



# National Association of Marine Laboratories

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May 15, 2006

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The National Association of Marine Laboratories (NAML) is pleased to submit its comments to the National Science and Technology Council (NSTC) Joint Subcommittee on Ocean Science and Technology (JSOST) on the Ocean Research Priorities Plan (ORPP). We offer our baseline comments in this letter and more detailed section-by-section comments on the framework document in the attachment to this letter.

## **TREASURER**

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NAML commends the Administration and the JSOST for initiating this open and participatory policy development process and for recognizing the vital importance of the oceans, coasts, and Great Lakes to the overall health, security, economy and quality of life of the United States. NAML, a nonprofit organization of over 120 member institutions representing coastal, marine, and Great Lakes laboratories in every coastal state, believes that the oceans, coasts, and Great Lakes are inextricably linked to the health, safety and well-being of all living organisms, including humans. NAML believes that the JSOST has a unique opportunity to influence the continued development of U.S. ocean policy to more adequately support vital research, infrastructure, and education activities important to the ocean, coastal, and Great Lakes research and education community. The outcome of such activities promises to provide improvements in quality of life – as it relates to people and our social institutions as well as the natural environment in which society and our institutions operate.

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Though “ocean” is defined in the first endnote of the developing document as including “open ocean, coasts and estuaries, Great Lakes and coastal watersheds,” the term “ocean, coastal, and Great Lakes research and education in the natural and social sciences” should be explicitly used throughout the document. The inclusion of common language, such as “ocean, coastal, and Great Lakes,” would not only acknowledge the Great Lakes clearly as the Nation’s fourth coast and the millions of people who live, work and utilize this fourth coast, but it would more accurately reflect the scope, the scholarship and complex dimensions of this research endeavor.

## **WASHINGTON REPRESENTATIVE**

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NAML believes, as do many others in the community as demonstrated at the ORPP workshop in Denver last month, that the needs of the public and how advances in research

*The National Association of Marine Laboratories (NAML) is a nonprofit organization of over 120 member institutions representing coastal, marine, and Great Lakes laboratories in every coastal state, stretching from Guam to Bermuda and Alaska to Puerto Rico. Members serve as unique “windows on the sea,” providing information on the rich environmental mosaic of coastal habitats as well as offshore oceanic regions and the Great Lakes. NAML member laboratories conduct research and provide a variety of academic, education and public service programs to enable local and regional communities to better understand and manage the ocean, coastal and Great Lake environments. NAML is comprised of three regional associations: the Northeastern Association of Marine and Great Lakes Laboratories (NEAMGL); the Southern Association of Marine Laboratories (SAML); and the Western Association of Marine Laboratories (WAML).*

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and education can lead to improvements in human quality of life should be one of the key overarching themes throughout any ocean, coastal, and Great Lakes research priorities plan. It is essential that the final plan address this topic in detail and that it set real targets for success in the area of quality of life, which includes the integrity of both natural and built environments. This may or may not be accomplished through making quality of life a cross-cutting theme as opposed to a societal theme. Either way, quality of life, as one of the most important markers in the public valuation of science and of the ocean, should be carefully addressed, with improvements in the quality of life identified as a prominent outcome of the plan.

Basic and cutting-edge scientific discovery, driven by competitive, merit-based investigations should always be at the foundation of our research and education enterprise – for a variety of very important reasons. Our Nation’s ability to continue to successfully compete in today’s global marketplace is dependent on the strength and output of our science and engineering research and education enterprise. The Administration’s multi-year American Competitiveness Initiative (ACI) recognizes this with its stated intent to double the federal investment in the physical sciences over the next ten years. NAML strongly supports the ACI.

At the same time, NAML strongly supports extending the ACI to the full spectrum of the natural sciences. Enhanced support for cutting edge ocean, coastal, and Great Lakes research in the natural and social sciences, and its application to education, outreach, and related infrastructure will also greatly improve the Nation’s competitiveness in the global marketplace. These disciplines have much to offer the Nation as it seeks to strengthen its ability to innovate and compete in today’s global economy and provide a vehicle for applying and illustrating the real-world relevance of mathematics and technology. They are inherently interdisciplinary, push the envelope in terms of technology development, test the boundaries of our data collection and analysis systems, and offer an effective training ground for future scientists and engineers. As the Nation seeks to augment its investment in the physical sciences to increase its international competitiveness, NAML calls on the JSOST to promote the integrated nature of the marine sciences and send a clarion call for enhanced investment in these as well as other science and engineering disciplines as part of the ORPP and the Administration’s long term economic competitiveness policy.

As important as basic research is, translating research results and discoveries into practical applications must become a more integral part of the way the academic research community operates. NAML feels that a cultural change that recognizes and rewards these important contributions is needed throughout the scientific community. The translation of research and discovery to usable information for policy makers and local resource managers is crucial, and the ORPP process provides an important opportunity for encouraging and supporting this cultural change.

In addition to this need for cutting-edge discovery and effective translation and application is the need for “timely” research. Understanding the factors that lead to “regime shifts” or “tipping points” is important but often not sufficient. The ocean, coastal, and Great Lakes research community must develop an understanding of such processes before severe damage or irretrievable change has occurred. Therefore, some research needs must be placed on a more urgent or preemptive track in order to gain the ability to understand the factors that contribute to a tipping point before it is reached.

A key outcome of the Denver workshop was an emphasis on the integration of the natural and social sciences. Across all themes, it will be important that the report addresses the effects of human activities and resource use patterns on the oceans, coasts, and Great Lakes and vice versa. The only element of coastal ecosystems we substantially control is human behavior. Ecosystem-based approaches to management – an integral part of this public policy exercise – will fail if we do not include humans as part of the ecosystem, including their economic and sociological motivations. An understanding that all human and natural systems are complex, non-linear, dynamical, and adaptive and the need for basic and applied research on this larger aspect of “systems” across all themes and questions will improve the final plan.

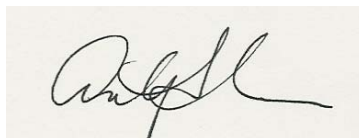
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The connection from what we study to the needs and activities of society must be front and center in any priority-setting plan. For that reason, NAML is pleased that the developing document includes throughout its societal themes discussions on education, outreach, the blend of basic science to decision-making, the nestling of scholarship in communities, and the need to reach out and engage the full strength and diversity of our society. Each aspect is complemented and strengthened by the others; this must continue to be encouraged and embedded in the final plan. In addition, the academic community should be utilized where ever possible, both for its own strengths and as effective partners, in educating the public, including policy makers. Further, competitive, peer-reviewed scholarship and education programs should be encouraged throughout the plan to ensure that decisions affecting the overall population are based on the most reliable science available.

Finally, NAML was pleased at the response at the Denver workshop to broaden the scope of infrastructure within the plan. For many of the most important discoveries and education activities, shore-based marine labs provide the needed infrastructure. In addition, marine labs have a unique capability, a capability that needs to be nourished, to connect to human needs and to communities through education and outreach, making them a particularly critical part of the ocean research and education infrastructure. Recognizing all types of infrastructure, including shore-based facilities, is crucial if the plan is to be truly comprehensive and effective.

On behalf of NAML, I would like to thank the Joint Subcommittee on Ocean Science and Technology for this opportunity to express our views and recommendations for the development of a comprehensive ocean, coastal, and Great Lakes research priorities plan. If you have any questions or would like to follow up in anyway regarding our comments please do not hesitate to contact me or NAML's Washington Representative Joel Widder (contact information is located in the left-hand margin on the first page). Thank you again, and we look forward to continuing to work with the Subcommittee as this research priorities plan develops.

Sincerely,

A handwritten signature in black ink on a light beige background. The signature is cursive and appears to read 'Anthony F. Michaels'.

Anthony F. Michaels  
President, National Association of Marine Laboratories  
Director, Wrigley Institute for Environmental Studies  
University of Southern California

Attachment



# National Association of Marine Laboratories

**Official Comment on the Ocean Research Priorities Plan Developing Document  
Submitted to the Joint Subcommittee on Ocean Science and Technology  
by the National Association of Marine Laboratories**

**May 15, 2006**

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## **GENERAL COMMENTS ON THE DOCUMENT**

- NAML supports the overall goal of identifying key science and education needs and setting priorities to guide the investments. Prioritization should be driven primarily by its impact on improving quality of life (including economy) and improving ecosystem health and integrity (equally). An essential consideration is how urgent the issue may be and how much of a return will occur for a defined investment.
- NAML feels that some of the overall issues embedded in the American Competitiveness Initiative (ACI) should be strongly reflected in this plan, particularly because the interdisciplinary training in ocean sciences and technology is a prime example of the skills needed by the future US workforce.
- The plan could be improved by engaging, in a comprehensive and thoughtful manner, the next generation of great advances in academic research - advances that will produce huge positive changes in the conduct of ocean, coastal, and Great Lakes research. These include:
  - genomics, proteomics and environmental genomics
  - robotics
  - nanotechnology
  - research in complex dynamical systems (living, engineered, physical)
  - advanced computational approaches
- The plan could be improved by changing its organizational structure. As the document currently stands, some topics are placed arbitrarily within certain themes while others are under-emphasized altogether. For example:
  - Fisheries management is placed in natural resources when one of the largest contributions to impacts on ecosystem health is the removal of fish, and the approaches to understanding it have more to do with ecosystem dynamics than extractive minerals and energy.
  - Aquaculture, the fastest growing source of new food production in the planet, is nearly absent except as it relates to negative impacts.
- Regional and geographic issues should be handled more comprehensively and carefully throughout the final report:
  - The Great Lakes are not handled evenly as a fourth coast.
  - Estuarine and coastal science is also under-emphasized compared to the definition of the word ocean.

- Common language such as, “ocean, coastal, and Great Lakes,” if inserted everywhere, would alleviate these inequities.
  - The document must also understand and reflect regional differences.
  - Essential to a number of “themes” (ecosystem health, natural hazards, etc.) is the need to understand the connection between coasts and the watershed. This issue is not currently dealt with in the draft document.
- 
- For many of the most important discoveries and education activities, marine labs provide key infrastructure. Marine labs should be explicitly mentioned where appropriate in the infrastructure sections as a valuable part of the nation's capability.
  - Overall, the plan seems to codify what is already being done in federal agencies rather than charting a course for the future. The final plan should act as a map for future research, science, discovery and policy development.
  - The plan could be improved by taking a more positive tone overall. Instead of focusing on mitigating problems, it should concentrate on the many ways in which research can create opportunities for individuals, companies, communities and the nation, including job creation and improvements to quality of life. In addition, JSOST should keep in mind that although the plan seeks to address “challenges,” these challenges do not necessarily mean “problems.” There is value in learning about the unknown, whose ultimate applications and significance often cannot be predicted. Any priorities plan should view these challenges as opportunities to further ocean, coastal, and Great Lakes knowledge and advance discovery of the unknown.
  - The document should mention U.S. maritime heritage. Significant research, exploration, and monitoring is needed to better understand our nation’s maritime history.

## **SOCIETAL THEMES**

### **I. ENHANCING HUMAN HEALTH**

#### **a. General Comments:**

- The balance between health benefits and health risks is narrowly targeted on known health risks.
- Positive health effects of seafood should be a major area of research (benefits of seafood consumption far outweigh the negative effects of most contaminants in the seafood).
- All health research should include behavioral, economic and other social science contributions.
- The drug and health discovery section understates the enormous opportunities gained from genomics. For example, using environmental genomics in common ecosystems, like open ocean planktonic systems, presents vast opportunities that must be exploited.
- NAML applauds the emphasis on HAB and pathogens and the recognition that there is a need for rapid detection of harmful compounds and a need to have similar detection capability for the organisms themselves.
- The plan should address the need to develop an understanding of planktonic systems as complex adaptive systems to predict the future outbreaks of HABs and fates of other pathogens.
- Freshwater systems (Great Lakes and estuaries) play a special human-health role as they affect human drinking water supplies.
- It is absolutely critical to do real epidemiology of human health issues, both positive and negative, to get away from the anecdotal and to build efficient programs and policies to improve health based on these data.

#### **b. Challenges:**

- Page 10, line 23 – “Expanding monitoring and assessment of pathogens, HABs, and contaminants.”
  - This speaks to the need for enhancing monitoring and assessment of a number of health related factors. However, the integration of these monitoring efforts with environmental/observational monitoring of other parameters, such as oceanographic and meteorological measurements, also needs to be enhanced. This will require data management development to accommodate the diverse range of physical, biological, and chemical factors that are relevant to the broad range of phenomena.

**c. Research Needs:**

- The importance of genetic and proteomic techniques for understanding/producing bioactive compound production could be emphasized.
- Research on the positive health impacts of seafood and interaction with the ocean should be conducted.
- Human health impacts should be studied quantitatively through epidemiological and other modern medical approaches.

**d. Infrastructural and Technological Needs:**

- This section speaks to the importance of coordinating federal and state data systems. This effort will also require the development of standards as well as integration with the monitoring and research capacities of IOOS and OOI.
- The last part of the section supports coupling to shore-based labs. This should be emphasized since the obvious benefits of marine labs include proximity to sampling sources and the capability to quickly deal with perishable organisms and systems.

## **II. IMPROVING ECOSYSTEM HEALTH**

### **a. General Comments:**

- The land-water interface is an important area for focus in order to better characterize ecosystem health. These margins are critical modifiers of biological, environmental, and physical processes which influence and modify coastal ecosystems.
- This margin is also the main conduit for anthropogenic influence on marine ecosystems. Efforts should focus first on understanding the role of this interface.
- More effort is needed in developing and implementing sensors for key properties in shallow systems.
- NAML strongly supports the intent for examination of cumulative effects, not just single stressors.
- There needs to be an increase on the emphasis of the connection between ecosystem health and human health throughout this document.
- “Energy” should be included within the definition of "goods and services," since it can include oil deposits, methane hydrates, wind farms, waves, etc.
- Ecosystem health is so fundamentally impacted by extractive uses, like fisheries, that these need to be included in this section as well.

### **b. Challenges:**

- Add: "Understand the relationship among the pelagic ocean, coastal regions, and the watershed."
- Add: “Understand ecosystems as complex dynamical systems and develop a capability to predict their future state.”

### **c. Infrastructural and Technological Needs:**

- Improved shore-based facilities and infrastructure will be a critical component for all the studies conducted under this theme.



### III. SUSTAINING NATURAL RESOURCES

#### a. General Comments:

- Essentially, this section takes the view that sustaining natural resources will be accomplished by better models, better assessments, greater technology, better environmental data, an ocean observation system, and vague references to risk management. While these are important, investment in science and technology alone will not be sufficient in sustaining vital resources.
- This section should address crises facing many of our marine fisheries, the ecosystems in which they reside, and/or an acknowledgement of the root causes for their decline.
- Sustaining natural resources is not only about managing the resource; it's about managing people, now the top predator in virtually all ocean ecosystems. The only element of coastal ecosystems we can control is human behavior. Ecosystem-based approaches to management will fail if we do not include humans as part of the ecosystem, including their economic and sociological motivations. This section should address the roles of economics, sociology, and political science in developing plans for sustainable use of living resources.
- The mining of non-living, non-renewable resources should not be lumped in with exploitation of living resources in this section. Doing so may inadvertently portray a lack of understanding of the real issues that confront the development of ecosystem-based sustainable practices.
- Aquaculture should be adequately addressed in this section, given that (1) there is legislation pending that would permit major offshore aquaculture operations on the continental shelves, (2) aquaculture is now approaching half of the seafood supply, and (3) it represents a significant component of the U.S. trade imbalance.
- NAML facilities are part of the social fabric of the communities in which they are embedded. NAML institutions are uniquely positioned to understand both the ecological and social impacts of changes in resource abundance and to communicate with stakeholders, the public, and policy makers about the need for changes in societal impacts on ecosystems.
- The human dimensions of “sustainability science” cannot be overlooked in the oceans anymore than they can on land or in the atmosphere. NAML can play an important role in this arena.

## **IV. PROMOTING MARINE OPERATIONS**

### **a. General Comments:**

- Improvements to maritime efficiency and safety through improvements to routing, search and rescue, sea state prediction, sea level, etc. will lower transportation costs and expand trade, among other things.

### **Air Pollution**

- As ship operations become concentrated in load centers around the world, we need improved methods of reducing ship-generated pollutants (NO<sub>x</sub>, CO, SO<sub>x</sub> and particulates); these load center ports absorb a disproportionate air pollution burden.
- The political nature of this problem is that the U.S. and other major trading nations have considerable clout in the International Maritime Organization (IMO) in London, the body that sets air emission standards worldwide for the shipping fleet. Those standards need to be strengthened by the IMO for carriers to significantly improve their emissions.
- Another effect of load centering is that these same seaports absorb a disproportionate burden of traffic congestion (and therefore, air pollution) as marine freight movement is concentrated in fewer, larger seaports. Ocean research in this respect intersects with terrestrial transportation research funded by the U.S. Department of Transportation and those connections need to be made stronger.

### **Dredging & Dredge Material Disposal**

- There is a national crisis for seaports as they struggle to find methods of disposing of contaminated sediments created by both construction and maintenance dredging. U.S. policies for disposal place the financial burden for landside disposal on local governments, many of whom cannot afford the high cost of remediation techniques. There is a crying need for low-cost remediation technologies as well as a need to consider deep-ocean disposal of these materials.

### **Integration of Seaport Planning into Coastal Management**

- Many U.S. states give only lip service to integrating seaport plans into their coastal management regimes. Additional emphasis should be placed on having states develop comprehensive seaport plans and then in integrating those plans into their coastal management regimes.

### **Abatement of Invasive Species in Vessel Ballast Water**

- Regional ballast water abatement schemes are needed for coastwise traffic (traffic that does not sail sufficiently offshore to exchange ballast water according to federal standards). Moreover, close-in (closer than 200 nm offshore) areas need to be identified where it is safe to exchange ballast water and those areas need to be identified on U.S. navigation charts.

### **Abatement of Invasive Species in Cruise Ships**

- Because of frequent port calls and coastal routes, cruise ships pose a particularly nettlesome problem for ballast water exchange. The industry needs a technique that will allow these vessels to bunker in port and yet abate the invasive species contained within their ballast tanks.

### **Create Centralized Clearinghouse for Maritime Transportation Research**

- The Transportation Research Board and the Marine Board of the National Academy of Sciences currently are the leaders in promoting marine transportation research. Their role should be strengthened but also better linked to the larger marine research community. Issues that are apparently obvious to the marine science community often have unforeseen consequences on the marine transportation community and vice-versa. There needs to be better communication between researchers working different sides of similar problems.

### **Short-sea Shipping – Port Issues**

- There are a multitude of opportunities and problems posed by the use of greater numbers of smaller freight handling vessels serving small seaports and linking them to the constellation of load center ports around the world. This is a movement that is gaining traction and additional research is needed to address issues of distribution of invasive species, navigation hazards from increased ship traffic, pollution from undercapitalized operators, new and innovative propulsion technologies, new and efficient vessel design and port and harbor design to accommodate these vessels.

### **Short-sea Shipping – Landside Issues**

- Short-sea shipping may also have a landside component where cargo is quickly moved from load centers to inland destinations for sorting and routing to distant consignees. Additional research is called for in this area to discern whether these techniques are effective at ameliorating the impacts on load center ports.

### **Railroads**

- A robust rail network can ameliorate some of the impacts of a heavy marine freight burden on coastal cities that are major ports entry. How much of an infrastructure investment would be required to upgrade existing rail routes to accommodate full double-stacked container service at high speeds? What is the role of the federal government in facilitating these new or expanded rail links? A number of major U.S. coastal ports are already burdened by inadequate rail links. If marine freight is expected to double by 2020, then this is a critical issue for freight movement in the country.

## **V. THE OCEAN'S ROLE IN CLIMATE VARIABILITY AND CHANGE**

- This section is comprehensive and consistent with the Climate Change Science Program that has been vetted by the academic and federal research community.

### **Key regions:**

- Coastal/continental margins should be highlighted as a key location where present uncertainty is preventing further improvements in estimates of oceanic CO<sub>2</sub> uptake and prediction of future atmospheric CO<sub>2</sub> levels and climate.

### **Processes and research needs:**

The following should be emphasized:

- Advancing the analysis of the paleoceanographic record. Without an improved record, predicted change cannot be placed in a temporal context.
- Acidification of the surface ocean and potential impact on species composition.
- Sea water - pore water exchange and interactions with CaCO<sub>3</sub> minerals which represents the long-term capture capacity of the ocean through neutralization of anthropogenic CO<sub>2</sub>.
- Possible destabilization of hydrates along continental margins.

## VI. MITIGATING EFFECTS OF NATURAL HAZARDS

### a. Challenges:

- Add: “Develop mechanisms for application of improved understanding and predictive power to social planning.”
- Understanding coastal hazards as a way to improve zoning and building codes which will save all communities money.

### b. Research Needs:

- Add: “Need improved predictive models, e.g. for storm intensity and inundation.”
- Add: “Develop research rapid response systems to capture perishable data immediately after extreme events; at a time when local researchers may be focused on personal ‘survival.’”
- Page 33, lines 24-27 – *“Develop an all-hazards information resource...”*
  - Add: “Requires investments in information management with defined standards and improved (high resolution/accurate) topographic and bathymetric data.”
- Page 33, lines 28-33 – *“Enhance hazard understanding...”*
  - Add: “Assessment, modeling, and prediction of coastal processes also require improved understanding of the connectivity of the coastal zone with the upland watershed and rivers.”

### c. Infrastructural and Technological Needs:

- Add: “Improvements in data quality, frequency, and density of marine and coastal observations.”
- Add: “Coastal laboratories are well positioned to house/oversee such monitoring and assessment activities, but they need to be structurally reinforced and prepared to withstand the severe stress of a catastrophic event to the extent possible. Marine laboratories provide a mechanism for mutual back-up, redundancy, and assistance, and protocols for mutual assistance should be developed and implemented in advance.”
- Add: “Need full integration of federal agency observations and regional system contributions through information management processes and software.”

### d. Expected Results:

- Page 35, lines 1-3 – *“Risk and vulnerability assessments will be based on coordinated federal efforts to develop and maintain the necessary geospatial framework and characterization of social and environmental conditions and change.”*
  - Though this statement is focused on coordinated federal efforts, it needs to include state and research institution input and participation as well.

## **VII. IMPROVING QUALITY OF LIFE**

### **a. General Comments:**

- Quality of life is one of the most important characteristics in the public valuation of science and of the ocean; improvements in the quality of life must be identified as one of the most prominent goals/outcomes of the plan.
- Every section of the plan should have quantitative outcomes that are determined by the effect on quality of life. These should be listed in the expected results section as targets, not platitudes.
- Challenges are currently listed as mostly mitigation of problems. Though these are real, this focus does not take into account the large number of positive improvements that are also possible in building better coastal communities, improving coastal economies and connecting the benefits of the ocean to the whole nation, both coastal and inland.
- Infrastructure needs indicate a focus on data correlation; human systems and natural systems are non-linear, complex systems and require fundamentally different approaches.
- Marine labs are a key infrastructure for conducting this research, for training both scholars and citizens and for connecting this scholarship to community needs.
- Quality of life can be enhanced by linking with our past, and promoting the human element of the oceans, coasts, and Great Lakes.

## CROSS-CUTTING THEMES

### I. ENHANCING OUR BASIC UNDERSTANDING OF THE OCEAN

#### a. General comments

- This section should take a global perspective and stress the U.S. role as a partner and leader within the global research community.

#### b. Introduction:

- The questions on page 39, lines 22-27 are very similar – all dealing with understanding change. More fundamental issues should be addressed:
  - Understanding the 3-dimensional linkages of the ocean systems – i.e. physical with the biological
  - Understanding the stability of the oceans
  - Understanding the response to stochastic/catastrophic events
- Page 39, lines 28-30 – *“Marine ecosystem dynamics, the physical complexity of the ocean environment, and biogeochemical processes occurring at boundaries are key to understanding living marine resources.”*

There is much more to understanding living marine resources than physical complexity and biogeochemical processes at boundaries:

- Role of ecological processes, particularly at large scales (i.e. macroecology) and the dynamics of ecological systems as complex, non-linear, multi-scale and adaptive.
- Role of biodiversity in communities – productivity, resilience etc.

#### c. Exploration:

- Add: “Exploration is also important for understanding the diversity, nature, and extremes of life on the planet, particularly those in deep oceans and highly productive areas, such as corals (reefs and deep corals), hydrothermal vents and methane seeps.”
- Page 40, lines 6-10 – *“At the opposite end of the spatial spectrum, measurements from remote-sensing platforms, including satellites and aircraft, are needed to enhance in situ data and provide a more comprehensive view of global and regional changes in the ocean environment, particularly in areas where in situ data are limited or unavailable.”*
  - Need to be able to link the fine scale in situ processes to the larger spatial scales as well.
- Page 40, lines 11-16 – *“Exploration can also focus on different temporal scales. Sustained time-series observations (including the ability to observe on extremely short and long time scales) are essential for understanding temporal trends in the ocean. For example, repeat measurements of physical processes over several decades in the Atlantic Ocean revealed a*

*decade scale variation in North Atlantic circulation, the North Atlantic Oscillation, which has explained various relationships that had perplexed oceanographers.”*

- Need to be able to link biological responses and trends to the longer temporal scale fluctuations.

**d. New Tools:**

- Page 40, lines 21-29
  - Need to capitalize on information technologies, greater computing power, and improved data transmission technologies/modalities.
  - Adaptive and smart sensor development based upon key variable thresholds is needed.



## II. RESEARCH SUPPORT THROUGH OCEAN OBSERVATIONS AND INFRASTRUCTURE

### a. New and Existing Platforms:

- Page 42, lines 18-24 – The necessity of land-based marine labs is acknowledged.
  - Add: “The coastal and marine laboratories can meet this need, and connectivity enhancements (optic fiber, satellite receivers) need to be in place.”

### b. Data and Model Developments:

- Page 42, lines 29-30 – *“Questions about how the ocean will react to conditions in the future or about the oceans of the past cannot be answered by observation.”*
  - Add: “They do require, however, long-term databases, and these need to be supported through older database restoration, metadata documentation, standards development, and archival procedures and infrastructure. The nation's marine and coastal laboratories are a major resource for long-term databases.”

### c. Observations/Technology Needs:

- Page 43, lines 14-15 – *“deploying enhanced sensor packages that are more precise and accurate, are automated, and require less maintenance...”*
  - This addresses the need for sensors that are more precise and accurate; however, they also need to be more robust.
  - We will also need expanded/cost effective ship support for instrumentation/platform deployment and maintenance as IOOS and OOI are implemented.
  - Also, we’ll need cost effective communications support, e.g. access to satellite telemetry.
- Page 43, lines 24-25 – *“advancing necessary aspects of observing data management, including data assimilation, distribution, and archiving...”*
  - This addresses some data management needs; this should include quality control/assessment and standards development.
- Add: “Increased interaction and collaboration among physical oceanographers and modelers and biological scientists, including not only biological and chemical oceanographers, but also resource (e.g. fisheries) assessors, social scientists, molecular scientists, and physiological, evolutionary, and behavioral biologists.”

### III. OCEAN EDUCATION

#### a. General Comments:

- The linkage between research and education/outreach makes ocean, coastal and Great Lakes education and outreach programs more exciting and memorable (enhances retention of the information) and more applicable to real-world problems; but it also greatly increases the value and impact of the research and the likelihood that research results will be rapidly put to use to improve management, quality of life, and economic competitiveness. The education section of the report should reflect these points.
- In addition to the educational programs outlined in the plan, emphasis should be placed on ensuring strong federal programs and financial support for graduate education in a variety of federal agencies and in fields important to ocean, coastal and Great Lakes research efforts. The research programs that will be developed through this overall plan will require an enlarged, and highly trained, workforce. Additional emphasis on graduate education will help to provide the skills and individuals that will be necessary in coming years.

#### b. General Comments: Diversity in Ocean, Coastal, and Great Lakes Research

- The education crosscut should be expanded to include a discussion on diversity in the context of the ocean, coastal, and Great Lakes workforce. In view of the rapidly changing demography of the U.S. and persistently low diversity of the ocean science workforce, efforts are needed to expand opportunities to groups currently underrepresented in ocean sciences.
- Greater coordination of education efforts, a holistic or at least inclusive view of education from informal to post-doctoral, and looking to what has worked for less diffusely organized enterprises such as human health for guidance, especially with respect to programs designed to increase representation from underrepresented groups are other important notions that rise from these policy documents.
- Field courses and field research experiences offered at field stations and marine laboratories are often life-changing for many students because they provide a highly focused venue for actually doing science, and for experiencing inquiry-based learning.

*For questions or comments about the views and recommendations expressed in this document, please contact:*

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