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VADM Conrad C. Lautenbacher
Under Secretary of Commerce for Oceans and Atmosphere and
NOAA Administrator
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Room 6811
14th Street and Constitution Avenue, NW
Washington, DC 20230

May 30, 2007

Re: Ocean Acidification Research in the National Oceanic and Atmospheric Administration (NOAA)

Dear VADM Lautenbacher,

At the March 2007 NOAA Science Advisory Board (SAB) meeting in Silver Spring Maryland, the SAB received and discussed a presentation on NOAA's activities related to ocean acidification. Dr. Richard Feely of the Pacific Marine Environmental Laboratory (PMEL) provided this presentation at the invitation of NOAA SAB.

The SAB feels that ocean acidification research is of critical importance and should be a focus of continued efforts within NOAA. This research program should include examination of the positive and negative feedback loops involved in ocean acidification and the extent to which net effects and potential impacts can be identified. In addition, how best to provide information to policy makers should be considered when determining related research investments.

Due to its mandate for ecosystem responsibility in the oceans and its unique capacity to develop and deploy ocean observation systems, NOAA is the appropriate agency to provide strong leadership for a federal interagency effort examining ocean acidification. NOAA's research must coordinate with parallel activities within other federal agencies, which should be involved as soon as is feasible to permit full integration of activities and to capture potential cost-sharing synergies. Further, as ocean acidification is of global concern, NOAA should work with the international research community to develop information and solutions for this issue.

NOAA is encouraged to move expeditiously on establishing the National Research Council review of ocean acidification effects on fisheries and on habitats and trophic interactions on which they depend. Care must be taken to properly scope the terms of reference to ensure policy relevance and a focus on the areas of greatest needs and impacts.

The SAB notes that ocean acidification strikes a chord with people across the country and around the globe, foremost because acid-related decalcification of shellfish and other marine organisms may affect food supplies and ocean health. Communication of this set of issues may raise awareness of the emerging field and NOAA's leading role in research on its progress, impacts and potential mitigation. NOAA is encouraged to continue and increase its efforts to communicate such examples of ecosystem relevant research to other segments of the federal government, to partners, and to the general public.

The SAB appreciates the opportunity to provide advice on this important topic. Please see the summary of our discussions [attached] and the recommendations we make on how NOAA might build on its current efforts. We look forward to receiving updates at critical times on ocean acidification, and welcome further discussion of this and other key emerging research areas within NOAA. I am sending a write up from the UW Alumni Magazine, *Columns* June 2007 that credits NOAA for its leadership on this issue.

Sincerely,

David Fluharty, Chair NOAA SAB

cc:

C. Lautenbacher
J. Kelly
C. Decker
R. Feely

Summary Notes on Ocean Acidification from the March SAB meeting:

Implications of Ocean Acidification for Marine Life - *Richard Feely – Supervisory Oceanographer, NOAA Pacific Marine Environmental Laboratory*

The purpose of the presentation was to provide information on ocean acidification to the SAB and to request guidance on NOAA's plans for ocean acidification research. Background on carbon dioxide (CO_2) chemistry in the oceans was provided, noting that human activities beginning in the industrial age have been shifting the pH and ocean CO_2 chemistry to a state that has not occurred for hundreds of thousands of years. This may have serious impacts on open-ocean and coastal marine ecosystems. Calcium carbonate ($CaCO_3$) is the major component of shells, tests, and hard corals; as such, formation of this molecule is essential to food webs. Increases in atmospheric CO_2 can change ocean chemistry because the oceans act as a sink for this greenhouse gas. Increased CO_2 increases ocean acidity (i.e. lowers ocean pH) and the carbonate ion concentration. Increased acidity makes the chemical reaction forming $CaCO_3$ more difficult, decreasing the ability of organisms to form $CaCO_3$ shells. Below a certain carbonate ion concentration, these shells would actually begin to dissolve, effectively stopping their growth.

Limited information exists on the overall biological impacts of such potential changes in ocean carbonate chemistry. Most current studies are short term, involve extreme pH changes, and are on single species or strains. Little is known about synergistic effects, responses by genetically diverse populations, acclimation and adaptations, species replacement, community to ecosystem responses, or impacts on overall global climate. There are both adverse and stimulating effects of ocean acidification on different organisms, which can in turn affect ecosystems differently. Some experiments indicate that CO_2 levels possible by the end of this century may cause animals to no longer be able to produce their shells. Other experiments in the open ocean indicate that this tipping point may occur sooner; the open ocean includes additional stresses than are present in controlled environments. Regardless of timing, increased ocean acidity due to increased CO_2 will likely increase the mortality of fish and king crab larvae. Modeling work is underway to predict how, when, and where acidification may affect the entire water column. Models are also being used to evaluate potential effects on coral reef calcification.

NOAA is conducting such research in several areas across the agency as well as with other federal agencies, universities, and foundations. NOAA has developed a five-year interdisciplinary program focused on ocean acidification research in order to provide leadership in coordinating research and engaging stakeholders and decision makers in this issue. The plan includes 1) establishing coral reef metabolic monitoring stations at major U.S. coral reefs designed to track changes in the system-level metabolic performance; 2) conducting physiological research; 3) socio-economic modeling; 4) technology development and standardization; and 5) ocean acidification environmental modeling. These five elements will include new directions and approaches for research as well as opportunities for international collaboration. Several key scientific questions

were discussed, as were the legislative and strategic requirements that these efforts support. The former includes the 2006 reauthorization of the Magnuson-Stevens Act that calls for a National Research Council (NRC) review of how ocean acidification may affect fisheries. The SAB was asked if NOAA's ocean acidification research plan seemed appropriate to address NOAA's requirements for science and policy information and if NOAA should be the lead federal agency for ocean acidification research in the United States.

Discussion:

A member asked if coral reefs are essentially the "canary in the coal mine" for ocean acidification. Dr. Feely responded that they are, because they are the organisms most sensitive to changes in the ocean. Another member asked what other agencies could lead the work on ocean acidification. Dr. Feely noted that all agency efforts could be combined into a national plan so that federal agencies could each contribute their own piece to a greater whole. NOAA, however, has ecosystem responsibility in the oceans and the clearest mandate and so could take the lead.

A member inquired as to the status of the NRC study. This was commissioned last December; the terms of reference need to be developed by NOAA. It was further noted that Magnuson-Stevens requires NOAA to fund the study, but that this is not yet specifically in the FY07 or FY08 budgets.

A NOAA representative asked why $CaCO_3$ saturation depths varied across oceans. Dr. Feely replied that this is part of the natural carbon and ocean circulation cycles: the oldest and most CO_2-laden waters are found in the Pacific and Indian Oceans. Changes in these patterns are being examined in conjunction with biological surveys. Deep corals will be considered for monitoring in addition to shallow corals; NOAA is developing criteria for selecting the best sites for this. The agency plans to develop a methodology for shallow ecosystems and then move into deeper waters. PMEL is working with the NESDIS group developing a warning system for coral stress due to ocean heating because a similar approach may be useful here.

Given the great consequences of ocean acidification, it is necessary to define the observation system needed to understand these long-term processes. A member of the SAB asked if there are other key chemical reactions and if any of these are restorative. The member also asked how the extrapolations over time presented in the briefing were done. The extrapolations were determined using global circulation models containing biogeochemical components. A primary restorative reaction is the release of calcium from ocean sediments, however it takes tens of thousands of years for this to be released and circulate back to the surface sufficient calcium to restore the normal chemical processes.

Regarding NOAA's investment in this topic, a member stated that the key to determining research investments should be how to best provide information to policy makers, which is different than simply supporting research. Potentially through the NRC study, the

activities required to provide a compelling case that supports appropriate policy decisions need to be determined. Because this is a large topic, the terms of reference for the NRC study must be carefully drafted, focusing on a set of policy-related questions, implications for the country and for NOAA, and on NOAA's stewardship role for marine sanctuaries. An upcoming set of policy questions may be scenario analyses of the lag time between actions and ecological effects, including how fast the effects clear out.

A member asked what factors regulate carbon saturation levels in the ocean's mixed layer, and whether different states exist in different oceans. Dr. Feely stated that these factors include carbonate concentration, temperature, pressure, and salinity. Current models do not accommodate changes in salinity, but these effects are not as strong as others. Because this involves whole-system modeling, Dr. Feely was asked to comment on the current computational ability to store the masses of ocean data and run useful tests. Dr. Feely noted that there have been great improvements in modeling and that scientists are developing ways to look at the ratio between calcifying and non-calcifying organisms, which drives the carbon feedback to the atmosphere.

It was noted that the ocean acidification issue is less mature than the understanding of atmospheric global warming. This shows the wisdom of NOAA's research reorganization based on the report of the Research Review Team. It allows examination of changes in the ocean in combination with effects on carbon levels and ocean life. This is similar to research on climate effects on vegetation and permafrost at high latitudes in the Northern Hemisphere. NOAA's Earth System Research Laboratory is beginning to address such earth system observations and identify ways to work on complex holistic models.

A member noted that ocean acidification connects personally to people through their food, which can help raise awareness and increase NOAA research funding in the area. The member asked if NOAA effectively communicates this and other such examples of good research or if it needs to improve its outreach methods. Outreach issues were addressed later in the meeting.

A member proposed four things that the SAB could recommend: 1) agreeing that NOAA is only agency with the capacity to develop and deploy the proper observing systems; 2) agreeing that NOAA should involve other interested agencies soon and potentially share the costs of the program; 3) noting that there is an international component to include; and 4) agreeing that the NRC study needs to move forward expeditiously but that the terms of reference need to be developed carefully to focus the group on the greatest needs.

Action:

- Further consider ocean acidification research and, if necessary, provide recommendations to NOAA on its related research programs. Recommendations could include:
  a) NOAA as the primary agency for ocean observations;
  b) NOAA coordinate its research with other agencies;

c) NOAA coordinate its research with the international research community;
d) NOAA move ahead quickly with a National Research Council study of this issue, but scope it out carefully to ensure policy relevance;
e) Include in research program studies on feedback loops, both positive and negative.