecosystems. A new report published by the Global Coral Reef Monitoring Network, *Status of Coral Reefs of the World: 2008*, states most of Earth's coral reefs could disappear within 40 years due to acidification and other factors. (The report is at http://iucn.org/index.cfm?uNewsID=2408.) In August 2008, reef scientists gathered in Hawai'i to craft strategies to address the threat of acidification. The resulting Honolulu Declaration focused not only on the need to reduce CO_2 emissions but on how to manage reef ecosystems in ways to aid their survival (see the article "The Honolulu Declaration…" on p.3).

As for impacts on non-reef organisms, many economically important species will be affected by acidification. Mollusks, including clams, mussels, and other shellfish, will have difficulty building their shells. Tim Wootton,

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Dear Reader:
This issue of *MPA News* covers the months of December 2008 and January 2009, allowing our staff a year-end holiday. In February, our regular monthly delivery will resume.

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a biologist at the University of Chicago, found in his long-term study of a mollusk community in the northwest U.S. that his water samples over eight years had acidified at a rate 20 times faster than what he had expected. According to his computer models, increased pH at his study site will likely lead to substantial declines in the number of mussels and large barnacle species, and increases in the populations of what those species eat, like algae and smaller barnacles. (Wootton's paper, "Dynamic patterns and ecological impacts of declining ocean pH in a high-resolution multi-year dataset", appeared in the 24 November 2008 edition of the journal *Proceedings of the National Academy of Sciences*.)

Wootton says other studies on the U.S. west coast offer similar acidification results. "There is reason to suspect that the strong decline in pH is not limited to our research site," he says. "More generally, it seems likely that the trends we are seeing are at least a feature of the larger northeastern Pacific."

Flexible MPA boundaries may be needed

Judy Kildow, a social scientist and policy analyst at the Monterey Bay Aquarium Research Institute in the U.S., says the compromising of shelled creatures as projected by Wootton could affect a wide array of marine life. "Marine mammals that feed on these shelled creatures will have to compete with other predators for other remaining food, and may not fare well," she says. "As some creatures disappear, others will fill the niches. What is clear is that the ecosystem will look different in 20-50 years, with many familiar commercial species gone and the likelihood that far less desirable creatures will replace them. So it is not just coral reefs and mollusks that will be affected but a much larger range of marine creatures, from phytoplankton to marine mammals. Everything in the oceans will be affected in some way."

Kildow points out several policy challenges associated with addressing acidification. These range from major global challenges (curbing greenhouse gas emissions) to more localized ones, like reducing other environmental stressors (such as pollution, runoff, and overfishing) that further weaken marine ecosystems and worsen any impacts of acidification. At the individual MPA level, she says, practitioners can take steps to plan ahead, including by anticipating a changing environment. "Boundaries of MPAs should not be geographic," she says. "Instead, they should be determined by ecological indicators, such as species diversity and other critical indicators that planners seek for sustaining biodiversity."

UNESCO, through its Intergovernmental Oceanographic Commission (IOC), has taken a leadership role in assessing the impacts of ocean acidification. The organization released a fact sheet this year that echoes Kildow's call for flexible MPA boundaries as part of better ecosystem management. "Marine reserves are being established throughout much of the coastal oceans to preserve biodiversity and boost fishing stocks," the fact sheet states. "Policies need to allow flexibility to shift the boundaries of these reserves as ocean chemistry and ecosystems change in response to acidification." (The three-page UNESCO fact sheet, "The Ocean in a High CO2 World", is available in English at http://ioc3.unesco.org/oanet/OAdocs/FactSheet_en.pdf, and in French at http://ioc3.unesco.org/oanet/OAdocs/FactSheet_fr.pdf.)

Maria Hood, Project Director of the IOC-sponsored International Ocean Carbon Coordination Project (www.ioccp.org), says much more research is needed on the impacts of acidification, including in MPAs. "Establishing baseline surveys and regular monitoring programs of the ecosystem and biodiversity will be key to detecting and understanding future changes brought on by ocean acidification," says Hood. "The coast environment and coral reef ecosystems undergo rapid and large diurnal variations in carbonate chemistry. Monitoring will require both frequent and long-term observations of the carbonate system as well as regular ecosystem surveys. Appropriately monitored, MPAs could provide a critical early-warning system for ocean acidification impacts." IOC is working with other organizations, including the European Project on Ocean Acidification (www.epoca-project.eu) and the U.S. Ocean Carbon and Biogeochemistry Program (www.us-ocb.org) to help coordinate global research on acidification, including setting priorities, standardizing experimental methods, and sharing data.

Remaining uncertainties surrounding the potential impacts of ocean acidification make it too early to sketch out a worst-case or best-case scenario for fish and fisheries, says Jan Helge Fosså, Chief Scientist at the Norwegian Institute for Marine Research. "The ecosystem consequences of ocean acidification are too unpredictable, and we know too little about direct physiological effects on fish species and their different life stags," says Fosså. "But there are reasons to believe that a low pH and high CO_2 can affect fish directly through their physiology and indirectly through ecosystem effects, such as changes in food quality, quantity, and timing." In certain invertebrates and some fish, CO_2 accumulation and lowered pH in animals' bodies could result in acidosis, a build-up of carbonic acid in body fluids, according to UNESCO. This would lead to lowered immune response, metabolic depression, and asphyxiation.

"The use of MPAs in fisheries management is still under debate, but I think that MPAs can play a role in addressing acidification," says Fosså. "It is important to maintain strong and robust fish stocks in a changing environment. By robust, I mean stocks that are not overfished and have suffered a minimal loss of genetic

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diversity; this allows them maximum potential for adapting to the expected and possibly irreversible changes in the environment. Although the use of MPAs in fisheries management is still under debate, they can play a role in protecting stocks that are either fished down or local and vulnerable. MPAs could help, for example, to secure reproduction and recruitment by protecting spawning grounds and nursery areas. Keeping the potential for high stock recruitment is very important."

For links to additional fact sheets, statements, Powerpoint presentations, research programs, and other general information on ocean acidification, go to the website for the Ocean Acidification Network at www.ocean-acidification.net.

The Honolulu Declaration on Ocean Acidification and Reef Management

Although ocean acidification will have effects throughout the world's oceans, most of the research on it so far has been in a tropical context, where its implications for coral reef health pose a major concern. Reduced pH levels of seawater are expected to lead to the breakdown of corals' calcium carbonate skeletons, causing significant and potentially irreversible changes in reef ecosystems.

In August 2008, The Nature Conservancy convened a meeting in Hawai'i of climate experts, marine scientists, and coral reef managers to identify strategies for addressing acidification and safeguarding the value of coral reef systems. It resulted in the Honolulu Declaration on Ocean Acidification and Reef Management, available at www.nature.org/wherewework/northamerica/states/hawaii/files/final_declaration_no_app.pdf.

In addition to calling for a stabilization in global CO_2 levels, the declaration seeks the inclusion of climate change actions (addressing acidification, sea level rise, and ocean warming) into MPA management plans. It details several ways reef managers can incorporate such actions, such as identifying and protecting high biodiversity coral reefs that are likely to be less vulnerable to the impacts of acidification.

Planning for resistance

Rod Salm of The Nature Conservancy, who directed the meeting, says there are several reef types that may be more resistant than others to both ocean acidification and the threat of ocean warming. "An example of overlap between lowered vulnerability to both acidification and warming/bleaching would be reefs that are washed by localized upwelling," says Salm. "Such mid-depth vertical mixing of the water column brings up cool water that mixes with the hot surface water, cools it, and reduces the heat stress on corals. The same water, as long as it is drawn up from water shallower than the deep acid layer, would have the potential to dilute the relatively CO_2-rich surface waters and reduce the acidity of these waters."

Another example, he says, would be reefs or parts of reefs that are well-flushed by ocean water. "Oceanic water has been shown to have lower CO_2 than inshore waters in general," says Salm. "Flushing with oceanic water would help dilute the CO_2 concentration of inshore waters while at the same time serving to wash away any toxic byproducts of heat-stressed corals, such as superoxides that weaken or kill coral tissues."

Salm says MPAs are essential to addressing acidification. "MPAs will always be an important tool for protecting marine ecosystems from all stressors, including ocean acidification, for two main reasons," he says. "First, we can select and zone these MPAs for their potential to resist or avoid climate change impacts and so maximize their survival prospects. Second, we can focus management attention on the MPAs and concentrate resources on reducing all stresses as much as possible. In this way we can increase the health and resilience of the reef ecosystem, leaving the component communities better able to absorb, adapt to, or recover from stress."

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MPA News is published monthly by Marine Affairs Research and Education (MARE), a 501(c)(3) not-for-profit corporation, in association with the School of Marine Affairs at the University of Washington.

Financial support for *MPA News* is provided in part by a grant from the David and Lucile Packard Foundation.

Applying Conservation and Management Lessons from the Great Barrier Reef to the Baltic Sea Region: Interview with Åsa Andersson

In September 2008, the conservation organization WWF held a series of workshops throughout the Baltic Sea region. The workshops were designed to provide lessons in marine spatial planning and management to Baltic decision-makers and stakeholders, and were noteworthy for at least two reasons. One, they featured people who had led a process to re-zone Australia's Great Barrier Reef Marine Park (*MPA News* 5:10) — a place quite different from the Baltic in many ways. Two, these visiting Australians included not just management personnel from the Great Barrier Reef but a politician from there as well.

Below, *MPA News* talks with Åsa Andersson, Director of WWF-Sweden's Baltic Sea Programme, about the workshops and the reasons behind their design.

MPA News: The global MPA field has seen several cases in which MPA managers have traveled to other sites to share their experiences, sometimes as part of "sister MPA" relationships (*MPA News* 7:2). However, similar visits by politicians to share lessons in MPA governance seem relatively rare. Why did WWF decide it was important to invite a politician — David Kemp, Australia's former federal environment minister — as well as MPA managers to come and speak to people in the Baltic region?

Andersson: The simple answer is, strong political support is very important to integrated management of the Baltic Sea, including the establishment of MPAs. The Baltic Sea is a heavily used area where many interests are competing for the same limited space. We have to create space for both humans and nature, and that requires a process where different interests are balanced against each other in a sustainable way. Balancing these interests is clearly a political issue. The success of ecosystem-based, integrated sea-use management requires strong political leadership and cooperation between managers and politicians — at all administrative levels and in all nine Baltic Sea countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden).

This was the reason we invited the three people we did: Minister Kemp, as the politician who drove the legislative process for the re-zoning; Jon Day, with his long experience as Conservation Director of the Great Barrier Reef Marine Park Authority (GBRMPA); and Virginia Chadwick as the Head of GBRMPA during the re-zoning. We wanted them to provide a full picture and share their different perspectives with their counterparts in the Baltic. What were the key factors for success in the Great Barrier Reef? What were their different roles and what kind of leadership did they provide? What were the relations among them, and how did they cooperate?

The whole idea of this tour was to inspire. By showing a successful example of how the Australians had managed to establish integrated management of the sea, including protection and zoning of different uses, we wanted to create enthusiasm that something similar was possible in the Baltic.

MPA News: What was each workshop like?

Andersson: We organized a road trip with workshops in four countries: Sweden, Finland, Estonia, and Germany. The audience consisted of managers, politicians, and representatives from different sectors and user groups. In most of the sessions, the Australians started with a two-hour presentation block among the three of them, with time for questions from the audience. This presentation block was important to provide a comprehensive picture of the Great Barrier Reef situation and zoning process, and to be able to discuss its possible application to the Baltic Sea. It was then followed by a few shorter presentations from the host Baltic country to give an overview of the situation in the region and place the Great Barrier Reef presentation in a Baltic Sea and national context. Afterward we had a longer, facilitated discussion on the lessons learned in Australia focusing on how we could create more integrated management of the Baltic Sea, including zoning and the establishment of MPAs. When preparing the tour, we gave the Australians a lot of information about the Baltic situation in advance so they could understand and contribute to the discussion.

Baltic reactions to the workshops have been very positive. What seems to have been most appreciated was that the Australians very openly shared all the fears, worries, and challenges they went through in their different positions — that the process was not easy, but was still worthwhile.

MPA News: There are many differences between the Baltic region and the Great Barrier Reef (GBR) — not least of which is that the Baltic is temperate and the GBR is tropical. Did these differences cause any problems for the information exchange?

Andersson: There are of course many differences between the GBR and us. The GBR is contained in just one country; the Baltic involves nine. The GBR has approximately one million people living in the region while we have 90 million. More significantly, the GBR is an established MPA with one responsible authority, while the Baltic exists under a myriad of governing

bodies on different levels with different regulations.

However, there are many similarities. The sizes of the two regions are almost the same. There are similar challenges to resource management like shipping, fisheries, agricultural run-off, climate change, etc. The need for political support and leadership, integrated policies and legislation, stakeholder involvement, data and information, and the importance of good communications work are all the same. Many aspects about nature conservation and management are not about nature, as such, but about people — and people are very much the same everywhere.

I found most key lessons from the GBR to be applicable here in the Baltic Sea. However, the aim of the seminars was not to "buy the whole package" and just implement the GBR approach in the Baltic, but to listen to the lessons, get inspiration, and discuss what aspects could be applicable in the Baltic Sea and what has to be done differently. From this perspective, the workshops were very useful. There is not one standard process that will fit everywhere. All areas and regions are unique. Therefore, it is important to look at different examples and create a process that is adapted to the specific area.

Note: More information on the workshops, including links to presentations, is available at www.panda.org/what_we_do/where_we_work/baltic/solution/sea_use_management/?147344/Great-Barrier-Reef-Workshops.

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U.S. Releases Final Framework for National MPA System

The U.S. has released the framework for its national system of marine protected areas. The framework outlines key components of the national system, including:

- A set of overarching national system goals and priority conservation objectives;
- MPA eligibility criteria and other definitions;
- A science-based public process for identifying conservation gaps; and
- A process for improving regional, national, and international coordination.

At this time, the national system remains only a framework: although the U.S. has nearly 1800 designated MPAs throughout its waters, the national system does not yet officially contain any of these sites. First, MPA programs must nominate their eligible sites for formal inclusion in the system. Inclusion will be judged on a set of criteria, including that the site has a management plan and that it contributes to at least one priority conservation objective of the national system, as outlined in the framework. After a public comment period, sites judged to meet these criteria by the nominating agency and the U.S. National MPA Center will become part of the system.

The purpose of this nomination process is to focus on those MPAs that are most likely to contribute to the national system's long-term viability and effectiveness. Inclusion in the national system is expected to confer several benefits to eligible MPAs, including opportunities for enhanced site management capacity and increased coordination with other MPAs in the system. The nomination process for the first group of sites to be included in the system is open through 31 January 2009.

In addition to strengthening and coordinating existing MPAs, the national system aims to identify gaps in current protection and inform future MPA planning. Beginning in 2009 and progressing on a region-by-region basis, the MPA Center will conduct gap analyses with institutional partners and stakeholders. The first gap analysis will be conducted for the West Coast (the states of California, Oregon, and Washington from the shoreline to the outer edge of the EEZ) and will focus on mapping areas that contribute to the national system's objectives for natural heritage and sustainable production priority conservation. Critical cultural heritage areas will be identified through a separate process.

Once the gap analyses are completed, relevant resource management authorities will be responsible for deciding whether to designate new MPAs, says Lauren Wenzel of the National MPA Center. "The MPA Center does not have the authority to designate new MPAs," says Wenzel. "It will be up to other agencies, with input from regional stakeholders, to determine which authority best addresses the conservation objectives they have helped to identify for that area." If or when MPAs are designated through this process, she says, the designation could come at the federal, state, territorial, tribal, or local level. Those new sites would then be eligible for inclusion in the growing national system of MPAs.

Wenzel points out that the national *system* of MPAs will eventually lead to a national *network*. "To be an MPA network, whether ecological or institutional, a group of MPAs must be designed or managed for the explicit purpose of connecting individual sites to enhance the benefits they provide," she says. "On a national and regional scale, that type of comprehensive approach has been lacking in the U.S. Most U.S. MPAs have been established over the past three decades, and have been created by a wide range of programs for diverse purposes with little consideration of their interconnec-

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tions. So although the U.S. has many MPAs, we are not maximizing their conservation benefits. The national system will build institutional networks to support MPAs nationally and regionally, working toward common conservation objectives. In addition, the conservation gap analysis process will identify opportunities to build or enhance ecological networks at the regional or sub-regional scale."

"Our vision for the national system as it evolves is: 'MPAs working together to conserve the nation's ocean ecosystems,'" says Joseph Uravitch, MPA Center Director. For directions on nominating a site for inclusion in the national system, and information on the framework in general, go to http://mpa.gov.

Notes & News

Ecuador designates three MPAs

The government of Ecuador designated three new MPAs in the months of September and October, totaling more than 1100 km^2 of coastal and marine area: Galera San-Francisco Marine Reserve, the coastal Pacoche Wildlife Refuge, and Puntilla de Santa Elena Wildlife Production Reserve. Management plans for the three sites, to determine which areas within the MPAs will be protected from fishing activity, will be developed within 180 days of designation. Planning of the MPAs was under the leadership of the Ministry of Environment, with support from various national and international NGOs, including Conservation International. **For more information: Antonio Matamoros**, Environment Ministry, Quito, Ecuador. E-mail: amatamoros@ambiente.gov.ec

Report examines MPA networking initiatives

A new report explores national and regional efforts to develop representative networks of MPAs, and offers recommendations for strengthening the planning of such networks worldwide. Published by the UNEP World Conservation Monitoring Centre and the UNEP Regional Seas Programme, the report reviews 30 nations' networking initiatives, including progress made and lessons learned. "The many initiatives underway provide much experience on how MPA networks can be established in practice, and how they can be adapted to different needs and priorities," writes report author Sue Wells. The 156-page report *National and Regional Networks of Marine Protected Areas: A Review of Progress* is available at www.unep-wcmc.org/oneocean/reports.aspx.

Report available on lessons from California MPA-planning process

The initiative to create a network of MPAs off the coast of the U.S. state of California has released a report of lessons learned from its work in the state's North Central Coast region, which began in early 2007. The multi-stage, region-by-region approach to implementing California's Marine Life Protection Act (MLPA) allows for distilling lessons learned along the way and applying them in ensuing phases. The North Central Coast efforts relied on a model derived from work in 2006 to plan MPAs for the state's Central Coast region (*MPA News* 8:11). Planning of the South Coast and North Coast is still to come. The 201-page *Report on Lessons Learned from the Marine Life Protection Act Initiative: North Central Coast Study Region* is available at www.dfg.ca.gov/mlpa/pdfs/agenda_110408a.pdf.

Lessons available from project to study fisheries management in protected areas

Advice and lessons derived from a project to develop fisheries management plans for MPAs in the German EEZ of the North Sea and Baltic Sea are now available. The three-year initiative, called the Environmentally Sound Fishery Management in Protected Areas project (EMPAS), analyzed conflicts between nature conservation goals and fishing activities. It was coordinated by the International Council for the Exploration of the Sea (ICES) and was meant to serve as a pilot for development of similar plans throughout offshore E.U. waters. A link to the 15-page *EMPAS Summary and Advice* document, an ICES Advice 2008, is available at www.ices.dk/projects/empas.asp.

Proceedings from MPA economics workshop

The proceedings from a May 2008 workshop in Suva, Fiji, to examine the economics of MPAs in the South Pacific are now available. The goal of the week-long workshop was to share information among stakeholders and discuss how economic tools — such as non-market ecosystem valuation techniques, benefit-cost analysis, and cost-effectiveness analysis — could be incorporated into MPA planning and management. Key outcomes included an agreement on common methodologies for conducting economic analyses of MPAs in the region, and the identification of case studies in Pacific island countries where these methodologies could be tested. The workshop was organized by the Coral Reef Initiatives for the Pacific (CRISP), IUCN, and the South Pacific Regional Environment Programme (SPREP). The report *Economics of Marine Managed Areas of the South-Pacific* is available at www.crisponline.net.

Draft texts available of resolutions from World Conservation Congress

Draft texts, in English, of the resolutions and recommendations adopted at the 4th IUCN World Conservation Congress, held in Barcelona, Spain, in October 2008, are now available at www.iucn.org/congress_08/assembly/policy/index.cfm. These texts have been edited to include the amendments agreed to during plenary sessions of the Members' Assembly and to include language and grammar corrections. Further minor amendments of an editorial nature may be made before final formatting, layout, and publication occur. Drafts in Spanish and French will be posted online in January 2009. As listed in our October 2008 issue (*MPA News* 10:4), several resolutions approved in Barcelona held direct or indirect implications for MPAs.