typical. This type of funding is useful for research on discrete topics of limited scope, and has the advantage of giving agencies the flexibility to adjust quickly to changing priorities. However, it is not adequate to acquire the continuous data sets that will be essential for examining environmental changes over time or to accommodate the practicalities and uncertainties of marine research in a dynamic and unpredictable environment.

In addition, a variety of mechanisms are used by federal agencies to review proposed ocean research grants, some of which work better than others. Grant systems that are not open to all applicants or that do not use an objective review process for ranking proposals are unlikely to produce the highest quality research. Systems that favor established researchers to the detriment of young scientists, whether intentionally or not, are also flawed, stifling diversity and limiting the infusion of new ideas. When all research proposals, including those from scientists working at federal laboratories, are subject to the same rigorous review process, tax dollars are more likely to support the best science. Streamlined grant application and review processes will also help get more good science done in a timely way.

The ocean science community includes many scientists outside academic and federal labs. Although coordination among sectors has steadily improved, the process will remain mainly ad hoc without the backing of a national strategy and leadership. A clearer understanding of the respective strengths and roles of the different sectors could lead to productive new research partnerships, foster intellectual risk-taking, leverage funding, and encourage participation in large multi-sector research efforts valuable to the nation.

There is also a need to gain feedback from managers at state and federal levels and from the private sector to guide new research directions and technology development and ensure that research results are translated into useful products in a timely manner. Coordination with the regional ocean information programs recommended in Chapter 5 and increased feedback through the Sea Grant programs will provide needed avenues for gaining such input.

Recommendation 25–5

The National Ocean Council (NOC) should direct ocean-related agencies to develop ten-year science plans and budgets consistent with the national strategy. The NOC should provide additional guidance concerning granting mechanisms.

The NOC guidance should:

- require agencies to provide multi-year (greater than five-year) funding opportunities in addition to traditional grant mechanisms.
- reiterate the importance of balancing basic and applied research projects and promote the transition of basic research results to applied uses.
- require a system of independent review for all grant applications, including those from federal laboratories.
- incorporate the science needs and priorities of local, state, regional, and national managers, working with the regional ocean information programs.

Each agency's first ten-year science plan should describe how the proposed doubling of federal ocean research investments would enhance new and ongoing activities.

Building a National Ocean Exploration Program

Ocean exploration missions conducted during the 19th and 20th centuries were the first attempts to document how deep the oceans are, to chart key bathymetric features, and to identify and study marine life. Previously, the oceans were viewed as mere highways for maritime commerce, void of life below 1,000 feet. But despite the important discoveries made during these missions, we still have only a cursory understanding of the deep ocean.

The Value of Ocean Exploration

About 95 percent of the ocean floor remains unexplored, much of it located in harsh environments such as the polar latitudes and the Southern Ocean. Experience teaches us, however, that these vast regions teem with undiscovered species and natural and cultural resources. On virtually every expedition, oceanographers make fascinating new discoveries. Hydrothermal vents in the Pacific, chemosynthetic communities in the Gulf of Mexico, numerous new species of fish and invertebrates, and important archeological sites are but a few of the important discoveries made in the past thirty years.

Advances in deep-sea technologies have made it easier to locate shipwrecks and historical artifacts lost in the ocean depths, such as the stunning discovery of the *RMS Titanic* in 1985. The continued exploration of marine archaeological sites will help us to better understand human history and our global cultural heritage. In addition, preliminary evidence indicates that immense new energy sources exist in the deep sea. The amount of carbon bound in frozen gas hydrates on the seafloor is conservatively estimated to be twice the total amount of carbon existing in all the other known fossil fuels on Earth.[6]

Ocean exploration also offers an unprecedented opportunity to engage the general public in marine science and conservation. Exploration missions to the depths of the ocean provide images of ancient human artifacts, amazing creatures, and never-before-seen ecosystems. These images fire the imagination of people of all ages and can be used in both formal and informal educational settings. This kind of popular excitement and support can be an enormous asset in sustaining exploration projects over the long term.

Given the importance of the ocean in human history and in regulating climate change, guaranteeing food security, providing energy resources, and enabling worldwide commerce, it is astounding that we still know so little about it. This is due primarily to the lack of a long-term, large-scale national commitment to ocean exploration. The ocean and its depths need to be systematically explored to serve the interests of the nation and humankind.

We have awakened a new understanding of the way the world works with new technologies that have taken us into the sea. Yet less than five percent of the ocean has been seen at all, let alone really fully explored.

—Dr. Sylvia Earle, *Explorer-in-Residence, National Geographic Society and Founder, Deep Ocean Exploration and Research, Inc., testimony to the Commission, June 2002*

Growing Calls for a National Program

Although our dependence on healthy marine ecosystems continues to grow, ocean exploration remains a relatively minor component of U.S. ocean science and is a missing link in the national strategy to better understand Earth's environment. Comprehending the genetic diversity of ocean life, developing fisheries, discovering energy resources, investigating submerged cultural resources, and mapping the seafloor all require more extensive exploration. U.S. leadership in ocean exploration will increase what is known about all aspects of ocean life and resources and make it possible to reach management decisions based on more complete scientific information.

There have been many calls for a dedicated national ocean exploration program. The Stratton Commission recommended an international program on a global scale.[7] In response, the United States led the International Decade of Ocean Exploration (IDOE) in the 1970s. IDOE programs greatly improved ocean observation systems, and led to such important research programs as Geochemical Ocean Sections, the Joint Global Ocean Flux Study, the Ridge Interdisciplinary Global Experiments, and the World Ocean Circulation Experiment. These initiatives dramatically enhanced understanding of the global climate system, geochemical cycling, ocean circulation, plate geodynamics, and life in extreme environments.

In 1983, President Reagan directed the U.S. Department of the Interior to take the lead role in exploring the waters of the newly-recognized U.S. exclusive economic zone (EEZ). Three years later, in a report to the President and Congress, the National Advisory Committee on Oceans and Atmosphere (NACOA) detailed the economic importance of the EEZ and emphasized the need to improve efforts to assess its resources.[8] The NACOA report recognized that federal science programs were making important contributions, but concluded that individual efforts based on separate agency missions were neither comprehensive nor making

acceptable progress. In response, the U.S. Geological Survey (USGS) and NOAA were tasked with developing a ten-year exploration plan. Although reconnaissance surveys of much of the EEZ were completed through 1990, more detailed assessments were never pursued. During the late 1990s, efforts to explore the EEZ and beyond lagged due to budgetary constraints.

In 2000, however, the President's Panel on Ocean Exploration called for a robust national ocean exploration program propelled by the spirit of discovery. The panel proposed multidisciplinary expeditions and annual funding of $75 million, not including the cost of providing a dedicated ship and undersea vehicle.[9] These recommendations led to the establishment of the Office of Exploration within NOAA, at a token funding level of $4 million in fiscal year 2001, increasing to $14 million in each of fiscal years 2002 and 2003. This is helping NOAA fulfill its applied science, environmental assessment, and technology development responsibilities, although the program's small budget and agency-specific focus limit its effectiveness.

A 2003 National Research Council report reiterated the need for a comprehensive national ocean exploration program strongly linked to traditional research, with broad international partnerships, and a commitment to educational opportunities.[10] The report offered specific recommendations on exploration priorities, management models, and technology and infrastructure requirements. It also presented detailed cost analyses and projections for programs at various levels of sophistication, including costs for capital construction and annual operations.

NOAA and the National Science Foundation (NSF), by virtue of their missions and mandates, are well positioned to lead a global U.S. ocean exploration effort. NOAA currently runs the Office of Ocean Exploration, but NSF's focus on basic research provides an excellent complement to NOAA's more applied mission. Working together, the two agencies have the capacity to systematically explore and conduct research in previously unexamined ocean environments. To succeed, coordination, joint funding, and interactions with academia and industry will be essential.

Recommendation 25–6

The National Oceanic and Atmospheric Administration and the National Science Foundation should lead an expanded national ocean exploration program, with additional involvement from the U.S. Geological Survey and the U.S. Navy's Office of Naval Research. Public outreach and education should be integral components of the program.

The dedicated infrastructure needed for an expanded national ocean exploration program is discussed in Chapter 27.

Coordinating and Consolidating Marine Operations

The need for routine mapping, monitoring, and assessment of U.S. ocean and coastal waters (referred to as marine operations) has grown significantly in the past two decades. Accurate, up-to-date maps and charts of harbors, coastlines, and the EEZ are necessary for many activities, including shipping, military operations, and scientific research. In addition, expanded regulatory regimes rely heavily on routine assessments of living and nonliving marine resources and water quality. Unfortunately, the accuracy and resolution of existing information is inadequate, and ocean and coastal environments are changing faster than can be documented by the current number and frequency of surveys.

Modern sensor technologies, which can detect new variables in greater detail in the water column and seafloor, have improved our ability to follow changing ocean and terrestrial dynamics. As these new technologies are implemented, they need to be calibrated against previous methods, as well as with each other, to provide useful environmental characterizations and ensure the consistency of long-term data sets.