ORRAP

Ocean Research & Resources Advisory Panel

A United States Federal Advisory Committee

Ocean Acidification Task Force

Summary of Work Completed and Recommendations for ORRAP to convey to the IWGOA

ORRAP Ocean Acidification Task Force

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The Ocean Research & Resources Advisory Panel (ORRAP) is a non-federal committee established by the Federal Advisory Committee Act. The ORRAP provides independent advice and recommendations to the heads of federal agencies with ocean-related missions.

OATF Background and Timeline

- Recognizing a topic of national priority, and with the objective of assisting the agencies responding to the FOARAM Act, ORRAP worked quickly to stand up an Ocean Acidification Task Force (OATF).

- OATF impaneled on March 15, 2010. Designed to:
  - Develop priorities and review gaps in federal plans
  - Bring perspectives from academic sector and beyond (NGO, foundation)
  - Present recommendations to ORRAP

- Conducted inaugural meeting on 22-23 June 2010. Discussed national needs and gaps in federal plans. Developed draft recommendations for ORRAP to consider.
  - Met jointly with IWGOA – previewed the content of the draft recommendations

- Made sure to preserve the appropriate reporting lines (OATF to ORRAP, not OATF to IWGOA)
  - ORRAP reviewed and approved OATF recommendations on 27 July 2010

- OATF met for the second time on 6-7 December 2010. Acted as a venue to incorporate the perspectives of industry and foundations.
  - Met jointly with IWGOA – to hear their response to the OATF report and recommendations
  - The OATF decided to update the report to note the NRC recommendations and to include additional input from industry and foundations

Ocean Acidification Task Force of the ORRAP

Consortium for Ocean Leadership, 1201 New York Ave NW, Washington, DC • June 22-23, 2010

Objectives:

1. Gather information: Hear from colleagues; Hear from agencies
2. Identify gaps in federal plans
3. Develop framework for input/recommendations to IWGOA

Tuesday, 22 June – Fourth floor conference room

8:30-9:00	Breakfast
9:00-9:15	Welcome (Betzer) • Introductions • Review of agenda and objectives
9:15-12:30	Ocean Acidification briefings – Two members collaborate on each • Open ocean ecosystem calcifiers – Hutchins and Doney (via phone) • Coral reef environment – Kleypas with input from Celia Smith and Jen Smith • Hypoxia upwelling environment – Chan and Hofmann (via phone) • State chemical instrumentation and in situ sensors – Byrne and Brewer (via phone)
10:30-10:45	Break • Human dimensions and economic impact – Huseby and Doney • Role of foundations – Huseby and Short • NRC briefing on their OA report – Fabry and Kleypas • Policy and agency interface – Caldwell and Cowen • Review of federal OA plans – Representative(s) from IWGOA
12:30-1:00	Lunch
1:00-5:00	Discussion • Focus on identifying gaps in federal plans • Develop framework for input/recommendations to IWGOA
5:00	Wrap-up Discussion / Review Action Items

Wednesday, 23 June – Fourth floor, Pacific Room

9:00-9:30	Breakfast
9:30-12:00	Reconvene (Betzer) • Review previous day's presentations, discussions and action items, and get ready for IWGOA
12:00-1:00	Lunch
1:00-5:00	Joint session with IWGOA (Fountain-level conference room) Topic for discussion: • Gaps in federal plans, for example: – Geographies that are underrepresented – Linkage between scientists and industry
5:00	Adjourn

Ocean Acidification Task Force of the ORRAP

Consortium for Ocean Leadership, 1201 New York Ave NW, Washington, DC • December 6-7, 2010

Objectives:

4. Hear the IWGOA's response to the OATF Report and OA recommendations that were submitted in August
5. Act as a venue to incorporate the perspectives of industry and foundations
6. Formulate any resultant recommendations.

Monday, 6 December – Fourth floor conference room

12:30-1:00	Lunch
1:00-2:00	Welcome (Costa) • Introductions • Review of agenda and objectives • Review OATF report and recommendations
2:00-5:00	Joint session with IWGOA Co-Chairs Topics for discussion: • IWGOA Strategic Plan and November Meeting • Response to OATF Recommendations, for example: – Logistics of a NOAA OA Office – Plans for International Collaboration Coordination
3:30-3:45	Break
5:00	Adjourn

Tuesday, 7 December –Fourth floor conference room

8:30-9:00	Breakfast
9:00-10:00	Reconvene (Costa) • Review previous day's discussion with IWGOA
10:00-12:30	Ocean Acidification briefings • Marine Aquaculture Industry – Barton • NOAA's Aquaculture Program / New National Policy – Rubino • Role of Foundations – Huseby
11:00-11:15	Break
12:30-1:00	Working Lunch – Joint Session with the Ocean Observations Sub-Panel
1:00-2:00	Continue Joint Session with the Ocean Observations Sub-Panel • Coordinating OA Sensor Testing and Development with IOOS/OOI • Existing Collaborations
2:00-5:00	OATF Discussion • Focus on ways ORRAP can interface with industry and foundations • Additional input to IWGOA
3:00-3:15	Break
5:00	Wrap-up Discussion / Review Recommendations

Executive Summary of OATF Recommendations

In September 2010, the National Research Council published the report, "Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean" which reviews the current state of scientific knowledge on ocean acidification, and identifies gaps in that knowledge, particularly with respect to information useful to policy makers and federal agencies. The OATF offers the following as additional details or emphasis to the NRC recommendations.

1. **Interagency Coordination** It is critical that the federal agencies participating in the Interagency Working Group on Ocean Acidification (IWGOA) consider the many ways to implement strong interagency coordination of activities and funding in building plans for addressing ocean acidification.
2. **Interagency National Program Office** We support the vision of the National Research Council that calls for establishing an Interagency National Ocean Acidification Program Office. This office would not only help maximize communication between agencies and participating scientists but also help avoid duplication.
3. **Foundations, NGOs and Industry** There is considerable potential value in having several major foundations and NGOs collaborate in supporting research into ocean acidification. We strongly encourage the participating federal agencies to develop linkages with these groups. We also believe there are many opportunities for scientists to advise the marine industrial community and that the IWGOA should encourage productive interactions such as those evolving between marine scientists on the west coast and the Pacific Shellfish Growers Association.
4. **International Collaboration** The robust research programs involving ocean acidification that are underway internationally offer many opportunities for important collaborations with scientific colleagues in the United States. It is important that the involved federal agencies develop plans that facilitate the participation of US scientists so we capitalize on the substantive investments that are being made abroad.
5. **Communication** Communication between scientists and education of the public at large is a challenge confronting our society. Indeed, there is growing evidence that the interest in, and appreciation for, science in the United States is extremely low. If we expect our federal legislators to provide substantive long-term support, the IWGOA will need to consider how they can effectively improve communication about Ocean Acidification research and its relevance to society.
6. **Science Needs** For many decades ocean science has been impeded by the lack of dependable in situ sensing systems. Sensor development has been perennially underfunded and substantial investments on the order of tens of millions a year are needed to develop and then sustainably deploy dependable new sensing systems for physical, chemical and biological variables and this should be integral to the decade-long effort the IWGOA is developing. In addition to National Oceanographic Partnership Program (NOPP) funding, the Defense Advanced Research Projects Agency (DARPA) and Homeland Security Advanced Research Projects Agency (HSARPA) should be approached to partner in the sensor development effort. An important goal of the observational, experimental and modeling studies being formulated by the IWGOA should include entire food webs and the biogeochemical cycles that support them.

Photo Credit: NOAA

7. **Management Actions and Multiple Stressors** A host of important management decisions will be made in response to the scientific insights developed during the decade-long investigations involving Ocean Acidification. The Task Force recognizes the particular challenges presented by the action of multiple stressors in the marine environment but contends they should be made an integral part of management strategies.
8. **Socioeconomic Recommendations** Social sciences need to be incorporated into the assessment of the impacts of ocean acidification on lives and livelihoods. This could build on existing models – NOAA Climate and Societal Interactions program (CSI) and The US Global Change Research Program (USGCRP) and should include econometric approaches. Risk assessments of ocean acidification, that incorporate low-probability, high-impact events as well as high-probability, low-to-mid impacts need to be considered. Given the global nature of OA, socio-economic impacts must be considered with regard to global security.
9. **National Ocean Acidification Data Management Plan** There needs to be effective interagency coordination and data sharing. Information about OA and relevant data are scattered; there needs to be a permanent, national, interagency cyberinfrastructure system that ties together or stores in a few places all relevant data archives relevant to ocean acidification. The IWGOA should also identify opportunities to integrate OA data into the eventual IOOS (Integrated Ocean Observing System) data management scheme.
10. **Federal, Regional, State and Local Interactions** Local, regional, and state governments can combat the causes of acidification in parallel with the federal government. Environmental laws currently in effect provide a network of pathways for intergovernmental cooperation and coordination. Below we list some of the environmental laws relevant for mitigating ocean acidification, and the governmental interactions that these laws trigger.

Box 1. Key findings from the NRC Report "Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean"

1. **Ocean chemistry is changing at an unprecedented rate and magnitude due to human-made carbon dioxide emissions to the atmosphere.** The average pH of ocean surface waters has decreased by about 0.1 pH unit – from about 8.2 to 8.1 – since the beginning of the industrial revolution, and model projections show an additional 0.2-0.3 drop by the end of the century, even under optimistic scenarios of carbon dioxide emissions.
2. **Changes in seawater chemistry are expected to affect marine organisms that use carbonate to build shells or skeletons.** For example, decreased concentrations of calcium carbonate make it difficult for organisms such as coral reef-building organisms, and commercially important mollusks like oysters and mussels, to grow or to repair damage. If the ocean continues to acidify, the water could become corrosive to calcium carbonate structures, dissolving coral reefs and even the shells of marine organisms.
3. **It is currently not known how various marine organisms will acclimate or adapt to the chemical changes resulting from acidification.** Based on current knowledge, it appears likely that there will be ecological winners and losers, leading to shifts in the composition of many marine ecosystems.
4. **The committee finds that the federal government has taken positive initial steps by developing a national ocean acidification program.** The recommendations in this report provide scientific advice to help guide the program.
5. **More information is needed to fully understand and address the threat that ocean acidification may pose to marine ecosystems and the services they provide.** Research is needed to assist federal and state agencies in evaluating the potential impacts of ocean acidification, particularly to:
    - understand processes affecting acidification in coastal waters;
    - understand the physiological mechanisms of biological responses;
6. **The national ocean acidification program will need to adapt in response to new research findings.** Because ocean acidification is a relatively new area of research, the program will need to adapt in response to findings, such as the identification of important biological metrics, analyses of the socioeconomic impact of ocean acidification, and inclusion of concerns from stakeholder communities.
7. **A global network of chemical and biological observations is needed to monitor changes in ocean conditions attributable to acidification.** Existing observation systems were not designed to monitor ocean acidification, and thus do not provide adequate coverage or measurements of carbon parameters, such as total alkalinity, pH, and dissolved inorganic carbon, or biological constituents such as nutrients, oxygen, and chlorophyll. Adding sites in vulnerable ecosystems, such as coral reefs or polar regions, and in areas of high variability, such as coastal regions, would improve the observation system.
8. **International collaboration will be critical to the success of the program.** Ocean acidification is a global problem that requires a multinational research approach. Such collaborations also afford opportunities to share resources, including expensive large-scale facilities for ecosystem-level manipulation, and expertise that may be beyond the capacity of a single nation.
9. **The national ocean acidification program should support the development of standards for measurements and data collection and archiving to ensure that data are accessible and useful to researchers now and in the future.** Steps should be taken to make information available to policy makers and the general public in a timely manner.

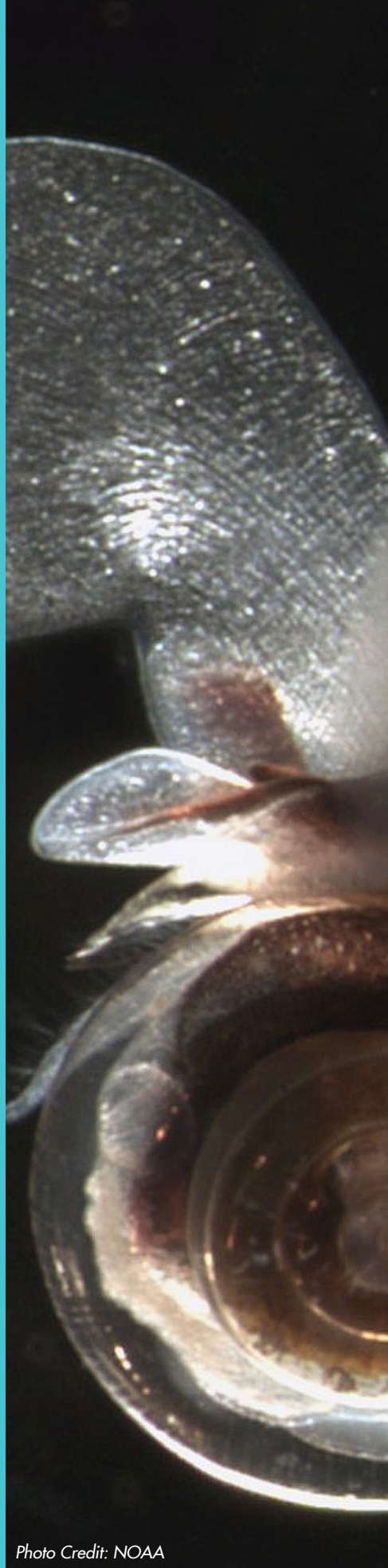

Photo Credit: NOAA

ORRAP Recommendations to IWGOA

In September 2010, the National Research Council published the report, "Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean" which reviews the current state of scientific knowledge on ocean acidification, and identifies gaps in that knowledge, particularly with respect to information useful to policy makers and federal agencies. Given the expertise, time and considerable effort that went into the production of this report, the OATF neither could nor should attempt to repeat that effort. It was therefore not the goal of the OATF to repeat or revisit the NRC report, but instead to build upon and provide additional details to the NRC recommendations. Box 1 is a summary of the key findings of the NRC report.

During its first meeting the OATF identified ten topics that were either in the NRC report and required emphasis or were additional areas of importance to OA that needed further clarification. The ten topics areas that were identified were: 1. Interagency Coordination, 2. National Program Office, 3. Foundations, NGOs and Industry, 4. International Collaboration, 5. Communication, 6. Science Needs, 7. Management Actions and Multiple Stressors, 8. Socioeconomic Recommendations, 9. National Ocean Acidification Data Management Plan, and 10. Federal, Regional, State and Local Interactions. These ten areas are more fully developed below.

1. Interagency Coordination

In an era of limited resources, yet critical scientific needs, it is important to focus on implementing strong interagency coordination of activities and funding so that duplication of activities is minimized and federal investments leveraged. A brief review of federal agency plans for addressing ocean acidification currently reflects reasonable plans *within* individual agencies but limited coordination *between* or *among* agencies. For example, monitoring of coastal waters for changes in pH, pCO_2, DIC and/or TA, as well as other relevant biological, chemical and physical parameters are often duplicated among agencies, without direct communication and sharing of such data and without a coordinated plan toward a well-conceived and designed overall sampling and management plan. To this end, there needs to be a national plan for developing, deploying and integrating real-time ocean ecological measurements into ongoing observing systems. Moreover, funding of such activities as a national ocean monitoring system should be a focus of all agencies and **coordinated as a single program and perhaps jointly funded through NOPP as a national program**. Similar effective coordination and data sharing activities through creation of a permanent, national, inter-agency cyberinfrastructure system should be a top priority in developing a national plan for addressing ocean acidification.

2. Interagency National Program Office

We support the vision of the National Research Council that calls for establishing a National Ocean Acidification Program Office that is jointly supported by all of the federal agencies involved in Ocean Acidification. This program office should not reside in a specific agency and would not only help maximize communication between agencies and participating scientists but also help avoid duplication. The logistics of such joint interagency support could be configured on the models of the past Joint Global Ocean Flux Study (JGOFS) and Global Ocean Ecosystem Dynamics (GLOBEC) programs, or the current Ocean Carbon Biogeochemistry (OCB) program office. Following the general structure used in these programs, the OA program office would be housed at an academic institution or possibly at the Consortium for Ocean Leadership. The program office structure would be simple, consisting of an executive director, a Chair of the Science Steering Committee (SSC), and an administrative assistant. These individuals would be full time

positions and would be hosted at the home institution of the SSC Chair, at least initially, or at a non-academic site such as Consortium for Ocean Leadership. The SSC would be made up of members of the scientific community that should include representatives of academia, industry, agency and foundations. These individuals would be selected by a nomination process and would serve a defined term (possible 3 years).

The program office would be funded by the IWGOA and could be selected by a Broad Agency Announcement for proposals to develop such an entity. In addition, the program office could house an education and outreach unit that would coordinate outreach and education efforts agency wide. This would facilitate getting the latest information out to the public. At the very least, the program office should coordinate education and outreach across the various agencies. A dedicated education and outreach unit that was well integrated into the program office was highly successful in the Census of Marine Life. This OA program office would provide a number of fundamental advantages over the present system whereby OA research and outreach activities are spread across several agencies. First, an OA program office would obviously be critical to better coordinating and avoiding duplication between the various agencies (see previous bullet). Second, such an office would serve an additional important function by facilitating direct, constructive dialog between the US academic OA community and funding agency representatives, since academic scientists and presumably colleagues from foundations, NGO's and industry would be members of the OA program Scientific Steering Committee. Finally, a national OA program office would fill a major gap by providing a badly needed united forum to represent US OA researchers in communications with the international ocean science community, with any participating foundations (see Section 3), and with related marine industries (see Section 3). OA research in the United States has historically lagged behind the more organized and coordinated efforts developed through organized programs, such as those from the European Union. A formal US OA program office would provide us with a stronger, more united voice in international OA issues instead of the "many small voices" which are all we now have as individual OA researchers.

3. Foundations, NGOs and Industry

As a follow up to ocean-related discussions that began to surface at COP-15 in Copenhagen in December 2009, a group of foundations decided that they needed to learn more about the broad and critical subject of ocean acidification. Towards that end, they devoted time at a meeting of the Consultative Group on Biological Diversity to provide an introduction to the subject to the member foundations present. The keynote speaker was Dr. Jane Lubchenco, the current administrative head of NOAA. Many of the foundations present acknowledged that they wanted to learn more. A steering committee was created and organized an educational conference at the Moore Foundation in Palo Alto, California from October 18-20, 2010 that included funders and scientists addressing what is known about the changes in ocean chemistry, about the causes of these changes and about what ocean modelers see in the decades ahead, especially if we continue generating CO_2 according to a "business as usual" scenario. A similar meeting of funders, NGOs and scientists was held on November 23, 2010 in London, England. One of the outcomes of these meetings is an effort to create a position for a joint foundation OA coordinator. The IWGOA needs to take advantage of the unusual opportunity to coordinate their effort with private foundations. We therefore recommend that the OA foundation coordinator be a member of the OA Science Steering Committee (SSC).

If our society is to move forward in addressing the daunting challenges associated with ocean acidification, **it is critical that we raise the level of collaboration between the various stakeholders**. In addition to collaborating with foundations, we urge the IWGOA to look closely at the work already being done by NGOs and the fishing industry in their efforts to understand and communicate what is needed to face the challenges of sustainability in our oceans.

Photo Credit: Dan Costa

An emerging collaboration between ocean scientists and the Pacific Coast Shellfish industry in the Pacific Northwest could well serve as a model for an expanded collaboration between scientists and marine industries. In this case, the Pacific Coast Shellfish Growers Association (PCSGA) has worked with NOAA to spearhead the formation of a scientific team with representatives from federal and state agencies, hatchery personnel and growers with the goal of understanding the ocean conditions leading to the mortality of oyster larvae, in both commercial hatcheries and in the natural environment. Shellfish growers recognize that accurate monitoring of seawater conditions offers the industry an important opportunity to develop adaptive strategies, and as a result are fully engaged in collaborative efforts with the research community. Significantly, Oregon State University, the University of Washington, NANOOS and NOAA are contributing to this effort by providing data from monitoring stations throughout the Puget Sound area and along the Washington/Oregon/California Coast, and are actively involved with the shellfish industry.

Near-Shore Monitoring stations now stretch from the Whiskey Creek Hatchery in Netarts Bay, Oregon, to Hood Canal, to Lummi Bay in Northern Puget Sound (the Salish Sea), and provide detailed environmental measurements adjacent to commercial hatcheries, or in sites of high natural recruitment of shellfish larvae. When correlated with biological data routinely gathered at each site, these data should provide valuable insight into the potential effects of ocean acidification on larvae in the coastal ocean. Research at Whiskey Creek Hatchery in 2009 and 2010 suggests a strong correlation between the upwelling of acidified seawater and mortality of oyster larvae, and provides strong support for expanding the current monitoring program.

Although many published laboratory experiments show the effects of high pCO_2 on shellfish larvae, most couch their results in reference to predicted pCO_2 scenarios for 2050 and beyond, when atmospheric CO_2 levels will reach 800-1000 μatm or higher. However, little attention has been focused thus far on the real ocean, where pCO_2 in the Pacific Northwest surface waters routinely exceeds 800-1000 μatm in the summer months. The larvae of many species in the natural environment, including the Pacific oyster larvae important to shellfish growers, are only present during this period. As a result, the sensitive life stages of these organisms are already being exposed to a high pCO_2 ocean. A primary goal of the collaborative research conducted through PCSGA is to inform the general public and legislative leaders, as well as underscoring the immediacy of acidification to growers throughout the Pacific Northwest.

Photo Credit: Peter Essick

Ultimately, any efforts to address the impacts of ocean acidification hinge on our ability to establish OA as an immediate concern to the general public. Although the concerns of the average citizen do not generally include seawater chemistry, they do include an interest in protecting life in the ocean, and the coastal communities whose survival is intimately linked to a healthy ocean. The collaboration between the shellfish industry and scientific researchers has helped establish a clear link between seawater chemistry and biology in oyster hatcheries, which for decades have been important to coastal communities in the northwest.

There is little question that collaboration between the public and private sectors in this area would be highly beneficial. If this is to happen, however, we have to: 1) develop effective means of highlighting the work that is being done; 2) clarify the sources of funding; and 3) develop detailed maps of the needs that lie ahead. In conclusion, we highly encourage the IWGOA to integrate foundations, NGOs and marine industries (fishing, aquaculture, cruise, etc.) into a plan for their respective agencies as they create a strategic program for working with ocean acidification.

4. International Collaboration

In recognition of the fact that ocean acidification is a global issue, the OATF thinks it is important that our federal agencies take leadership in coordinating with the international scientific community. Such international efforts could be targeted toward large scale topics such as the significant effect ocean acidification will have on the food web in the Southern Ocean. Work by McNeil and Matear (PNAS 2008) suggests that the Southern Ocean could become undersaturated with regard to aragonite by 2030, which is much sooner than the regions just north of the Polar Front. There are a number of US national agencies participating in Southern Ocean research including the Office of Polar Programs at the National Science Foundation, the US Antarctic Marine Living Resources Program (AMLR), in NMFS-NOAA and NASA. Further, a number of international organizations, with which the USA participates, coordinate research and resource management in the Southern Ocean such as the Scientific Committee on Antarctic Research (SCAR), and Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). SCAR is currently considering creation of a formal Working Group on Ocean Acidification. Significantly, the Australian Government has recently initiated scientific research cruises in the Antarctic on their icebreaker,

Aurora Australis, and is looking for scientific collaborators. They have also set up a coral reef research site on Heron Island in the Great Barrier Reef and are encouraging international participation.

Substantial international efforts are already underway (e.g., European Project on Ocean Acidification (EPOCA) and SOLAS-IMBER) that support the scientific research that is a key to understanding the evolution of open-ocean and coastal food webs. Indeed the EPOCA group has a number of mesocosms that are being applied to OA research and they are open to proposals from their US colleagues to carry out experiments. In fact, there is some funding to support US scientists who want to collaborate with them. In addition, EPOCA has initiated a public education campaign directed at helping citizens understand the daunting challenges and financial/societal consequences of OA. Given the challenges inherent in the public's perception/attitudes toward science in the United States, it might be helpful to build on the effort of our European colleagues some of whom have been accorded special recognition for scientific communication by the Royal Society of Chemistry. Significantly, a powerful and widely heralded animation – *The other CO_2 Problem* - resulted from a collaboration of EPOCA, Plymouth Marine Laboratory and students at the Ridgeway School in Plymouth, England. The production can be viewed at ***www.youtube.com/watch?v=55D8TGRs14k***. In short, building productive interfaces between US scientists and their international colleagues should become a long-term priority of the decadal plan the IWGOA is formulating.

5. Communication

The scientific community has had significant challenges building trust with the general public and policy makers regarding the societal challenges that will result from climate change. In the ocean health realm, the Pew Oceans Commission report had a similar muted public and policy response as well. At the root of these issues is the inability of the scientific community to effectively connect and communicate with the non-scientific community. Because of these challenges, the Ocean Acidification Task Force of ORRAP recommends federal agencies focus significant resources, including engaging foundations and other stake holders (federal/state agencies, industry and NGOs), to provide a robust and effective ocean acidification communications/social marketing effort. These efforts should be structured in ways that compliment the science, build capacity and expand research funding opportunities. The new initiatives should include feedback metrics to measure effectiveness. As previously stated, a centralized unit that would coordinate outreach and education efforts agency wide would facilitate getting the latest information out to the public with a consistent theme and or message. This should be one of the foci of a national program office.

Priority Communication/Social Marketing Recommendations include:

- Significant resources must be allocated to communicating the scientific and socio-economic findings to policy makers and the general public. This would be provided through a public/private relationship with foundations such as the Packard Foundation, Oak Foundation, and Moore Foundation, as well as major industry stakeholders such as the seafood/aquaculture industry.
- Social scientists (conservation and social psychologists), public relations professionals, educators, and researchers should integrate to determine communication and behavioral change strategies. NOAA's Human Dimensions Program can assist with the structure.
- Facilitate and engage stakeholders such as the aquaculture and sea food industry to help shape messages and assist with communications about OA to target audiences.
- Target audiences (both internal and external) must be identified to craft communications strategies for effective messaging.

- Develop and refine key messages and boilerplate copy and use them consistently and repeatedly to increase effective communications to key audiences. Public affairs offices of the key agencies such as NOAA, NMFS, USGS and USFWS must be integrated to provide a unified voice.
- Support education and outreach programs of NOAA, NMFS, USGS, and USFWS agencies to implement education and outreach about OA through their avenues as well as work in partnership with major communication/education outlets such as individual science centers, zoos and aquariums, the National Science Teachers Association, the National Marine Educators, and the National Association of Science Writers. to include messages about OA in their programs.
- Engage and encourage meteorologists and other trusted public spokespeople to provide climate and ocean science background to compliment weather information (i.e. last earth day Sam Champion of ABC News has provided short stories around ocean acidification that included the challenges within the Whiskey Creek Oyster Hatchery).
- Feedback metrics should be included to measure effectiveness and to adapt message strategies.
- Provide communications and informal education training for OA scientists. This would be especially important during graduate training in academia. Partnerships with local museums, zoos and aquariums can help facilitate this effort. "Portal to the Public" program may be one example.
- Target key scientific meetings to provide strategic OA presentations to a diverse group of scientific disciplines in order to "cross pollinate" information and stimulate discussion.
- Sciences, specifically marine sciences, need to be emphasized throughout the nation's K-12 school curriculums to build a more science-savvy population.

6. Science Needs

The NRC report highlighted nine key findings in support of a National Strategy, and identified multiple research and monitoring needs within that strategy:

Research:

- processes affecting acidification in coastal waters
- physiological mechanisms of biological responses
- potential for acclimation and adaptation
- response of individuals, populations, and communities
- ecosystem-level consequences
- interactive effects of multiple stressors
- implications for biogeochemical cycles
- socioeconomic impacts

Monitoring:

- adequate measurement of the seawater carbonate system and a range of biological parameters
- identifying and leveraging other long-term ocean monitoring programs by adding relevant chemical and biological measurements at existing and new sites
- adding additional time-series sites, repeat transects, and in situ sensors in key areas that are currently undersampled

Photo Credit: Dan Costa

- deploying and field testing new remote sensing and in situ technologies for observing ocean acidification and its impacts.
- supporting the development and application of new data analysis and modeling techniques for integrating satellite, ship-based, and in situ observations.

In addition to the above recommendations provided by the NRC report, the OATF offers the following recommendations for emphasis or additional detail.

A. Instrumentation

In situ measurements are one of the most important aspects of the research that scientists will need to address many aspects of ocean acidification. Development of instrumentation is a critically needed enabler for OA research. The OATF suggests that an instrument development program focused on measuring the carbon-system variables (e.g., pH, DIC, TA and pCO_2) be made a high priority. Such a program would address what has been a major shortcoming of scientific research on the oceans' carbon dioxide system for decades. Sensor development has been perennially underfunded and substantial investments on the order of tens of millions a year are needed to develop and then sustainably deploy dependable new sensing systems for physical, chemical and biological variables. Further, the OATF suggests that there should be a sustained investment in sensor system development and deployment that will address the need for new biological and biogeochemical metrics of ocean acidification impact, as they become available. We further recommend that the IWGOA **consider using NOPP as a way to focus critical financial resources on this project and also approaching DARPA or HSARPA as possible partners in sensor development and deployment**. Such a program will not only enhance research in the field and laboratory but long-term monitoring as well.

B. Ocean Acidification and Multiple Stressors

One important gap in the federal ocean acidification agency plans is insufficient emphasis on the combined impacts of ocean acidification and other stressors. This gap is specifically identified in the NRC report,

and the need to address this issue is becoming increasingly apparent, particularly in coastal regions that are subject to multiple natural and anthropogenic stresses. For instance, in many large estuaries with inputs of freshwater, sediments, organic matter, nutrients, and pollutants combined with restricted circulation, the combined impacts of lowered seawater pH and low oxygen concentrations may have a compounding impact on marine organisms. The natural and anthropogenic enrichment of nutrients may enhance the production and subsequent remineralization of organic matter leading to hypoxia and low pH waters. Upwelling regions, which bring deeper waters to the surface, are thus acidifying due to nutrient enrichment as well as from atmospheric input of CO_2 to produce very low pH conditions along some coastlines. Studies are needed to determine if it will be possible to mitigate the continued development and impacts of corrosive conditions by addressing and reducing regional-scale anthropogenic stressors, such as additional nutrient inputs associated with agriculture, development and urbanization (see section 7 of this document). Coastal oceans are also extremely complex and dynamic environments where hypoxia, warming and upwelling can compound the stresses related to ocean acidification. In consideration of this complexity, as well as the economic importance of coastal zones to marine fisheries, we emphasize the need to increase monitoring in coastal regions.

C. Ocean Acidification and Trophic Structure

Most research has focused on the effects of OA on organisms that rely on some form of carbonate skeleton (corals, pteropods, coccolithophores, forams, etc.). However, there is little information on how changes in the abundance or status of populations of these organisms will affect other components of the food chain. For example, while pteropods are known to be preyed upon by upper trophic levels, their relative importance as a prey item is not well understood. Therefore, we have little understanding of how the loss of pteropods as a prey resource will affect commercially important (fisheries) and protected species (turtles, seabirds and marine mammals). The role of coccolithophores in marine ecosystem interactions is even less clear. Finally, OA is likely to have direct effects on organisms that do not rely on carbonate skeletons. For example, small changes in pH could interfere with respiration and or ion exchange across the gills of many marine organisms. The complexity of the ecosystem responses to acidification of the upper ocean is immense and it will be a daunting task to not only document but to understand the evolution of ocean food webs and nutrient cycles. We need to make sure that an important **goal of our observational, experimental and modeling studies is to consider the entire oceanic food web and the biogeochemical cycles that support it**. This is critical for management of fisheries and other marine resources. As a first step, we need to fill the critical gap of monitoring not only the chemical changes of these regions but the biological changes as well. Without both aspects we will fail to understand how changes in ocean acidification, either alone or in combination with environmental stressors, will affect these resources.

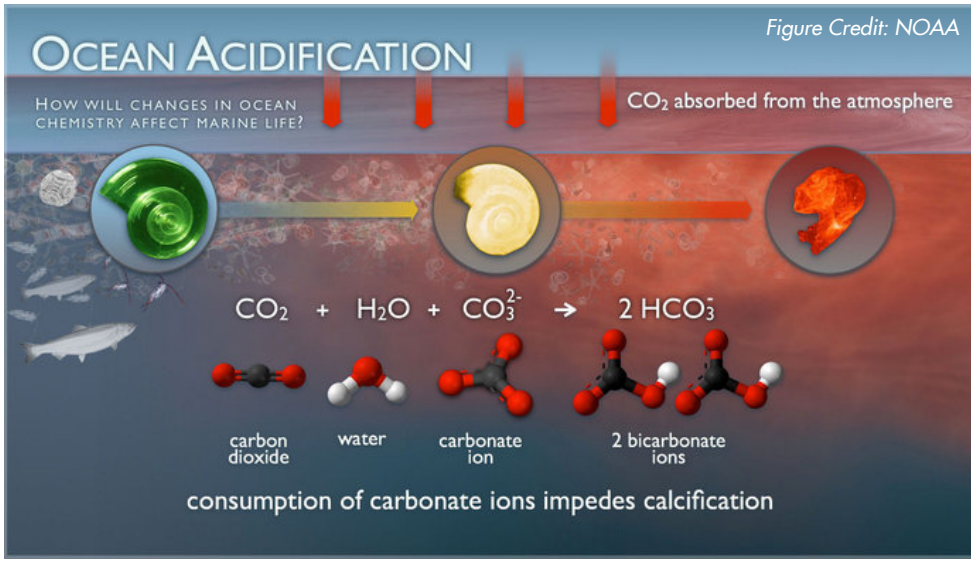

Figure Credit: NOAA

7. Management Actions and Multiple Stressors

Ocean acidification is occurring simultaneously with climate changes associated with rising atmospheric CO_2, such as ocean warming and increased stratification of surface waters, as well as stresses of overfishing and pollution. The combined effects of these multiple stressors on marine organisms and ecosystems will be difficult to assess, and research should be designed to look for broad patterns and unifying concepts, by not only taking advantage of experimental testing, but also modeling (from molecular to ecosystem scales), cross-site field comparisons of organism and ecosystem functioning, and genetic/molecular studies.

Management actions will naturally change over time. In the near-term, an obvious strategy for dealing with the effects of ocean acidification is to reduce those stressors that can be controlled, such as runoff that would further alter ocean chemistry, as well as stressors from overfishing, invasive species, and habitat destruction/degradation. Some management decisions may be simple but effective; for example, seasonal regulation of chemical runoff may prevent additional stress on shellfish larvae during times of recruitment.

Over longer time periods, management strategies will need to consider new findings regarding multiple stressors, determine which of these can be controlled, and which will need to be considered over the long term as habitats migrate in response to climate change and ocean acidification. For example, while rising temperatures may drive many species poleward, carbonate chemistry conditions most favorable to calcification are contracting equatorward. Such antagonistic changes present a real challenge to management, highlighting the need for research into the effects of multiple stressors on marine organisms and their habitats.

8. Socioeconomic Recommendations

The OATF advocates support of the social sciences (sociology, psychology, anthropology, economics, and political science) research to better assess the potential impacts (both threats and opportunities) of ocean acidification on lives and livelihoods. Research should encompass aspects to support prevention, mitigation and adaption. Research needs include, for example, assessments of the net benefits and possible losses associated with marine resources and ecosystem services that are sensitive to ocean acidification, including both market and non-market values. Specific areas of focus should include commercial and recreational fisheries, aquaculture, recreation, tourism, shoreline protection, ecosystem services, and cultural services as well as global and national security. Where possible, the agencies should engage a wide-range of stakeholder groups including national, state and local resource managers, business groups and NGOs in developing these socio-economic assessments. Strategies should be shared with international efforts. Research is also needed to better understand the response of coupled human-natural systems to ocean acidification, factoring in changing human behavior and choices under evolving environmental conditions. This work should be coordinated with research and modeling of other global influences such as ocean warming and growing food demand, considering the aggregate effects of multiple natural and human stressors.

The Federal agencies and the IWGOA involved in planning and implementing ocean acidification research (i.e., the IWGOA: Department of State, EPA, NASA, NOAA, USFWS, NSF, USGS and BOEMRE) should:

- Engage and support the social sciences to better assess the impacts of ocean acidification on lives and livelihoods. Several models, the NOAA Climate and Societal Interactions program (CSI), the US Global Change Research Program (USGCRP) *www.usgcrp.gov* (specifically the Unified Synthesis Product Global Climate Change in the United States), and the International Research Institute for Climate and Society, should be examined for pros and cons as well as best practices.

- Undertake careful risk assessments of ocean acidification to better evaluate how to form policy with regard to low-probability, high-impact events as well as high-probability, low-to-mid impacts. One approach would be to integrate OA research with ongoing work on decision-making under uncertainty for related environmental issues.
- Federal agencies should develop and assess adaptation strategies to minimize the socioeconomic impacts of ocean acidification examining both near and long-term time-horizons. Also needed are estimates of the value of new information for decision makers and the development of user-friendly tools for decision support with regards to ocean acidification.
- With the global nature of OA, federal agencies should engage in international efforts to examine socio-economic impacts in regards to global food supply and security.
- Explore using econometric approaches to gauging public concern for ocean acidification impacts (e.g. food security, contingent valuation of species extinctions, connection between livelihoods and deteriorating oceans, understanding of ecosystem services).
- Socioeconomic research should be adaptive and continual to reflect changes in information and socioeconomic dynamics.

9. National OA Data Management Plan

Timely access to quality observational and experimental data sets will play a vital role in accelerating our understanding of the trajectories and impacts of ocean acidification. To enhance important synthesis activities such as biogeochemical and ecological time-series, identifying the spatial distribution of OA risks, meta-analyses of OA impacts across taxonomic and functional groups, coupled models of ocean physics, biogeochemistry and food web change, the OATF recommends the development of a National OA Data Management Plan. Furthermore, OA data should be integrated into the eventual Integrated Ocean Observing System (IOOS) data management scheme.

Currently, datasets that inform OA research reside across a multitude of agencies and institutions at the state, regional, national, international levels or are held by individual researchers or research programs. As a result, datasets can vary greatly in quality (in terms of metadata documentation in particular) and accessibility. For researchers, the absence of a lead office for the deposition of OA-relevant datasets and/or uncertainties in the structural relationship between data centers in data replication and cross-linkage can slow the process of data submission. The core objectives of a National OA Data Management Plan will be to ensure the coordinated archiving and standardization of OA-relevant datasets and their effective dissemination to researchers. An additional objective will be to provide public transparency in the source and quality of data that are used to inform the policy decision process.

To meet these objectives, we concur with the recommendation set forth by the NRC report for the creation and support of a National OA Data Management Office that can serve as a single access point for OA data resources. While calls for investments in oceanographic data management are not new, OA is likely to pose new challenges for the current system of data management. For example, OA-relevant data encompasses not only traditional oceanographic measurements that are readily cataloged but also data from manipulative experiments, emerging genomic datasets, as well as socioeconomic data (e.g. fishery) that will be critical for informing OA science and policy. The OATF recognizes that these activities currently fall under the purview of a number of long-standing as well as nascent data management efforts and that the diversity of relevant datasets clearly precludes the use of any single database structure across

disciplines. In this regard, a core charge of a National OA Data Management Office will be to develop a mechanism for cataloging and cross-referencing OA-relevant data from a diversity of data sources including complementary international OA-data and metadata (e.g. SOLAS-IMBER, EPOCA) management and rescue efforts (e.g. EPOCA/EUR-OCEANS) that are already underway internationally. This mechanism can take the form of a metadata catalog that facilitates both data access and standardization. For example, entries in an OA metadata catalog will include not only water chemistry profile datasets held by data centers such as the National Oceanographic Data Center (NODC) but also microbial genomic data deposited and accessed through facilities such as the National Center for Biotechnology Information (NCBI) or Community Cyberinfrastructure for Advanced Microbial Ecology Research and Analysis (CAMERA). This approach would allow the National OA Data Management Office to make full use of existing community data standards as well as bio- and eco-informatics infrastructures. Our recommendation also does not preclude the development and/or use of data management capacity at the National OA Data Management Office. In fact, the ability to meet emerging data management needs from expanding areas of OA-research and/or to ensure long-term data archival and access will be important. We further recognize that the National OA Data Management Office does not necessarily require the de novo development of a data management organization. Expansion of an existing data center such as the Biological and Chemical Oceanography Data Management Office (BCO-DMO) may provide an effective means for leveraging ongoing data management expertise and to minimize time lags in implementing a data management plan.

As noted above, ocean research is diverse and by its nature is disparate in information content. Most of the data gathered from remote sensors, ship instrumentation, gliders, buoys, and field samples are captured and stored in adhoc formats, at physically separate locations and often hosted on computers not accessible from the internet. The OATF was impressed by the need to bring uniformity in data gathering and dissemination to the ocean research community. It is important to note that the Department of Defense (DoD) has funded research and development programs for the creation of open-standard, open-architecture "platforms" for data management. Specifically, data capture, data fusion, and the translation of data into information are important capabilities of such platforms, as is their application to virtually any data domain. One such approach uses a service-oriented architecture (SOA) platform that is based on non-proprietary, open standards. An SOA platform creates an open, independent "marketplace" that hosts services (software modules) for collecting, analyzing and disseminating both sensor and non-sensor data to ultimately provide meaningful information to scientists, resource managers and decision makers. An SOA platform also provides an opportunity for the scientific community to integrate heterogeneous data sets in a meaningful way which will encourage and enable holistic analysis rather than traditional independent "point" analysis. The OATF suggests that a focused program to transition and implement existing DoD data management capability for the benefit of the ocean research community **be considered** by the IWGOA. Leveraging DoD investments will also promote sharing of information, data standards, and scientific findings that are important to homeland security, our nation's defense and to ocean research while also providing a costeffective solution for ocean research data management.

10. Federal, regional, state and local interactions

Local, regional, and state governments can combat the causes of acidification in parallel with the federal government. Environmental laws currently in effect provide a network of pathways for intergovernmental cooperation and coordination. In the box below we list some of the environmental laws relevant for mitigating ocean acidification and the governmental interactions that these laws trigger.

Federal–State Interactions

At the most basic level, any laws useful for preventing acidifying substances – liquid, solid, or gas – from entering the ocean are potential tools for redressing ocean acidification. The broadest and most influential of these are federal environmental laws that regulate air and water pollutants; control the use, disposal, and cleanup of toxic and hazardous substances; and promote responsible environmental management through planning requirements. Many of these federal laws, such as the Clean Air Act, Clean Water Act and Coastal Zone Management Act, have state components, requiring state implementation and enshrining some level of vertical interaction between state and federal governments. The EPA is considering altering some policies to reflect the importance of limiting pH effects such as reiterating that states list pH impaired water bodies, revising the National Water Quality Standard for pH, and setting standards for a Total Maximum Daily Load of pollutants for pH impaired waters. In addition, the EPA is poised to give states the power to regulate CO_2 emissions from vehicles under the Clean Air Act. Similarly, state laws can require local implementation, and in some cases federal laws reach all the way down to the local level.

	Federal	**State**	**Regional/Local**
Federal	RCRA[i] CERCLA[ii] NEPA[iii]	Clean Air Act[iv] Clean Water Act[v] FIFRA[vi] CZMA[vii] NEPA Grants and Matching Funds[viii]	Clean Air Act - PSD Clean Water Act - TMDLs (FOARAM) NEPA ESA: HCPs, etc.
State		State Pollution Laws State Stormwater Mgmt. Laws Coastal Mgmt Laws, incl. erosion prevention Little NEPAs	State Pollution Laws State Stormwater Mgmt. Laws Coastal Mgmt Laws, including erosion prevention Little NEPAs
Regional/Local			Land Use Laws and Zoning provisions Habitat conservation and open- space ordinances.

Existing Governmental Interactions that Can Help Address Ocean Acidification Issues – It is crucial that local, regional, and state governments actively address the local causes of ocean acidification.

State–Local/Regional Interactions

To minimize the impacts of ocean acidification locally, it is imperative that state, local, and regional governments act to mitigate other (non-acidification) stressors on the coastal environment to ensure that synergistic stressors do not worsen acidification's effects. Further, local efforts could reduce or eliminate stressors that might not have any direct connection to ocean acidification, but removal of these stressors could increase the environments tolerance to stress in general, thereby providing a buffer to the direct effects of ocean acidification. States have authority under the Clean Water Act to establish designated uses

and criteria for physical, chemical and biological integrity, which can include limits on amount (load) of pollutants (e.g., sediment, contaminants, nutrients) that enter a water body. Some states, including California, have their own laws that parallel those at the federal level. For example, California's Water Code defines pollutants in such a way that it could include acidification agents. Water Code § 13376, definitions in § 13050. To the extent that this and other state statutes differ from the federal law, they should be used to minimize changes to coastal pH at the local level.

Controlling coastal erosion is a classic function of local and state governments, and one that could significantly aid coastal ecosystems. Controlling erosion within coastal watersheds can reduce nutrient and sediment loading into the nearshore marine environment as well as protect the physical integrity of the habitat itself. Concerted action among multiple local jurisdictions—as is likely necessary to address erosion across an entire coastline, for example—may require coordination among state or regional governments, but independent local actions may be effective at smaller scales.

Stormwater management, coastal runoff buffer zones, riparian buffers, robust wetlands, and improved onsite water treatment facilities can each help ease nonpoint source pollution and are often controlled at the state level, but they may require local measures. Many states have stormwater management programs; see, e.g., F.S. §§403.0891, 403.061(32) (Florida); Environment Article 4 §201.1 and §203 (Maryland). These local measures are key to minimizing runoff that can contribute to acidification.

State land use planning laws – such as California's SB375 – can help reduce the direct and indirect greenhouse gases that cause ocean acidification, and these require regional and local participation. Sprawl-inducing land-use plans—another function of municipal and county governments—increase vehicle-miles-traveled and impermeable surface cover, increasing both emissions and runoff. Zoning and other planning ordinances may seem remote from a change in ocean pH, but reducing sprawl reduces CO_2 very effectively, and open-space ordinances can create buffer zones that help stop runoff into the ocean.

Lastly, simply enforcing existing emissions limits for pollutants such as NOx and SOx would help ameliorate local contributions to global causes of ocean acidification. In some cases doing so would also have immediate local benefits because some pollutants, like SOx, have short atmospheric residence times.

Federal–Local Interactions

The Clean Water Act is implemented through state programs, and may require local-level stormwater management through the National Pollutant Discharge Elimination System (NPDES) provision. For example, New York's model local law for meeting state and federal guidelines, available at: *www.dec.ny.gov/docs/water_pdf/localaw06.pdf*.

The new Federal Ocean Acidification Research and Monitoring Act (FOARAM), 33 U.S.C. § 3701 et seq., requires the Joint Subcommittee on Ocean Science and Technology to "facilitate communication and outreach opportunities with nongovernmental organizations and members of the stakeholder community with interests in marine resources." 33 U.S.C. § 3703. Local governments and other interested parties should use these opportunities to participate in federal efforts to mitigate ocean acidification. The federal Endangered Species Act (ESA), 16 U.S.C. § 1531 et seq., may also play a local role in the form of Habitat Conservation Plans (HCP) for listed species, and by influencing local land use decisions to avoid harm to those species. Four marine invertebrate species are listed as endangered or threatened at present, and many more may warrant listing. As ocean acidification increasingly threatens marine invertebrates that secrete calcium carbonate shells, the ESA is bound to play a more prominent role in local measures to mitigate acidification.

Acronyms and Abbreviations

AMLR	Antarctic Marine Living Resources
BCO-DMO	Biological and Chemical Oceanography Data Management Office
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
CAMERA	Community Cyberinfrastructure for Advanced Microbial Ecology Research
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CERCLA.	Comprehensive Environmental Response, Compensation, and Liability Act
COP	Conference of the Parties
CSI	Climate and Societal Interactions
CWA.	Clean Water Act
CZMA	Coastal Zone Management Act
DARPA	Defense Advanced Research Projects Agency
DIC	Dissolved Inorganic Carbon
DoD	Department of Defense
EPA	Environmental Protection Agency
EPOCA	European Project on Ocean Acidification
EUR-OCEANS	European Network of Excellence for Ocean Ecosystems Analysis
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FOARAM	Federal Ocean Acidification Research and Monitoring Act
F.S.	Florida Senate
GLOBEC	Global Ocean Ecosystem Dynamics
HCP	Habitat Conservation Plan
HSARPA	Homeland Security Advanced Research Projects Agency
IOOS	Integrated Ocean Observing System
IWGOA	Interagency Working Group on Ocean Acidification
JGOFS	Joint Global Ocean Flux Study
JSOST	Joint Subcommittee on Science and Technology
NANOOS.	Northwest Association of Networked Ocean Observing Systems
NASA	National Aeronautics and Space Administration
NCBI.	National Center for Biotechnology Information
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOPP	National Oceanographic Partnership Program
NOx	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NSF	National Science Foundation
OA	Ocean Acidification
OATF	Ocean Acidification Task Force
OCB	Ocean Carbon Biogeochemistry
OOI	Ocean Observatories Initiative
ORRAP	Ocean Research and Resources Advisory Panel
pCO2	Partial Pressure of CO2
PCSGA	Pacific Coast Shellfish Growers Association
pH	Concentration of Hydrogen Ions
PNAS	Proceedings of the National Academy of Sciences
PSD	Prevention of Significant Deterioration
SCAR	Scientific Committee on Antarctic Research
RCRA	Resource Conservation and Recovery Act
SB	Senate Bill
SOA	Service-oriented Architecture
SOLAS-IMBER	Surface Ocean Lower Atmosphere Study-Integrated Marine Biogeochemistry and Ecosystem Research
SOx	Sulfer Oxides
SSC	Scientific Steering Committee
TA	Total Alkalinity
TMDL	Total Maximum Daily Load
µatm	Micro-atmospheres
U.S.C.	United States Code
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
USGCRP	US Global Change Research Program

Statement of Work

A. Official Designation

This Task Force will be designated as the Ocean Research and Resources Advisory Panel (ORRAP) Ocean Acidification Task Force (hereinafter referred to as the OATF).

B. Objectives and Scope of Activity

The OATF is convened by the ORRAP to facilitate a means for experts on the topic of ocean acidification to provide their input, views and expertise to ORRAP on issues relating to interagency federal ocean acidification activities.

The OATF shall provide preliminary advice and recommendations to the ORRAP on principles and issues relating to ocean acidification. It is intended that the advice and recommendations will be approved and delivered by the ORRAP to the federal government by way of the Interagency Working Group on Ocean Acidification (IWGOA) of the Joint Subcommittee on Ocean Science and Technology (JSOST).

Working with other allied groups and individuals, the OATF will work to enhance the coordination and implementation of ocean acidification efforts among academic, state, private, federal and other stakeholders.

C. Membership

Membership of the OATF shall be comprised of non-federal individuals that have expertise and/or experience in the field of ocean acidification. Membership shall not exceed the number of ORRAP members at any time. Service on the OATF is voluntary.

D. Workload

In accomplishing its work, it is expected that the OATF will meet in person twice, and no more than three times, over the course of its existence and will communicate between meetings via conference calls and emails. The objectives of the first meeting will include scoping and assignment of work. The objective of the final meeting will be to reach consensus on a final product for delivery to ORRAP. The ORRAP staff will assist the OATF in accomplishing its work.

E. Period of Existence

The OATF will be impaneled effective March 15, 2010, and will terminate effective March 31, 2011, with the option for an extension, if needed, to complete its work.

i *The Resource Conservation and Recovery Act regulates many highly acidic substances. See 40 C.F.R. § 261.40 et seq. Because the law does not have a significant state component, it is only listed under federal law.*

ii *The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9601 et seq., provides federal authority to respond to a release of substances that may endanger the environment. As low-pH substances can cause local acidification in the marine environment with potentially catastrophic results for marine life and habitat, state and local authorities should alert the National Response Center and request a remediation in the event of a local release.*

iii *The National Environmental Policy Act (NEPA), 42 U.S.C. § 4321 et seq., requires any major federal action, which may include state or local actions that use federal funds, to account for the environmental impacts of that action and to consider alternatives to it. Importantly, NEPA can have local and regional interactions via its public notice provisions. State-law equivalents ("little NEPAs") play a similar role and require interactions between state and local governments.*

iv *42 U.S.C. § 7401 et seq. Following the federal EPA's finding that CO_2 and other greenhouse gases threaten human health and welfare, states must evaluate their CO_2 emissions under the Clean Air Act's Prevention of Significant Deterioration provision. States should take steps to minimize their CO_2 (and other greenhouse gas) emissions before seeking federal approval for their plans.*

v *Under the Clean Water Act (CWA), 33 U.S.C. § 1251 et seq., states must prepare a list of impaired waters and Total Maximum Daily Loads. Most relevant to ocean acidification, TMDLs may be required for CO_2. States should ensure they have adequate monitoring to accurately identify which waters are impaired by pH.*

vi *Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 U.S.C. § 136 et seq., a state may regulate the sale or use of any federally registered pesticide" so long as it does not allow a sale or use prohibited federally. 7 U.S.C. § 136v(c)(1). If a coastal state is aware that a registered pesticide is contributing to acidification along coastal waters, it therefore has the authority to restrict the use of that pesticide.*

vii *Under the Coastal Zone Management Act (CZMA), 16 U.S.C. § 1451 et seq., states could declare pH to be a factor in maintaining the quality of significant coastal habitat. The states could then use the CZMA to influence local land use policies that negatively impact coastal ocean pH.*

viii *States should apply for available grants and matching funds under the Coastal Wetlands Planning, Protection and Restoration Act,16 U.S.C. 3951-3956, the CZMA,16 U.S.C. § 1455, and the Clean Water Act (see http://www.epa.gov/owm/cwfinance/ for program details). States should also leverage the National Coastal Monitoring Program (established by 33 U.S.C. §§ 2801-2805) data in order to monitor the pH of their coastal waters closely.*

National
Oceanographic
Partnership
Program