CORE Responses to Questions from the U.S. Commission on Ocean Policy

February 12, 2002

1. *There are obviously a number of complicated issues that the Commission will have to grapple with where the basic scientific underpinnings are not yet understood. What is the best mechanism for the academic community to become engaged in science to understand specific problems in the oceans?*

   Since the end of World War II and the adoption of Vannevar Bush's model of public support for basic research, the academic community has been the leader in understanding problems related to the oceans. Providing public funding for competitively selected, peer-reviewed investigation ensures that high quality, pioneering science is the final product. The innovation inherent to the structure of academia has provided the primary source of knowledge of the oceans for several decades. The very best Ph.D. graduate student in oceanography in 1950, drawing upon the understanding of the oceans at that time, would not last five minutes in an oral exam today – fifty years ago, many characteristics and causes of ocean circulation were unknown. During the same period, plate tectonics was discovered almost solely as a result of investigations confined to the oceans.

   The key, of course, is to strengthen the basic research components of agency budgets. While we have explored the oceans for two centuries using oceanographic vessels, modern problems require the observation of oceanographic phenomena for extended periods. The role of ships in oceanography is secure; however, growing numbers of problems require time-series observations. This scientific requirement necessitates a commitment at least as large as the one we have made and continue to make to the expeditionary approach. The current investment in UNOLS is at least $500 million and an additional $50 million is required each year for maintenance. A comparable level of investment is needed for an integrated ocean observing system that provides for long-term observations on a global basis for scientific purposes.

   No single government agency will be able to support modern oceanography unilaterally. A means for integrating agency contributions to ocean research that bridges agency missions and Congressional committee responsibilities must be found. The National Oceanographic Partnership Program (NOPP) is one model, but there must be an incentive for agency contributions to the program – this is the biggest problem facing the program today. The insurance of improved and sustained partnerships is an issue worthy of attention by the Ocean Policy Commission. The health of research in the oceans and the implementation of a coherent approach to operational oceanography depend upon a solution.

2. *What has been the federal agency contribution to the National Oceanographic Partnership Program (by agency) and to Ocean.US (by agency)?*

   Since its inception in FY 1997 until FY 2001 (the current fiscal year 2002 is still underway), the NOPP received more than $90 million in designated federal funding. Of that amount, almost $11 million was managed on behalf of NOAA for the Argo float project. The following table provides funding profiles by fiscal year:

NOPP Funding ($m)	*FY 1997*	*FY 1998*	*FY 1999*	*FY 2000*	*FY 2001*
U.S. Navy – direct	$13.00	$17.00	$10.00	$10.00	$10.00
NSF			$5.5	$2.00	$5.00
NASA				$2.00	$2.00
NOAA - direct			$2.00	$4.00	
NOAA – managed					$7.5
Total	$13.00	$17.00	$17.50	$18.00	$24.50

Funding for Ocean.US comes from direct contributions provided by members of the interagency NOPP governing body, the National Ocean Research Leadership Council (NORLC). NORLC members also contribute personnel to Ocean.US and bear the costs for the salaries, travel and benefits of those personnel. Finally, major Ocean.US events, such as workshops, are supported by federal contributions on a case-by-case basis. The direct funding for Ocean.US in FY 2002 is provided below.

Agency	*Amount ($ in thousands)*
Navy	$ 75
NOAA	$ 75
NSF	$ 75
NASA	$ 75
MMS	$ 10
USGS	$ 10
Total Annually	$320

Given the large number of federal agencies that fund ocean research and that could benefit from an integrated ocean observing system, NOPP and Ocean.US are important mechanisms to ensure that federal activities are effectively coordinated and interagency partnerships encouraged. For this reason, CORE members believe that the NORLC members should increase substantially their support for both NOPP and an operational entity, such as Ocean.US.

3. *How can the U.S. become a leader in ocean management and stewardship? Neither industry nor NGOs have been part of any of the major oceanographic initiatives of the past 20 years. Could key ocean-related NGOs as well as key industries be invited to participate in science advisory panels to the NSF, NASA, USGS, and ONR? Can they be better integrated with our science funding and proposal selection process?*

First, it is important to recognize that the United States has long been a global leader in ocean science and management. Not only has U.S. ocean science been paramount, but U.S. scientists have led diverse international ocean science programs ranging from ocean drilling to global change research to ocean observation systems. In many areas, U.S. approaches to ocean management and stewardship have served as global models, particularly with regard to the use of science in integrated coastal management[1]. This noted, CORE believes that maintaining and strengthening the world leadership of U.S. ocean science and improving the effective application of science in ocean management and stewardship are essential elements of future U.S. ocean policy.

As the National Research Council's 1992 report *Oceanography in the Next Decade*[2] points out, one way to strengthen U.S. leadership is to build new partnerships with governmental, commercial and nongovernmental institutions. Advancing the agenda laid out in this report has been a central objective

[1] von Bodungen, B., and R.K. Turner. 2001. *Science and Integrated Coastal Management*. Dahlem University Press, Berlin.
[2] National Research Council. 1992. Oceanography in the Next Decade. National Academy Press, Washington, DC.

for CORE since it was established. As a result, NOPP was created to engage the nation's ocean scientists, federal and state agencies and the private sector in new partnership arrangements for ocean science. In addition to the NORLC, the NOPP legislation created the Ocean Research Advisory Panel (ORAP) comprised of representatives from various sectors of the broader ocean community. One of the recommendations from the ORAP, which currently is in the initial stages, is the development of an integrated and sustained ocean and coastal observing system.

As indicated above, CORE views NOPP as successful but under-subscribed by federal agencies. Adaptation and expansion of the NOPP model could be an effective mechanism for catalyzing additional involvement of industry and other nongovernmental organizations (NGOs) in U.S. ocean science. Similarly, an ocean and coastal observing system could engage and serve the needs of both industry (e.g. in shipping and offshore energy industries) and other NGOs (in environmental monitoring and education).

In addition to the ORAP, representatives of industry and NGOs have served on the science advisory panels of many agencies and on boards and committees of the National Research Council. Their participation has been responsible for numerous ocean science initiatives. In CORE's experience, greater representation of ocean constituencies contributes to the partnership approach and should be encouraged. As the organization representing the vast majority of ocean research and educational institutions in the United States, CORE stands ready to facilitate communication and consensus building among all sectors on national ocean science priorities. Strengthening the scientific basis for effective stewardship of ocean resources should be one of the focal points of these efforts.

However, while there is value in greater industry and NGO involvement in setting science priorities and judging its policy relevance, scientific rigor as judged by peer review must remain a requisite for funding specific proposals. It is CORE's view that the credibility of scientific research must be maintained and that is best achieved by reducing and eliminating bias, including the perception of bias, in selecting avenues for scientific exploration.

4. *Technical infrastructure:*
   How do we ensure that the U.S. has a robust and innovative technical infrastructure?

From the late 1960s to the mid 1980s, the federal investment in basic research for the ocean sciences comprised seven percent of the federal basic research budget. It was during this time that the ocean sciences community developed the knowledge base and modeling skills that allowed us to do such things as:

- predict the El Nino Southern Oscillation allowing communities to prepare for its sometimes devastating effects on regional climates and fisheries;
- plan, predict and warn of coastal hazards such as hurricanes and tsunamis;
- develop the science and research tools to manage the commercial and recreational fishing industries, including development of the aquaculture industry; and
- improve understanding of the chemical, physical, biological and geological properties of the ocean, allowing us to maintain and enhance our national superiority in undersea surveillance and antisubmarine warfare.

The ocean sciences community relies extensively on its research platforms. The most successful research requires access to modern surface ships, manned submersibles, autonomous underwater vehicles (AUVs), scientific buoys and research satellites. In addition, we must be poised to take advantage of new technologies in computing, fiberoptics and nanotechnology, capitalizing on the tremendous progress made in the last decade in the area of predictive modeling of ocean and climate interactions.

Unfortunately, U.S. funding for basic research in ocean sciences has remained stagnant for nearly two decades, effectively halving its buying power. At the same time, the total federal support of basic research has nearly doubled. Thus, we are faced today with growing problems requiring increased understanding of the earth's oceans but without sufficient resources to address them. Globally, there is an increased awareness of the importance of the world's oceans and coasts, principally driven by a broad international concern for the global environment and possible changes to it. All these changes are inextricably interrelated. The totality and rate of these changes present us with formidable challenges. Ocean issues are clearly a major concern of domestic and international interests. Society's increasing demands on the sea and the growing awareness of human impact on the environment have combined to place ocean sciences at the forefront of scientific and social research.

Government agencies must restore the ocean sciences portion of the federal basic research budget to its historic level of 7 percent. The remarkable fundamental discoveries about the natural world have opened the way for an even more exciting and productive future. We need to adopt newly available technologies in high-speed, large-bandwidth communications that allow researchers to receive data in real time, all the time. New advances in energy delivery to underwater locations are available to power AUVs and sea floor observatories using state-of-the-art chemical, physical and biological sensor technology, providing significantly increased resolution of data on ocean processes. Developing and applying these new technologies to the ocean sciences are essential to deepening our understanding of the ocean and its processes so that effective solutions are available to policymakers facing such problems as global climate change and loss of marine diversity.

Finally, we must not overlook a central key component to developing and maintaining our technical infrastructure - a cadre of trained professionals and capable students working in the field, in our schools and for government and industry. Recognizing the interdisciplinary and interrelated nature of marine activities, we must develop partnerships allowing the exchange of personnel between academic, industry and government. Current mechanisms, such as the Intergovernmental Personnel Act, need to be made more efficient and readily available. Those partnerships already existing must be extended within the K-16 education system so that ocean sciences are a part of the science curriculum.

5. *Another dimension of the technical infrastructure issue is that while ships are in some sense national assets, many other experimental capabilities are not, and we have no straightforward way to canonize such assets: we need one, as well as a support infrastructure to sustain such national capabilities. What policies need to be changed or created to change this?*

In responding to the need for a mechanism to "canonize" seagoing and sea-deployed assets as a national capability, the first step is to clarify the intended meaning of that term. On one hand, a mechanism that involves central control by a hierarchical administrative system to optimize operational efficiency is likely to look good initially but ultimately present problems for the conduct of research. On the other hand, a mechanism to canonize ocean research assets that provides for their identification and support as well as easy access by investigators at academic institutions would make a substantial contribution to national research capabilities. Three issues should be considered in developing an optimal solution. What made us world-class initially? Where is the field of oceanography going? And, how do we ensure world class leadership by establishing a solidly based operational infrastructure that consistently uses cutting edge technology?

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How did we first establish the high quality of U.S. research? The vigor of our national academic oceanographic research enterprise derives from the distributed creativity and incredible productivity that has been its hallmark since the Office of Naval Research (ONR) began funding a variety of investigators at multiple institutions more than 50 years ago. This was supplemented by a growing emphasis by the NSF's International Decade of Ocean Exploration. The combined efforts of the two agencies account for today's U.S. leadership in the ocean sciences. Our challenge is to maintain this proven paradigm for world-class research and education while effectively integrating and supporting an ever expanding and ever evolving facilities base.

Where is the field going? A diverse sea-going capability is the essential infrastructure that underpins current and foreseeable academic research in the United States. But, the oceanographic community is rapidly expanding from traditional operations in which ships (and to a lesser extent satellites) are the platforms from which science is conducted, toward one in which in situ, remote sensing platforms distributed throughout the oceans give us a continuous and interactive presence available to all. Future ship use will be even more demanding than it is now, but the role of ships must also be broadened to provide for servicing of near shore, deep sea, and high latitude remote laboratories. The real-time role of moorings, drifters, gliders, and sophisticated AUV's will continue to grow exponentially as bandwidth, miniaturization, and computational speed improve. Of equal importance, cabled observatories will revolutionize what can be attempted in the oceans by providing real time broadband information to researchers and providing power to instrumentation on the sea floor. This watershed period of innovation in oceanography involves extending the interactive power of the Internet to deep ocean systems. At present, the United States has the lead in most aspects of the development and use of a continual tele-presence within our oceans.

The ultimate answer is that the United States needs the combined power of operational oceanography and innovative research facilities to remain the dominant force within ocean sciences. Routine operations most logically belong within the purview of the ocean agencies, while cutting edge research efforts are best served by flexible partnerships among a host of academic institutions and the appropriate parts of government agencies. It is crucial to canonize a spectrum of ocean-deployed capabilities as critical infrastructure for national security and the economic health of our society. Whatever path this effort takes, it is critical that operational dependability and innovative evolution be balanced at the national level. Policies to ensure that this balance is optimized will be a major challenge for the Ocean Commission. As an adjunct to the decisions made by the Commission, a board should be formed to conduct five to ten year reviews that assess infrastructure health and the effectiveness of the balance between research and operations, and to make mid course corrections across all of oceanography.

Finally, data management and public education are two important considerations that must not be overlooked. The data recovered from the new, real-time, interactive oceanographic assets that are coming on line will become a major national and international treasure. In 30 years we do not want to look back and wish we had archived it more wisely. These assets also will give us a valuable new tool for improving public understanding, providing support for maritime activities, and training personnel to operate and make use of the data they provide.

6. *Integration of operational vs. research oceanography:*
How can we capitalize in the substantial research infrastructure and creative potential and freedom present at academic institutions, and focus government agency and government lab resources on operational implementation and information management? Is there a formula to reduce competition for research dollars between academic institutions and government labs?

These are two interesting questions. The answers should be predicated on agreement as to the relationships between research oceanography and operational oceanography. Here the term operational oceanography is used as it is embodied in the principles of the Global Ocean Observing System.

Research benefits operational oceanography in several ways:

- Research provides the knowledge used in deciding what observations are required to produce the needed products and services via operational oceanography.

- Research provides the strategic design for the operational system.

- Research provides the tools and expertise to obtain the needed observations, the techniques required to produce the needed products and services from those observations, and the capabilities

to deliver those products and services in a timely manner. This is an ongoing process by which the observing system is continually improved as a result of new research results.

Operational oceanography benefits research in several ways:

- Long time series are obtained that otherwise could not be afforded by the research community. Such records are essential to understanding long-period variability of the environment and its interactions with mankind.

- Operational measurements can provide the background information needed to properly interpret research measurements made as part of process studies, which constitute the bulk of scientific field measurements.

Clearly government agencies and laboratories complement the academic institutions' missions. Their emphasis is appropriately focused on operations and mission-driven requirements derived from their mandate. However, the competitive, peer-reviewed scientific process practiced by academic institutions provides the environment necessary to develop the scope, substance and components of an operational ocean and coastal observing system.

There are two readily apparent problems with our present system that should be redressed to reduce tension or competition between academic institutions and government laboratories.

First, many federal laboratories are engaged in research not required to support the operational activities of their agencies. Examples can be found in laboratories operated by the National Oceanic and Atmospheric Administration (NOAA), NASA, and the Department of Energy. To some extent, scientists at these laboratories work in direct competition with academic scientists on problems that are not of direct consequence to the operational missions of that agency. This *modus operandi* not only creates competition for resources between federal laboratory scientists and academic researchers because the federal lab budgets do not include adequate resources for that research, it also means that human resources that could be applied to improve the implementation of operational oceanography and information management within the federal laboratories are not so used. The formula for fixing this problem would be to more clearly define the scope of federal laboratory research and to redirect federal laboratory scientists toward research within that scope and in support of the operational missions of their agencies, as well as to provide the requisite funding for that operational research.

Second, it must be recognized by academic laboratory directors and others that operational oceanography is not the central province of academic institutions. It is understandable and desirable that many elements of operational oceanography are initiated and tested at academic institutions. It is also likely that the scarcity of research funding has spurred many academic researchers to propose elements of operational oceanography. However, those institutions are unlikely to be the venue for observing system elements, which must be sustained indefinitely and integrated with one another for effective and efficient operation.

The formula for fixing this inherent competition would be a clear enunciation that the federal government intends to provide the backbone of the operational oceanographic observing system. It should also be clear that enhancements to that system of specific regional and local utility would be funded by state and local government and the private sector. At this time, the roles of academia in the operational system may be unclear, but the benefits of research to the operational system, as stated above, should provide guidance as to what those roles should be.

7. *It is clear that we need a carefully thought out process to define what data need to be collected more systematically and what tools are needed to detect and manage resources and change. We need to define and implement policy based on sound scientific information. The U.S. needs to reconcile the present gaps in knowledge (what to measure and how to sample) as we move to operational*

oceanography. How do you envision this process taking place, so that we develop a sound and widespread "operational oceanography" program?

Only a few oceanographic variables can be measured today over long periods of time. This is true of air-sea interaction, the water column, and the underlying seafloor. These are all valid directions for oceanographic observations, but in all cases, the measurable variables are physical (e.g. temperature, ground motion, wind speed). There is a tremendous need to develop sensors, which can make useful contributions to chemical and biological measurements. The challenges posed by corrosion, sensor drift, and fouling are great, but the oceanographic community must begin to address these measurements in a meaningful way.

Committees of oceanographers or managers in funding agencies cannot settle the decision of what data need to be collected. For example, mantle geodynamicists have one set of data requirements while those studying life in the seafloor have vastly different priorities for data collection. Nevertheless, progress in one field is likely to have unpredictable benefits to another. The interactions between apparently isolated Earth systems will be the most important factor leading to understanding of emergent phenomena and nonlinear dynamics.

In order to maximize these important interactions, a coordinated, comprehensive observational infrastructure is critical. While in the past, ships have served as one of the traditional and primary ocean science platforms, clearly we need to supplement these intermittent observations with a real-time, all-the-time ocean observing system.

In addition, the only way to expand capabilities in operational oceanography is to couple the innovation inherent in academic basic research to the development of instrumentation and the investigation of Earth systems to the solution of practical problems of interest. It's not possible to have a viable operational oceanography program without an associated research program. Both require long-term investments.

The breadth of necessary oceanographic research is great and the need for systematic data collection is extraordinarily large. The biggest mistake would be to err on the side of timidity in the face of the challenge. It is crucial that, through the NORLC, the federal agencies arrive at a consensus for the operational requirements of an ocean and coastal observing system.

8. *Please provide additional information on operational implementation of research in the area of the integrated ocean observing system.*

The once sharp distinction between research and operational ocean observing systems is becoming increasingly inapplicable. It is now apparent that the most resilient ocean observing system will have a mixed research and operational character. Observations that must endure for years to accomplish their scientific goals have a greater chance of support if they also serve practical users. Operational systems too stringently designed around today's user needs are less able to evolve to accommodate new scientific knowledge, and thus new types of users. The design flexibility needed to include research goals also encourages continuous technological innovation, making it increasingly important to ensure the constructive interaction between observing systems and research. Observations reveal patterns of variation and research determines the causes and consequences of changes. Together, they allow the development of more effective capabilities to detect and predict meaningful changes.

Sustained long-term observations must be used to constantly improve the design of the observing system. Scientific understanding and observational technology are evolving; new applications are being created; thus, the observing system must accommodate change, address numerous scientific and practical objectives simultaneously, and encourage a seamless relationship between research and monitoring. The plan for the system will never be static; there must be continual evaluation and

incorporation of new research and technologies as needs and knowledge evolve, as well as a robust development program to insure that sensor technology attains the levels of reliability required in an operational system.

Currently some observing elements are being supported by industry (e.g., SeaWifs global color measurements by satellite or the PORTS to provide sea level and current nowcasts and forecasts in major U.S. ports and harbors), and their continued involvement in the U.S. observing system must be encouraged and supported by the federal agencies. In addition, the academic community which houses most of the knowledge, observations, and capability for producing needed products, has a critical role to play in the implementation of the system and must be supported by the agencies. The federal responsibility toward implementation of an ocean observing system has two distinct facets: direct support of the round-the-clock operations of the observing system, and support of the research and development required by the constantly evolving system. An example of such an observing system already exists for the atmosphere – it is the National Weather Service. The problem with this observing system is that it ignores the influence and interaction of the ocean with the atmosphere. An integrated ocean observing system will substantially enhance our ability to understand earth system dynamics and contribute to the conduct of science leading to practical benefits in national security, economic development, human health, and natural resource use and management.

9. *In the category of coastal oceanography, there is currently no coherent, national strategy to conduct research in the coastal ocean. This has led to the current situation where approximately a half dozen earmark efforts are underway to establish coastal observing initiatives in various regional bases. Lack of leadership by the NSF in establishing such legislated programs is leading to systems that are potentially uncoordinated efforts that do not consider national interest and impacts, and that may not have the best science basis. How do we address this?*

In the absence of an overarching federally supported program, regional interests will work to secure directed funding for individual projects. Although these projects may be individually meritorious, they are funded without adequate peer review and competition as well as without regard to a national plan implementing an ocean observing system.

NOPP is a response to the organizational weakness in the federal ocean sciences program. Nine federal agencies seek funding from Congress for ocean science and technology associated with their missions. In Congress, more than forty committees and subcommittees of the House and Senate are involved in relevant authorization and appropriations of ocean research. Reaching a consensus in this environment is very difficult. Unfortunately, as seen in the response to Question 2, NOPP is dependent on contributions from its member agencies, of which only one, the U.S. Navy, requests money from Congress for distribution through the NOPP process.

From CORE's viewpoint, there must be a process in the federal government responsible for setting priorities for non-mission related, basic ocean science research. In addition, the organization responsible for this process needs to have the authority to review agency budget requests in order to evaluate the relevance of mission related work to the ocean sciences, and to ensure that national priorities for ocean science research are being met. Without an organizational mechanism that achieves this goal, priority-setting for ocean sciences will continue to be weak, creating an environment that allows piece-meal, inefficient funding of projects without regard to national requirements or scientific appropriateness. While NOPP presents the basis for this type of mechanism, it must be given the wherewithal and resources to manage it.

10. *Major oceanographic programs that have provided a focus to oceanography are rapidly winding down (JGOFS, WOCE). New ones are being planned, but there is no strategy to balance large and small or even medium (7 investigators or less) projects. Global scale issues are beyond the capability of individual PIs, but creativity in solving specific problems is frequently accomplished via smaller viable projects. How can we find the balance point?*

    The oceanographic community has relied to a great extent on 'core' projects and large projects. The large projects emerge when a compelling national need or leader appears, and these tend to squeeze lower profile, smaller investigations from the limited amount of funding available for oceans science research. When policymakers agree on government support for a large oceanographic project but overall funding remains inadequate to support necessary ongoing research, the funding agency should specifically segregate the funding for the initiative from underlying oceanographic research funding. Proper segregation should help prevent cannibalization of "core" research funding by initiatives. The National Science Foundation accomplishes this to a certain degree through its Major Research Equipment account that funds the acquisition and deployment of major equipment and Directorate level accounts that fund the research using the equipment. A further benefit of the segregation of large projects from smaller projects is that it will provide for a dedicated "pool" of funds to support investigator-initiated proposals. Increased support for medium- sized projects, as well as small ones, will depend to a great degree on the support that research generally, and oceanographic research specifically, receives from policymakers. To date, the ocean sciences have been grossly under funded.

    To quote a recent editorial in the *American Scientist*[3], "Most Americans recognize that new discoveries and incremental developments in science, engineering and technology drive product innovation and, hence, provide great opportunity for national prosperity and improved quality of life." Unbiased scientific knowledge is critical to wise public policy decisions. Discovery and innovation form the foundation of the U.S. economy. Policymakers need to become more aware that while thematic initiatives (ocean observing research because of its role in global climate change discussions, atmospheric research for its role in storm prediction and hazard mitigation) are legitimate reasons for supporting research, the federal government is responsible for funding basic research. Federal support of fundamental research is crucial, essential, and must be robust.

    It is the challenge and opportunity of the Commission on Ocean Policy to explain the impact of oceanographic research upon broader national needs to federal policymakers as well, as the public at large. Military leaders have stated fundamental oceanographic research led to the naval superiority that helped end the Cold War. However, federal appropriators have not heard this message. Members of the oceanographic community often muse among themselves that we know less about the depths of the oceans covering 70 percent of our planet's surface than we know about the surface of the Moon. It is now essential that ocean scientists come together to address the underfunding of ocean sciences and the organizational obstacles that frustrate the attempts for interagency collaboration. This will require a cohesiveness of purpose by the oceanographic community to date not achieved and a commitment to education at all levels of society, not just to matriculated university students.

[3] Fox, M.A. *In Praise of Peer Review.* American Scientist, 90:106.