NSF Responses to Questions from the Commission on Ocean Policy

1. How is NSF's proposed ocean observation initiative linked with the broader effort to develop an integrated ocean observation system?

In response to increasing demands by researchers for sustained observations and as a result of recent advances in technology, NSF has developed an Ocean Observatories Initiative (OOI). The OOI is a five-year infrastructure development and construction project that will provide a new means of acquiring oceanographic data for research, exploration, education, and operational purposes. The National Science Board has approved consideration of the OOI for inclusion in the Major Research Equipment and Facilities Construction (MREFC) account of a future NSF budget request. The OOI would provide basic hardware and infrastructure needed to establish a network of ocean observatories, with different capabilities, to enable advances in ocean research and exploration, and to extend systems planning for the components of the OOI.

The OOI builds upon recent successful pilot projects and has three elements: 1) a tectonic plate-scale cabled observatory that spans several geological and oceanographic features, 2) re-locatable deep-sea observatories based around a system of moorings, and 3) an expanded network of coastal observatories.

It is anticipated that the observatories enabled by this initiative will be electronically linked and become a significant, research-oriented component of the proposed Integrated Ocean Observing System (IOOS) that is being developed and coordinated by Ocean.US through the National Oceanographic Partnership Program (NOPP). Basic research conducted using the observatories, which will span a wide range of science topics and themes, will help stimulate new discoveries based on the unique sustained time-series data sets. The resulting knowledge will feed into operational systems by identifying what measurements will best characterize changes in the ocean, how many measurements are required, and where they should be obtained.

A system of networked seafloor observatories allowing real-time access to the oceans holds great promise for capturing the public's imagination for ocean observations through both formal and informal education activities. Observatory data will flow in real time via the Internet to laboratories, libraries, and living rooms around the world. Scientists, students, decision makers, and the general public will be able to interact with the network to gain understanding of earthquakes, fisheries, mineral resources, and human influences on ocean and climate systems.

2. **Can you quantify the steady state requirement for oceangoing fleet/facilities? If that steady state is reached, are NSF, Navy and NOAA likely to sponsor the science ($) to keep those ships gainfully employed? Recent support for science at sea (last 5 years or so) has been poor enough as to make arguments for new ships difficult.**

The Federal Oceanographic Facilities Committee (FOFC) of the National Ocean Partnership Program (NOPP) recently produced a report entitled "Charting the Future for the National Academic Research Fleet – a Long-Range Plan for Renewal". This report was accepted by the National Ocean Leadership Research Council (NORLC) in December 2001 and can be viewed at http://www.geo-prose.com/projects/projects_narf.html. Copies of the report, published in late December, will be sent to the Ocean Commission. The Chair of FOFC, Dr. Margaret Leinen, is available to discuss the contents of the Report and its implications with the Commission.

In the Fleet Plan, FOFC emphasizes that the majority of the ships of the fleet will have exceeded their 30-year design lifetime by the end of this decade, and it customarily takes 5-10 years from concept design until the commissioning of a new ship. Although there is some overcapacity in the current fleet, the Plan documents that research funds have remained stable over the past decade and, consequently, the demand for ship time has also remained relatively stable.

Within this context, the Plan recognizes the need to build at least 10 new large ships (>130 feet) over the next two decades, as old ships are retired. This minimum renewal plan will result in six fewer ships than at present. Although smaller in number, the fleet of the future will be much more sophisticated, will accommodate larger interdisciplinary science parties, and will be equipped with advanced technology. Many in the academic community believe that the servicing of planned ocean observatories and observing systems and the testing of hypotheses from the resulting data, as well as greater efforts in ocean exploration, will significantly increase the demand for ship time, necessitating the construction of up to three additional ships.

Finally, we can and do quantify long-term trends in average ship operating days for the global, intermediate and regional ships in the academic fleet. The results in the FOFC report show that the average ship operating days for each class has been relatively constant since 1978, although there is considerable year-to-year variability. In summary, FOFC believes a new shipbuilding program must be instituted immediately to renew the aging academic fleet.

3. **Would you comment on NSF's plan for under-ice research and survey missions/platforms?**

The major NSF Arctic Ocean research effort in the next few years will be the Shelf-Basin Interactions (SBI) program, jointly funded with ONR. Field work will begin in FY02 on the R/V Alpha Helix and the USCGC Healy and USCGC Polar Star. Mooring deployments will continue in FY03-04 and a second major cruise on the Healy will occur in FY04. It is anticipated that proposals will be received in February 2002 for follow-up cruises on Healy in FY03 to the Gakkel Ridge to study hydrothermal processes and the biota revealed by this year's Arctic Mid-Ocean Ridge Expedition (AMORE) program.

We continue to cooperate with the Navy in joint use of submarines and ice-camps planned for operational purposes. However, conditions of the agreement now preclude adding scientific instruments to the submarine platform and do not allow deployment of scientists. This reduces the prospects for scientific discovery.

In an attempt to replace some of the lost submarine capability, the Office of Polar Programs (OPP) has supported the development of a long-range, high endurance autonomous underwater vehicle (AUV) for Arctic surveys. Initial sea trials were conducted on Healy in 2001.

4. Could you comment on the value of MEDEA and defense/intelligence data source declassification/derived products?

MEDEA, whose membership includes a number of prestigious oceanographic experts, has provided considerable value to the oceanographic community. Examples of MEDEA accomplishments include:

1) Scientific Utility of Naval Environmental Data -- a 1995 report noted the value of naval data holdings to the broader scientific community;

2) Arctic Meteorological and Ice Atlases -- three digital databases were made available using formerly restricted information;

3) Surface Heat Budget of the Arctic (SHEBA) -- scientifically important ice cover imagery was provided for use in research determining Arctic Ocean heat fluxes for climate change and other investigations.

MEDEA continues to address relevant problems for the oceanographic community through its focus on environmental issues related, for example, to climate, carbon storage, food security, and regional impacts. It will likely make major contributions by identifying and analyzing critical data as well as the technological capabilities to obtain them. Experts serving with MEDEA need to work more closely with the broader oceanographic community to ensure that more are aware of the potential value of the data and products that are de-classified.

5. **Can we design and implement a more robust data archive and distribution system than the one presently in place in the U.S.?**

Ocean Sciences is unique among scientific disciplines in the variety and complexity of the observations it collects in the context of scientific investigations. Data are collected by diverse means, across a broad range of disciplines, and by wide-ranging organizations (individual researchers, institutions, private industry, state and local agencies and government organizations) for a wide variety of purposes. These data come in many different forms, from a single variable measured at a single point to multi-variate three-dimensional data sets. Since the inception of the current fixed entity data archive system, multiple new data types have evolved in ways that cannot be easily incorporated or redistributed into the archive. The nature of this growth in data categories and the many methods of data submission (some are in digital form, others consist of physical samples or specimens) taxes established archive systems that have not chosen a flexible architecture.

The challenge before us is to develop an efficient and attractive way for people and organizations that have collected ocean data to effectively document and share their data. The old paradigm of mandating that federally-funded data collectors send their data to national data centers has not been effective. Lessons learned from the past tell us that the design and implementation of nationwide data archives and distribution systems should provide the flexibility to incorporate new developments in information technology, hardware, data types, and data aggregation methods. A wealth of new data is generated by local, state and commercial enterprises that are now not submitted or linked to the national network. The architecture of the next generation data archive needs to embrace a customer service concept if it is to be fully populated as an archive and used to serve the ocean community.

Recent research results indicate that this necessitates a virtual, distributed system. In the past few years (since 1997) new concepts to manage distributed data sets (e.g., DODS and Unidata data exchange protocols) have evolved and are providing much more attractive solutions to sharing data. Funding for this software development has come from individual Federal agencies (e.g., NASA, NOAA and NSF) and this distributed data system is now being implemented under the National Ocean Partnership Program (NOPP). In addition, under the NSF Information Technology Research (ITR) program, new tools for distributing, accessing, combining and analyzing heterogeneous data sets are being proposed and/or developed under the names of geoinformatics, bioinformatics and digital libraries. Again, the key concept in this new paradigm is a distributed system in which the difference between data user and provider is blurred. Finally, ocean scientists, through community workshops, are working on developing much needed metadata standards that can provide potential data users the information they need to determine if a particular data set is useful for their application. Redesign or reinvention of a national archive system that utilizes many of these concepts would markedly improve the utility and robustness of a data archive and distribution system.

6. **How can we better understand the role of open oceans vs. continental margins and coastal zones in controlling climate change? Is there a good pathway to incorporate NSF results into national or even local policy?**

Climate change is an extraordinarily complex topic, and the role of coastal ocean versus continental margins versus open ocean in influencing it depends on the specific phenomena considered. Often the influences cannot be easily separated. To further understanding of climate change, NSF generally issues solicitations focusing on relevant phenomena and receives proposals focusing on a range of regions of the ocean relating to that topic.

NSF climate research links studies of modern processes, analyses of the instrumental record and studies of prehistorical records of climate to understand the basic causes and results of climate variability and change. Research on the general role of open oceans and near shore environments in climate change is actively supported, but climate is a complex ocean-atmosphere-land system, and the goal of NSF is to understand the integrated system and the forces that drive it. Because of increasing concerns with human influences on the climate system, NSF has asked the research community to develop more focused research efforts that emphasize climate change and variability on human time-scales.

Two new efforts that include a significant component of ocean research are the Holocene Climate Variability study and the Integrated Carbon Cycle Research Program. The Holocene study is designed to document and understand the controls of natural climate variability during the warm climate interval that presently exists. The effort is needed to extend the instrumental record back far enough to detect and analyze multidecadal to century scale natural climate variability and determine whether or not changes in ocean processes, such as thermohaline circulation, are associated with the variability. This effort will also provide information needed to separate natural variation in the climate system from any human-induced changes.

The Integrated Carbon Cycle Research Program encompasses global carbon biogeochemistry within and across the boundaries of land, sea, and air. The ocean component specifically addresses research on the ocean margins as well as the deep ocean. Important goals of the carbon cycle research include understanding major sources and sinks of carbon and their variation through time.

Results of NSF-supported research on climate are made available to national and local policymakers in several ways. NSF participates in the US Global Change Research Program, the intent of which is to produce results and information used in formulating national policy. At the international level, NSF supports the IPCC Assessment reports. Perhaps one of the most effective mechanisms for results from NSF-supported, as well as other, research efforts to be considered in policy formulation is via the occasional publications of the National Research Council. The NRC groups that produce special publications are charged with reviewing the open research literature (that reports the results of NSF-funded research on a particular topic), critiquing the conclusions, and making research and policy recommendations.

7. **What can we do to better understand how climate change affects marine resources?**

In the context of research supported through the US Global Change Research Program, the Global Climate Models consistently predict increases in atmospheric temperature and changes in wind patterns and precipitation. The anticipated changes are greatest at higher latitudes. These changes can be expected to have several direct consequences for the oceans and for marine life. Increased air temperatures will result in increases in water temperatures and increased melting of sea ice in the polar regions, leading to freshening of waters. Increases in rainfall will result in increases in freshwater runoff into the sea with resulting impacts on salinity. As the temperature difference between the tropics and the higher latitude regions decreases, we can expect reduced strength in the trade-winds and other important wind fields.

Collectively, these changes in temperature, salinity, and winds will have important effects on ocean currents and other oceanic structures such as frontal zones and upwelling regions. The predicted changes in the oceans include a potential weakening of wind-driven currents such as the Gulf Stream, an intensification of currents dominated by the effects of freshwater inputs (e.g. the Alaska Coastal Current and the Labrador Current) and a strengthening of the layering (or stratification) of coastal waters due to differences in seawater density with depth. Reduction in wind strength could result in a reduction in upwelling in some areas depending on local wind and temperature conditions on land. Increases in the intensity and frequency of El Niño events are predicted in some climate models.

The Global Ocean Ecosystem Dynamics (GLOBEC) program is an example of a research program that seeks to better understand the relation between climate change and marine resources and provides a model for future research efforts related to this theme.

U.S. GLOBEC studies have begun in several locations where the effects on marine populations and ecosystems of changes in currents, circulation patterns, upwelling and downwelling, stability of the water column, or sea ice can be examined in detail. Research sites have been specifically chosen to afford opportunities to study one or more of these processes and their effects on selected species. To study these processes and systems, U.S.GLOBEC researchers are developing and applying computer models of the physics and biology of the seas, conducting studies of key processes to be included in these models, undertaking large-scale observational programs using advanced observational systems, and extracting new information from long-standing programs and data sets. This inter-related sequence of modeling, process-oriented studies, broad scale observations, and retrospective studies is a key element of the GLOBEC research strategy. These program elements provide essential pieces of information on a broad spectrum of spatial and temporal scales. The various components of the program will then integrated in synthesis programs within regional study areas and among sites.

The U.S. GLOBEC Northwest Atlantic (*Georges Bank)* Program is a large multi-disciplinary multi-year oceanographic effort to understand the population dynamics of key species on the Bank - Cod, Haddock, and two species of zooplankton - in terms of their coupling to the physical environment and in terms of their predators and prey. The ultimate goal is to be able to predict changes in the distribution and abundance of these marine resource species as a result of changes in their physical and biotic environment as well as to anticipate how their populations might respond to climate change.

The U.S. GLOBEC Northeast Pacific Program seeks to understand the effects of climate variability and climate change on the distribution, abundance and production of marine animals, including salmon, in the eastern North Pacific. The research seeks to embody this understanding in diagnostic and prognostic ecosystem models, capable of capturing the ecosystem response to major climatic fluctuations.

The Southern Ocean GLOBEC Program focuses on the Antarctic marine food web. This is characterized by dependence on a single key species, the Antarctic Krill and by the dependence of many of the components of this food web on sea-ice during some or all of their life histories. Key species in the Antarctic food web, such as the krill, use sea-ice as a winter refuge and feeding ground. The seasonal retreat of sea ice has a major influence on the rapid phytoplankton growth in the zone influenced by ice edge melt-water. This is where a major portion of the region's annual primary production occurs, especially in areas where the ice edge and ocean current boundaries overlap. This annually recurring, rich food source is easy to track and exploit for animals over-wintering under or on the ice. Indeed, the krill-based food chain is an exceptionally efficient one because of the predictability of the physical environment over evolutionary time scales. These special characteristics make the Southern Ocean marine ecosystem especially vulnerable to global climate change. Southern Ocean GLOBEC will investigate and compare the population dynamics of zooplankton and their various predators with these differing life cycle strategies.

These programs represent almost the entire suite of activities in the USGCRP focused on the responses of marine animal ecological systems to changing climate. Further inter-disciplinary studies will be central to teasing apart the intricate relationships between a changing climate and the health of marine resources and ecological systems.

8. How else can we better integrate interdisciplinary research and minimize the traditional rivalries between ocean disciplines? Such rivalries affect programs within agencies and hamper interdisciplinary program management.

Rivalries will exist in a competitive environment, but do not have to hamper interdisciplinary program management. Some degree of rivalry is good, in that it enhances the likelihood that the best research will be supported. Rivalries are counter-productive when resources for highly competitive core disciplinary research programs are necessary for initiating and maintaining interdisciplinary projects. Frequently, components of interdisciplinary proposals are highly rated and fundable by one program, but of low priority for another. This can result in failure of the proposal.

One plan for improving integration suggests that interdisciplinary research can best be supported by having clearly identified resources and protocols in place for interdisciplinary projects. These resources would be available to the traditional core disciplinary research programs on a cost-sharing basis. Interdisciplinary research proposals would be considered and reviewed by two or more disciplinary programs. The most meritorious projects would then be supported by the interdisciplinary research fund, with a small percentage of core program funds representing “buy-in.”

Critical to long-term success of an interdisciplinary program is "ownership" by program officers. Ideally, the intellectual area of the interdisciplinary program will have emerged from growing community interest and consensus. What works best is that firm financial commitments are made in advance, for whatever number of years the program is planned.

An example where these principles were recently implemented within the Geosciences Directorate, including substantial involvement from the Division of Ocean Sciences, is the "Integrated Carbon Cycle Research Program", Program Announcement NSF 02-106. The purpose of this announcement is to solicit innovative proposals from U.S. academic institutions to conduct basic research into the scientific aspects of the global carbon cycle involving terrestrial, atmospheric and oceanic environments.

9. Can or should NGOs and industry be better integrated with our science funding and proposal selection process?

NGOs and industry have a role to play in the context of basic research. At present, representatives of NGOs and industry are invited to participate in the science planning and funding process at several stages. The planning stage offers an excellent opportunity for individuals outside the academic community to contribute to the development of a new program, or refine an existing one, to ensure that it addresses areas of social impact. The National Ocean Partnership Program has included NGO partners (Sloan Foundation) in one of their research programs, and industry participation in NOPP is also encouraged and actively sought. Industry and NGO members are also invited to serve on NSF advisory and other committees and panels. NGOs and industry can also participate by submitting research proposals in collaboration with members of the academic community and, in so doing, compete for funding. And finally, program managers seek experts, including representatives of such groups, to participate in the proposal review process either as ad hoc or panel reviewers.

While NGOs and industry have a role in science funding, they cannot always be equal partners with federal agencies supporting basic research. To be successful, basic research requires the scientific method, whereas industry and NGOs must at times be strong advocates for a particular position. Advocacy, which is the approach used by the U.S. legal system, is different than the scientific method. It is not realistic to expect that integrating these two different approaches will improve selection of basic research proposals.