CHAPTER 25:
CREATING A NATIONAL STRATEGY FOR INCREASING SCIENTIFIC KNOWLEDGE

Ocean managers and policy makers need comprehensive scientific information about the ocean and its environment to make wise decisions. Increased knowledge will help achieve sustainable resource use, economic development, and conservation of the ocean's biological diversity and natural beauty. However, to ensure the highest return on the nation's investment in ocean research, exploration, and marine operations, a national strategy is needed. The strategy should coordinate and prioritize basic and applied ocean and coastal research supported by all federal agencies, increase partnerships with the academic and private sectors, promote enhanced ocean exploration, and coordinate federal marine operations to reduce redundancies. Significantly increased support for research in ocean-related natural and social sciences will be key to fostering a new era of science-based ecosystem-based management.

FORTIFYING THE FOUNDATIONS OF OCEAN UNDERSTANDING

Ocean science and technology are integral parts of the overall U.S. research enterprise and contribute greatly to society. They are essential to understanding the Earth's environment and how it changes over time, improving climate predictions, managing marine resources wisely, finding beneficial new uses of ocean resources, protecting national security, and unlocking the basic mysteries of life on Earth. In addition, important technological advances have resulted from devices originally developed for ocean research and exploration, such as medical acoustic tools that grew out of sonar technologies.

Components of Ocean Science and Technology

For the purpose of this and the following three chapters of Part VII, the term *ocean science and technology* is defined as:

- the exploration of ocean environments and the conduct of basic and applied research to increase understanding of (1) the biology, chemistry, physics, and geology of the oceans and coasts, (2) oceanic and coastal processes and interactions with terrestrial, hydrologic, and atmospheric systems, and (3) the impacts of oceans and coasts on society and of humans on these environments; and
- the development of methodologies and instruments to improve that understanding.

Knowledge about the oceans advanced remarkably during the 20th century due to significant financial investments, a host of multidisciplinary and interdisciplinary studies, new technologies, and an expanding community of dedicated experts. Despite this progress, the ocean remains one of the least explored and understood environments on the planet and a frontier for discoveries that could provide important benefits. Broader understanding is essential to make ecosystem-based, multi-use, and adaptive management possible

and to conserve marine biodiversity. Ocean science and technology will play an increasingly central role in the multidisciplinary study and management of the whole Earth system.

The chapters of Part VII focus on four building blocks of a renewed and restructured U.S. commitment to improving ocean science, technology, and infrastructure in support of sound management practices:

- This chapter presents a national strategy for conducting research, exploration, and marine operations at the federal level, in close partnership with academia and private organizations.
- Chapter 26 explains the need for an integrated ocean observing system to monitor and predict ocean conditions and processes.
- Chapter 27 outlines the infrastructure and technology needed to support ocean and coastal research, management, assessments, enforcement, and monitoring.
- Chapter 28 discusses new requirements in data and information management to receive data from many sources and generate useful products for managers, policy makers, and the general public.

Federal Leadership in Ocean Science and Technology

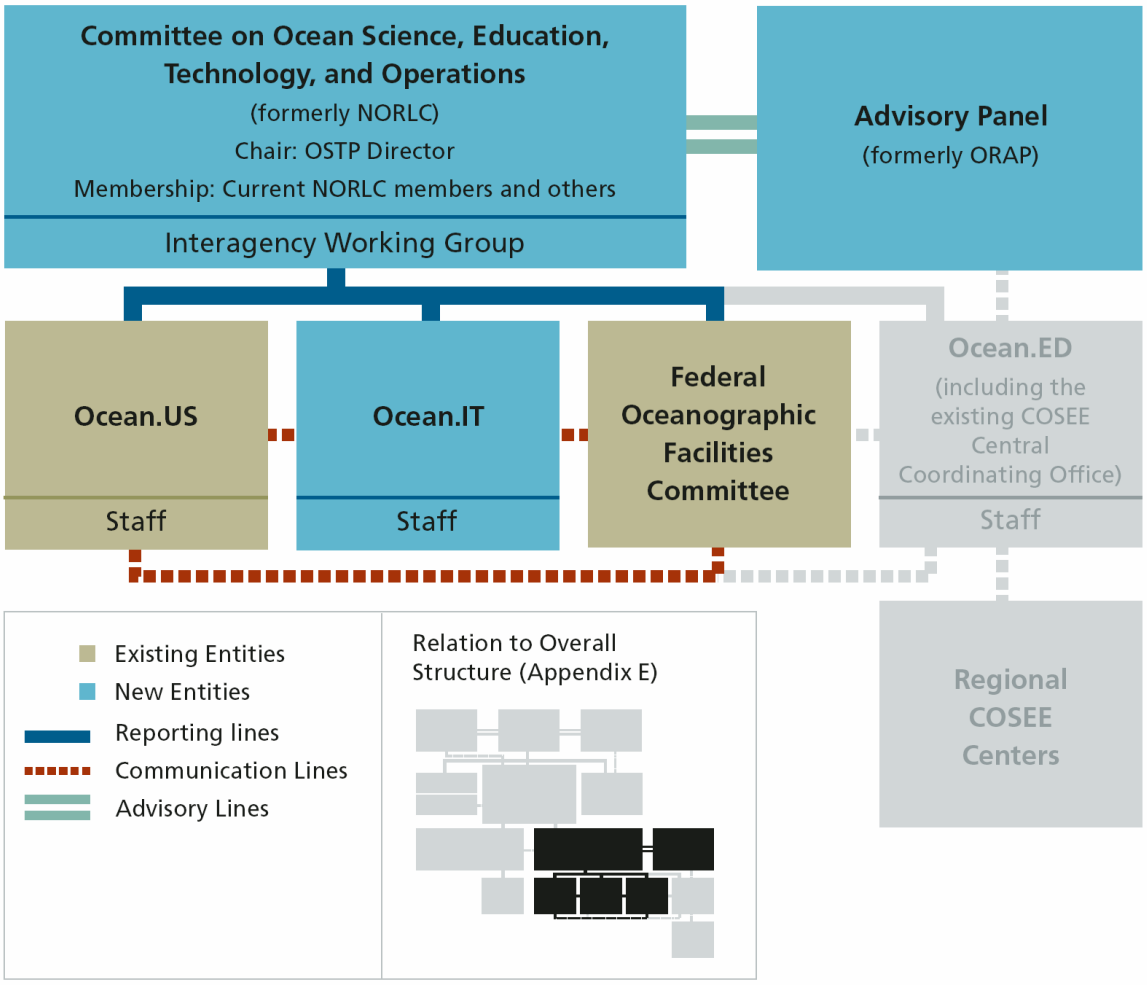
Since the mid-1900s, the U.S. government has achieved a leadership role in ocean science and technology. For many years, the U.S. Navy was the major supporter, primarily through the Office of Naval Research (ONR). Since the National Science Foundation (NSF) was created in 1950, it has gradually assumed a larger role in this research portfolio, although ONR remains a significant contributor in certain fields. Today, fifteen federal agencies support or conduct diverse activities in ocean research, assessment, and technology. The heads of these agencies direct the National Oceanographic Partnership Program (NOPP), created by Congress in 1997 to coordinate national oceanographic research and education. NOPP has provided a useful venue for agencies to jointly support selected ocean science and technology projects, but it has not realized its full potential as an overarching mechanism for coordination among federal agencies, or between federal activities and those of state, local, academic, and private entities.

Under the new National Ocean Policy Framework proposed in Chapter 4, the National Ocean Council (NOC) will serve as the federal coordinating body for all ocean-related activities and the NOC's Committee on Ocean Science, Education, Technology, and Operations (COSETO) will assume leadership of NOPP. This new structure will allow for creation of a national strategy to promote ocean research, education, observation, exploration, and marine operations. NOPP's existing offices and committees will be incorporated within this structure (Figure 25.1). Ocean.US, the lead office for planning the Integrated Ocean Observing System (IOOS), and the Federal Oceanographic Facilities Committee, which provides advice related to oceanographic facilities, will both report to COSETO. An additional planning and coordinating body, Ocean.IT should be added to COSETO to provide stronger integration for information technology activities. (The creation of Ocean.IT is discussed in Chapter 28.)

REVIVING THE FEDERAL INVESTMENT

The United States has a wealth of ocean research expertise spread across a network of government and industry laboratories and world-class universities, colleges, and marine centers. With strong federal support, these institutions made the United States the world leader in oceanography during the 20th century. However, a leader cannot stand still. Ocean and coastal management issues continue to grow in number and complexity, new fields of study have emerged, new interdisciplinary approaches are being tried, and there is a growing need to understand the planet on a global and regional scale. All this has created a corresponding demand for high-quality scientific information.

Figure 25.1 Proposed Structure for the Coordination of Federal Ocean Science Activities



Shown here are the institutional components that should be established under the National Ocean Council's Committee on Ocean Science, Education, Technology, and Operations (COSETO) recommended in Chapter 4. COSETO's purpose is to improve federal leadership and coordination in ocean science, education, technology, and marine operations. This diagram also illustrates the organizational links between existing and planned units under COSETO, discussed in subsequent chapters. Entities shaded in gray are discussed in Chapters 4 and 8.

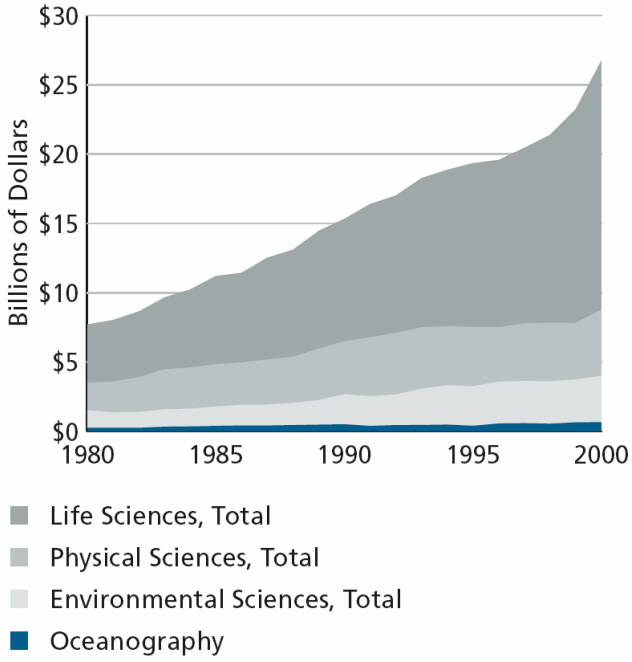
Significant federal investments by the Navy and NSF during the cold war years of the 1960s and 1970s enabled scientists to help promote the U.S. economy and security by supporting research on the fundamental physical, chemical, biological, and geological properties of the oceans. During that period, funding for ocean-related research constituted 7 percent of the federal research budget. However, the federal investment began to stagnate in the early 1980s (Figure 25.2), so that ocean research now comprises a meager 3.5 percent or less of the federal research portfolio. Due to this decrease, the NSF must reluctantly turn down about one-half of the highly-rated grant proposals it receives in the ocean sciences.

The current annual federal investment of approximately $650 million in marine science is well below the level necessary to adequately address the nation's needs for coastal and ocean information. Unless funding increases sharply, the gap between requirements and resources will continue to grow and the United States will not be able to generate the information it needs to wisely manage its ocean resources.

Equally important, a failure to invest in fundamental ocean research now will cut off the pipeline of creative ideas that can produce breakthroughs in decades to come. ONR has a proud history of investing in basic research, primarily conducted at universities and private sector research institutions, with long-term benefits in areas such as ocean acoustics and ocean optics. Navy leaders would be wise to recognize and maintain this tradition. In addition to national security payoffs, past investments have also made significant contributions to the nation's overall well-being and have been a major force in the education and preparation of an internationally superior, multi-disciplinary workforce.

Recommendation 25–1. Congress should double the federal ocean and coastal research budget over the next five years. The new funds should be used to support a balance of basic and applied research.

Figure 25.2 Ocean Research Is Neglected as Part of the National Research Budget



Funding for oceanography has remained stagnant for twenty years, while similar scientific disciplines have experienced steady increases in research funding.

Source: National Science Foundation. "Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1951–2002." <http://www.nsf.gov/sbe/srs/nsf03325/> (Accessed January 2004).

Creating a National Strategy

The United States has never developed a national strategy for ocean and coastal research that integrates ongoing efforts, promotes synergies among federal, state, and local governments, academia, and the private sector, translates scientific and technological advances into operational applications, and establishes national goals and objectives for addressing high-priority issues. Instead, for the most part, each federal ocean agency independently addresses its own mission needs.

A national strategy can help meet the ocean resource management challenges of the 21st century and ensure that useful products result from federal investments in ocean research. The move toward ecosystem-based management approaches will provide strong motivation for a new generation of scientific understanding. More information is needed about how marine ecosystems function on varying spatial scales, how human activities affect marine ecosystems and how, in turn, these ecosystem changes affect society.

Ecosystem-based management will require a deeper understanding of biological, physical, chemical, and socioeconomic processes and interactions. For example, as coastal population growth feeds a demand for new construction, managers will need to know which activities may cause rapid erosion, increased turbidity that harms a coral reef, or economic disruption. In the area of fishery management, scientists and managers must understand the fundamental biology of fish species to protect spawning grounds and other essential habitat, while appreciating the social, cultural, and economic realities in fishing communities.

It is time for the United States to establish a national strategy for ocean and coastal research investments, and oversee implementation and funding of programs throughout the ocean science community. This plan should address issues at the global, regional, state, and local levels. It should emphasize ecosystem-based science to help resolve the current mismatch between the size and complexity of marine ecosystems and the fragmented nature of the scientific enterprise and federal structure. At the same time, the strategy must leave room for creative individuals to pursue the kind of fundamental scientific research that can lead to unforeseen breakthroughs.

Better coordination and integration will help provide the information needed to sustain resources, protect human lives and property, identify and nurture new beneficial uses, and resolve issues that result from competing activities. A unified national approach to ocean research, structured around national investment priorities but with the flexibility to incorporate new ideas, will also result in wiser and more efficient use of resources.

Recommendation 25–2. The National Ocean Council should develop a national ocean and coastal research strategy that reflects a long-term vision and promotes advances in basic and applied ocean science and technology. The strategy should recognize the different ocean science sectors (government, academic, commercial, and nongovernmental), acknowledge their different roles, and maximize the use of partnerships.

ADVANCING OCEAN AND COASTAL RESEARCH

The national ocean and coastal research strategy designed by the NOC will need to include both substantive and procedural guidance for the federal agencies. It should encompass a broad range of issues, as discussed throughout this report and as summarized in Box 25.1. Changes in grant practices and the establishment of strong partnerships are also essential to optimize the national research enterprise.

The national strategy should promote the scientific and technological advances required to observe, monitor, assess, and predict environmental and socioeconomic events and long-term trends. A few areas are worthy of special note.

Box 25.1 Examples of Ocean and Coastal Science Needs

Fundamental knowledge about oceans and coasts is essential for assessing and predicting the status of marine resources, finding beneficial new uses of ocean resources, and implementing an ecosystem-based management approach. Greater understanding of these environments will enable policy makers and managers to make wise, science-based decisions at the national, regional, state, tribal, and local levels. However, to achieve this level of understanding, significantly more research will be needed as indicated throughout this report. The list below gives some idea of the range of topics to be covered, although it is by no means a comprehensive list of all needed research.

Climate Change—

- better understanding of the ocean's role in global carbon heat cycling
- predictive models of the effects of global warming including sea-level rise and changes in global circulation

Biodiversity—

- baseline measurements of marine biodiversity on different scales (i.e., communities, populations, and individuals)
- methods to mitigate human activities that adversely affect biodiversity and marine ecosystems

Regional Understanding—

- regional-scale research programs to understand ecosystem processes
- integration of biological, physical, and chemical research on an regional, ecosystem basis

Coastal Habitat—

- knowledge about the structure and functioning of coastal habitats and how human activities and natural events affect them
- effective habitat restoration techniques

Sediments—

- data on sediment processes in the marine environment on a regional and national basis
- innovative techniques and technologies for managing marine sediments
- comprehensive information about the source, movement, volume, quality, and appropriate use or disposal of sediment—particularly contaminated sediments

Invasive Species—

- comprehension of how or why certain species become invasive
- understanding about why certain factors make an ecosystem more susceptible to invasions
- new techniques for invasive species identification and eradication
- new ballast water treatment and exchange techniques

Coastal Hazards—

- basic understanding and site-specific knowledge about a range of natural coastal hazards
- new methods for tracking and predicting hazards and assessing risks
- techniques to mitigate hazard events

Water Pollution—

- advanced treatment options for eliminating nitrogen, phosphorus, and other emerging contaminants, such as pharmaceuticals, from wastewater discharges
- new methods for removing nutrients and pathogens in coastal runoff
- new models and measures of atmospheric transport and deposition of pollutants

Fisheries—

- better understanding of relationship between fisheries and ecosystem dynamics, including the identification of essential habitat
- measures of the social science and economic aspects of fisheries

Aquaculture—

- determination of the environmental impacts of marine aquaculture and the development of best management practices
- knowledge about the impacts of aquaculture feeds, species introductions, and the use of chemicals and pharmaceuticals in aquaculture practices

Vessel Pollution—

- understanding of cumulative impacts of commercial and recreational vessel pollution on ecologically sensitive areas
- knowledge of impacts of vessel air emissions, particularly in ports and inland
- disposal options for concentrated sludge resulting from advanced sewage treatment on large passenger vessels

Marine Mammals and Protected Species—

- expanded understanding of basic biology and population status
- understanding of the effects of noise, coastal development, offshore oil and gas exploration, vessel traffic, military activities, and marine debris on these species
- methods to mitigate harmful impacts to these animals

Marine Debris—

- knowledge about debris behavior in the marine environment and its ecological effects on organisms and ecosystems
- effective debris control measures
- identification of marine debris sources

Coral Reefs—

- measurements of ocean temperature, currents, and other variables that affect changes in coral communities
- prediction of the impacts of global climate change and other natural and human-induced events on coral communities
- comprehension about the distribution and ecology of cold water corals

Oceans and Human Health—

- discovery of new marine bioproducts
- elucidation of the interrelations and causal effects of marine pollution, harmful algal blooms, ecosystem alteration, and emerging marine diseases in disease events
- new methods to monitor and mitigate threats to human health in marine and freshwater systems

Offshore Energy and Minerals—

- understanding of cumulative, low-level, and chronic impacts of oil and gas activities on marine environments
- evaluation of the risks to the marine environment due to aging offshore and onshore pipelines
- evaluation of the environmental effects of OCS mineral and sediment use

International Science—

- international scientific partnerships to enhance long-term ocean science and management capacity in other nations

Socioeconomic Science—

- operational data on the economic factors and human dimension affecting ocean and coastal areas and activities

Climate Change

One of the most important environmental trends to explore is climate change and variability. Although the ocean plays a critical role in climate—it has 1000 times the heat capacity of freshwater lakes and rivers, its circulation drives the global heat balance, and it plays a primary role in the global carbon cycle—these phenomena remain understudied and poorly understood.

The process of climate change should be examined both on geologic time scales that characterize the transitions between ice ages, and over shorter periods of time. The buildup of greenhouse gases in the atmosphere will increase the melting of polar ice, introducing large quantities of fresh water into the North Atlantic. Many researchers now believe this process could drastically change ocean circulation and weather patterns in the span of a few years.[1] In particular, the Gulf Stream could slow or stop, causing colder temperatures along the eastern seaboard of the United States and ramifications around the globe. It is in the nation's interest to learn more about the processes that lead to abrupt climate changes, as well as their potential ecological, economic, and social impacts.

Even as we try to comprehend the role of the ocean in climate change, we need also to understand the effects of climate change on ocean ecosystems. If temperatures around the globe continue to warm, sea level will continue to rise, putting many coastal residents at greater risk from storm surges and erosion. For individual ecosystems, even small changes in ocean temperature can put the health and lives of sea creatures and humans at risk. Changing concentrations of carbon dioxide due to human activities also appear to be harming some marine organisms. Ocean monitoring will be essential for detecting and predicting changes more accurately, thereby improving prospects for minimizing harmful effects.

Marine Biodiversity

Maintaining overall ecosystem health requires an improved understanding of biological diversity on different levels, including genetic diversity (the variety of genetic traits within a single species), species diversity (the number of species within an ecosystem), and ecosystem diversity (the number of different ecosystems on Earth). The largest threats to maintaining diversity on all three scales are human activities, such as overfishing, pollution, habitat alteration, and introductions of non-native species. The extent of marine biological diversity, like so much about the ocean, remains unknown. But based on the rate at which new marine species are currently being discovered, continued exploration of the ocean is almost certain to result in the documentation of thousands of additional species that can provide fresh insights into the origins of life and human biology.

Regional Ecosystem Dynamics

Major initiatives, such as the U.S. Climate Change Science Program and the Census of Marine Life, have been launched in the last couple of years to study the large-scale research topics mentioned above. While these are important, many issues relevant to the everyday needs of coastal managers do not occur on such global scales. Implementation of ecosystem-based management approaches will require greater knowledge of physical and biological dynamics on a regional scale. Ocean and coastal research targeted at regional concerns, such as the origins of nonpoint source pollution, the impacts of development on coastal habitat and water quality, socioeconomic trends in coastal areas, and the impacts of global-scale processes on local resources is urgently needed. Currently, insufficient emphasis is placed on this kind of research, although the regional ocean information programs recommended in Chapter 5 could help close this gap.

Social and Economic Research

The ocean and coastal environment is rife with conflicts among competing users and groups of people applying different sets of values to the same issues. To resolve these conflicts, information is needed not only about the natural environment but also about relevant social, cultural, and economic factors. The funding required to increase knowledge in these areas is modest when compared to the cost of the ships, labs, and instruments used in oceanographic research. Nevertheless, social and economic research related to our coasts and oceans has long been overlooked.

A Neglected Research Area

The National Sea Grant College Program does fund some studies that examine legal, political, economic, anthropological, and other human dimensions of ocean and coastal affairs. However, these projects often receive less than 10 percent of the Program's overall research budget. In other programs, social and economic sciences garner even less support, creating a situation where basic information is not available to support management and planning.

To meet specific programmatic requirements of the National Environmental Policy Act (NEPA) and other laws that require impact analyses, individual resource management agencies have had to pull together social science and economic information at various times. For example, National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service hired anthropologists and economic researchers following enactment of the 1976 Magnuson–Stevens Fishery Conservation and Management Act. The Minerals Management Service instituted a relatively comprehensive socioeconomic research program in the 1970s to aid in developing five-year leasing plans that would meet NEPA standards, and to address the requirements of the OCS Lands Act Amendments for monitoring the impacts of offshore oil and gas development on the human environment. The U.S. Army Corps of Engineers has also funded research into marine cultural heritage to meet its NEPA obligations. And, in the 1990s, NOAA's National Ocean Service created the Coastal Services Center to help generate information on coastal demographics. Although wide-ranging, these efforts remain ad hoc, uncoordinated, and related to specific issues that wax and wane in importance over time. Furthermore, the data developed on an agency-by-agency basis are often mutually incompatible and hard to access.

Recently, NOAA has begun to reassess its needs for social and economic information. In 2003, a panel of social scientists established by its Science Advisory Board concluded that NOAA's support for social sciences is not comparable to that of other agencies with similar environmental assessment and stewardship responsibilities and that this shortcoming has hindered the agency's ability to accomplish its mission.[2] NOAA's National Marine Protected Areas Center also issued a report identifying high-priority social science needs to support the planning, management, and evaluation of marine protected areas.[3]

Some existing and emerging ocean and coastal issues that will require better social and economic information include:

- Multiple-use controversies in the coastal zone.
- Novel offshore uses, such as the proposed introduction of wind farms.
- Consensus-based decision making involving stakeholders, watershed councils, public-private partnerships, and numerous nongovernmental organizations.
- Global climate change and its potential effects on a range of issues including agriculture, water supply, and coastal development.
- Changes in coastal communities due to shifts in fishery policy, growth of the tourism industry, and redevelopment of ports and waterfronts.
- Changes in coastal demographics.
- Varying perceptions of coastal environmental values.

Any decision affecting our oceans and coasts should take socioeconomic information into account, harnessing expertise from a wide range of specialties to deal with issues that demand a broad range of knowledge. This will require integrated assessments by teams of natural and social scientists working together with stakeholders and policy makers. Such an approach, which has been employed in the context of climate change, is especially well suited to emerging ocean issues that require a merger of natural and social sciences, technology, and policy.

The Coastal and Ocean Economies

Cost-benefit analyses to support ocean and coastal decisions require enhanced economic data. However, the major federal economic statistical agencies have neither the mandate nor the means to study the ocean and coastal economies.

NOAA undertakes some economic analyses in support of its various missions. For example, its Coastal and Ocean Resource Economics Program has assessed the economic impacts of fishery management plans and marine sanctuaries. NOAA has also worked with other federal agencies to conduct the first major examination of the economics of marine-related recreation.[4] But NOAA's economic analyses tend to be directed at very specific purposes associated with particular programs. NOAA has not supported sustained, consistent, and comprehensive data collection and analyses on the ocean and coastal economies.

To lay the groundwork for a broader program, NOAA and the U.S. Environmental Protection Agency are helping support the National Ocean Economics Project, a multi-year research initiative involving economists from several universities. While this effort is generating valuable information, including much of the economic data used in this report, it remains a research project. To be useful in understanding coastal and ocean economies and assessing the impacts of management policies on individuals, businesses and communities, a long-term, operational program is needed. Coordination between the federal government and other entities will be needed to generate the socioeconomic data required for operational activities (Table 25.1). NOAA, as the federal agency with principal responsibility for the oceans, should take the lead in bringing these parties together to provide the economic data needed for ocean and coastal decision making at the federal, state, regional, and local levels. (A study of U.S. ocean and coastal economies, prepared for the Commission by the National Ocean Economics Project, is included as Appendix C to this report.)

Key functions of an operational program for ocean and coastal economic data should include:

- *Data Collection*—Standard measures of employment, income, and output for ocean and coastal economies must be developed. The National Ocean Economics Project provides a foundation for this work, but additional measures are needed to assess: the influence of oceans and coasts on land values; the role of the oceans in the tourism and recreation industries in terms of both market and non-market values; and the economic value of ecosystem services provided by the oceans and coasts.
- *Data Distribution*—The data that would be generated by this program are urgently needed by local and state managers, researchers, and stakeholders, and must be easily accessible. The availability of modern database and Internet delivery systems has made this function much easier and cheaper than in the past.
- *Data Analysis*—Data only become useful outside the academic realm when they are analyzed and transformed into information products. Data analyses should be tailored to federal, regional, state, and local needs. Socioeconomic trends should be analyzed and linked to environmental trends. Geographic Information Systems will facilitate the integration of socioeconomic and natural resource data.
- *Education and Research*—Additional research should focus on improving measurements of nonmarket values, developing ways to quantify the use of ocean and coastal resources, and standardizing

measures such as employment and output. The field of ocean and coastal economics is relatively new and primarily confined to a small group of specialists. To accommodate the growing demand for expertise in this field, expanded training of scientists and policy specialists will be required.

Table 25.1 Organizations Collecting Socioeconomic Data on the Ocean and Coasts

The organizations listed below will play key roles in creating an operational coastal and ocean economics program to support management activities.

Entity	Role
National Oceanic and Atmospheric Administration	Current economic activities are performed by NOAA's National Marine Fisheries Service to help draft and defend Fishery Management Plans and by the Coastal and Ocean Resource Economics (CORE) Program, which conducts individual studies on issues of interest, such as economic valuations of beaches or coral reefs.
Bureau of Labor Statistics	In cooperation with the states, the Bureau collects the largest amount of basic employment and wage data on the U.S. economy. These data will continue to be the fundamental elements used for monitoring the coastal and ocean economies at national, regional, and local levels.
Bureau of the Census	The Census Bureau is the other major collector of primary data on the economy, including the tabulation of population, housing, and major economic sectors.
U.S. Department of Agriculture	USDA has responsibility for the Census of Agriculture, which includes data on marine aquaculture.
Bureau of Economic Analysis	BEA uses data from other agencies to maintain the most important measure of annual economic activity: the national income and product accounts, whose best-known element is the gross domestic product. Related measures, such as the gross state product, are key to understanding regional economies.
Minerals Management Service	MMS collects and analyzes socioeconomic data to examine the impacts of outer Continental Shelf activities on natural, historical, and human resources.
U.S. Environmental Protection Agency	EPA undertakes substantial economic research in the fields of land, water, and air pollution. EPA's economic research focuses particular attention on nonmarket values, and provides an important supplement to NOAA's work in this area.
National Science Foundation	NSF supports much of the basic research in the sciences, including the social sciences. It has recently undertaken new initiatives to better integrate the natural and social sciences to improve management of the environment and natural resources.
Bureau of Transportation Statistics	BTS collects and analyzes data related to maritime trade and transportation, such as tonnage of U.S. commerce shipped and foreign vessel entries and departures at major U.S. ports.
Universities and Other Research Organizations	The majority of research on coastal and ocean economies is conducted as a cooperative arrangement between the federal government and researchers in the nation's universities and private research organizations. The interactions among federal, academic, and private researchers strengthen the quality of research by introducing multiple perspectives and organizational missions.

Recommendation 25–3. The National Ocean Council (NOC) research strategy should include a national program for social science and economic research to examine the human dimensions and economic value of the nation's oceans and coasts. The NOC should direct relevant agencies to include socioeconomic research as an integral part of their efforts.

The national program should include:

- *an operational socioeconomic research and assessment function within the National Oceanic and Atmospheric Administration (NOAA).*

- *an interagency steering group, chaired by NOAA and including the Bureau of Labor Statistics (BLS), Bureau of the Census, Bureau of Economic Analysis (BEA), U.S. Department of Agriculture, U.S. Environmental Protection Agency, and National Science Foundation to coordinate ocean-related socioeconomic research.*
- *biennial reports by BLS and BEA on the employment, wages, and output associated with U.S. coasts and oceans.*
- *biennial reports by the Bureau of Transportation Statistics on intermodal access to U.S. ports and maritime facilities and assessments of relevant maritime system performance and economic data.*
- *periodic reports on such topics as coastal demographics, geographic patterns and trends of ocean and coastal use, economic contributions, attitudes and perceptions, functioning of governance arrangements, and public-private partnerships.*
- *establishment of partnerships to take maximum advantage of the expertise resident within government agencies, academic institutions, and the private sector.*
- *increased interactions with regional, state, and local stakeholders through regional ocean councils and regional ocean information programs so their information needs can be met and socioeconomic changes at these levels can be documented and analyzed.*

These efforts deserve, and will require, significant new funding, as discussed in Chapter 30. While this may prove challenging in a time of scarce budgetary resources, major federal funding is already devoted to economic research in the agricultural sector, although the ocean economy is two and a half times larger than agriculture in terms of total production of goods and services (Appendix C).

The National Sea Grant College Program

The National Sea Grant College Program offers a unique opportunity to gather state and local input in determining research needs, and provides a proven mechanism for applying research results to management activities. The Sea Grant program, a partnership between NOAA, thirty state Sea Grant programs, and over 200 universities, is a highly-leveraged program. To the $60 million in federal funds appropriated in fiscal year 2003, the states contributed an additional $36 million, a match of nearly 60 percent.

Sea Grant's emphasis on applied research, education, and outreach results in projects that respond directly to local and national needs as determined by the marine industry, government representatives, resource managers, and the public. Sea Grant advisory specialists and coastal field agents convey the needs of the marine communities to university scientists, and in turn, transfer research results to resource users and managers at the state and local level. Sea Grant also advances formal and informal education. Its communications specialists package and deliver research, outreach, and educational information on a wide range of topics.

Sea Grant's current strategic plan focuses on promoting ecosystem-based management and involving constituencies from government, universities, and the private sector to strengthen the U.S. marine research enterprise.[5] The Sea Grant program has additional untapped capacity to promote coastal economic growth, improve the quality of coastal environments, educate students in marine sciences, and solve critical marine and Great Lakes resource problems. However, limited funding has stymied Sea Grant's ability to fund research and outreach activities.

In addition, in some regions, Sea Grant could potentially assume responsibility for the regional ocean information programs discussed in Chapter 5, if it is able to take on new tasks and its organizational structure can be extended beyond the state level.

Recommendation 25–4. Congress should significantly expand the National Sea Grant College Program as part of doubling ocean and coastal research funding.

Agency Strategies and Funding Mechanisms

To ensure that new investments are used wisely and that important research activities continue, federal agencies will need to create their own long-term strategic plans and remedy structural problems in their grant mechanisms. Improved cooperation between federal ocean agencies, academic institutions, and industry can draw on the strengths of each, ensure that quality research is conducted, satisfy multiple national objectives, and achieve a balance between basic and applied science.

In creating long-term plans, a balance must be reached between support for basic, curiosity-driven research conducted mostly at universities and marine research centers, and more applied research, often conducted at government laboratories to support operations, management, and monitoring activities. Immediate national needs tend to exert pressure for more applied research, but the enduring value, and often unexpected outcomes, of basic research should never be underestimated. Basic oceanographic research in the 1940s, 1950s, and 1960s, primarily supported by the U.S. Navy, increased our understanding of ocean circulation and stratification, marine optics, marine acoustics, seafloor geology, and robotics, and led to many widely-used and versatile new technologies with both military and domestic applications, such as the Global Positioning System.

Problems in the current system for awarding federal research grants make it difficult to conduct the kind of interdisciplinary, ecosystem-based research required to understand the ocean environment. Short-term research grants of two- to five-years duration are now 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.

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 program is helping NOAA to 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.

Integrated National Maps and Assessments

At least eleven federal agencies, almost all coastal states, and many local agencies, academic institutions, and private companies are involved in mapping, charting, and assessing living and nonliving resources in U.S. waters. However, different organizations use varying methods for collecting and presenting these data, leading to disparate products that contain gaps in the information they present.

Box 25.2 Primary Federal Agencies that Conduct Science-based Marine Operations

U.S. Environmental Protection Agency
Minerals Management Service
National Geospatial-Intelligence Agency
National Oceanic and Atmospheric Administration
U.S. Army Corps of Engineers
Federal Emergency Management Agency
U.S. Coast Guard
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Navy
National Science Foundation

Ideally, a variety of information, such as bathymetry, topography, bottom type, habitat, salinity, and vulnerability, should be integrated into a single map using Global Positioning System coordinates and a common geodetic reference frame. In addition, it is important for these maps to include information on living marine resources, energy resources, and environmental data when available. Only then will it be possible to create the complete ocean characterizations necessary for developing and implementing science-based, ecosystem-based management approaches. However, achieving this integration in the coastal zone is an extremely complex proposition.

By launching the Geospatial One-Stop Portal, the Office of Management and Budget has taken steps to avoid the collection of redundant data, facilitate information sharing, and plan for future integrated mapping and charting. This Web-based server provides national base maps with administrative and political boundaries that can also incorporate information on agriculture, atmosphere and climate, hazards vulnerability, ecology,

economics, conservation, human health, inland water resources, transportation networks, and utilities. Federal agency coordination is led by the Federal Geographic Data Committee (FGDC)—a nineteen member interagency committee composed of representatives from the Executive Office of the President and departments and independent agencies that promotes the coordinated use, sharing, and dissemination of geospatial data on a national basis. The FGDC is currently developing the National Spatial Data Infrastructure in cooperation with state, tribal, and local governments, the academic community, and the private sector. This initiative includes policies, standards, and procedures for organizations to cooperatively produce and share geographically-linked data.

Federal agencies must continue to integrate and share data in the quest to create readily accessible maps that track geological, physical, biological, and chemical features in three dimensions. The fourth dimension—time—should also be incorporated wherever possible to track changes in ocean and coastal resources over the short and long terms.

Federal Mapping and Charting Activities

Maps of coastal land areas, and charts of nearshore and offshore areas, are essential for safe navigation and for defining boundaries, mitigating hazards, tracking environmental changes, and monitoring uses. Because many organizations have mapping and charting responsibilities, there are significant overlaps. This situation results in multiple entities within government, industry, and academia undertaking the expensive and time-consuming task of repeating surveys of the same area for different purposes. Furthermore, differences in scale, resolution, projection, and reference frames inhibit the integration of onshore and offshore data. It is impossible to merge most existing maps and charts to provide a continuous picture of the coastal zone. However, recent advances in the development of satellite positioning systems, sensors, and data manipulation techniques have created a new generation of geospatial data products that address some of the key challenges faced by ocean and coastal managers and policy makers.

The U.S. marine transportation system is in particular need of better charts. As this industry prepares for exponential growth over the next twenty years, a backlog of required surveys is developing. Approximately 35,000 square nautical miles of navigationally significant U.S. waters have been designated by NOAA as critical areas requiring updated information on depth and obstructions.[11] New maps and charts of these waters and ports are essential to minimize shipping accidents and to support the national security missions of the U.S. Navy and Coast Guard.

Another significant issue is the need to conduct extensive multi-beam sonar mapping of the U.S. continental shelf, where a potential $1.3 trillion in resources (including oil, minerals, and sedentary species) could become available under provisions of the United Nations Convention on the Law of the Sea (LOS Convention). If the United States accedes to the LOS Convention, it will be able to present evidence to the United Nations Commission on the Limits of the Continental Shelf in support of U.S. jurisdictional claims to its continental shelf. The University of New Hampshire's Center for Coastal and Ocean Mapping/Joint Hydrographic Center, in conjunction with NOAA and USGS, has already identified regions in U.S. waters where the continental shelf is likely to extend beyond 200 nautical miles and is developing strategies for surveying these areas.[12] Bathymetric and seismic data will also be required to establish and meet a range of other environmental, geologic, engineering, and resource needs.

A recent National Research Council report on national needs in coastal mapping and charting provides a comprehensive review of the topic and offers sound recommendations for: setting common reference frames and protocols; achieving data integration, interchangeability, and accuracy; and improving data accessibility.[13] While all of these steps are essential to improving federal mapping and charting activities, the National Research Council's recommendations for reducing redundancy in mapping and charting missions are of utmost importance.

Coordination of the many existing federal mapping activities is necessary to increase efficiency and help ensure that all necessary surveys are conducted. Registering all federally funded mapping and charting activities within a common database will allow agencies to know what missions are being scheduled and will provide opportunities for coordinating similar activities. Once implemented, this registry could serve as the focal point for national coordination of geospatial data collection and analysis efforts.

The Marine and Coastal Spatial Data Subcommittee of the FGDC, whose membership is composed of representatives from NOAA, USACE, National Geospatial-Intelligence Agency, U.S. Navy, USGS, and MMS, plus other relevant organizations such as the U.S. Department of State and EPA, is the logical organization to coordinate and standardize federal mapping and charting activities. To achieve the best results at the lowest cost, it will be essential to draw on mapping and charting expertise found in the private sector and academia. Coordination with state efforts will further reduce redundancies.

Recommendation 25–7. The Federal Geographic Data Committee (FGDC) should coordinate federal ocean and coastal mapping and charting activities with the goal of creating standardized, easily accessible national maps. These maps should be able to incorporate living and nonliving marine resource data along with bathymetry, topography, and other natural features, and should provide seamless data across the shoreline, coastal zone, nearshore areas, and open ocean waters.

To accomplish these goals, the FGDC should:

- *coordinate an interagency budget strategy to accelerate the completion of mapping priorities throughout coastal areas, the exclusive economic zone, and continental shelf.*
- *establish and maintain a Web-accessible registry that allows federal agencies to coordinate mapping and charting missions.*
- *establish and maintain a single Web-based source to provide easy access to geospatial data and integrated national maps.*
- *ensure that federal mapping and charting activities take full advantage of resources available in the academic and private sectors.*
- *ensure that federal mapping activities take advantage of state resources and address state information needs.*

PROVIDING USEFUL INFORMATION TO CONGRESS

A theme reiterated throughout this report is that increased research, exploration, and marine operations can provide decision makers with the information they need to make better decisions. While Chapters 26 and 28 address the collection, analysis, and presentation of environmental data for research and management, a specific gap remains in the flow of scientific information to Congress.

Until its termination in 1995, the Office of Technology Assessment (OTA) provided nonpartisan analytical information to Congress and assisted members and staff in understanding the complex and highly technical issues that increasingly affect society. While OTA's mission covered a wide range of issues, it produced many reports important to ocean and coastal policy, including studies on fisheries, wetlands, marine technologies, oil pollution, climate, aquaculture, and more.

OTA occupied a unique role among the congressional information agencies. Although the General Accounting Office evaluates ongoing government programs and the Congressional Research Service provides congressional members and staff with information on legislative topics, OTA's assignments covered a broad range of technical areas and its studies were comprehensive, serving as an important congressional resource for crafting public policy. OTA's work influenced many pieces of legislation and contributed to improved communication between policy makers and the scientific, technical, and business communities.

Congress's need for comprehensive scientific and technical information is as strong today as it has ever been, if not stronger. In particular, many emerging ocean and coastal activities will require comprehensive analyses in order to ensure that new legislation is based on the best information possible.

Recommendation 25–8. Congress should re-establish an Office of Technology Assessment to provide it with objective and authoritative analyses of complex scientific and technical issues.

Box 25.3 Selected Ocean and Coastal Reports from the Former Congressional Office of Technology Assessment

- Establishing a 200-Mile Fisheries Zone (1977)
- Wetlands: Their Use and Regulation (1984)
- Technologies for Underwater Archaeology and Maritime Preservation (1987)
- Bioremediation for Marine Oil Spills (1991)
- Science and Technology Issues in Coastal Ecotourism (1992)
- Preparing for an Uncertain Climate-Vols. I and II (1993)
- Global Change Research and NASA's Earth Observing System (1993)
- Fish Passage Technologies: Protection at Hydropower Facilities (1995)
- Selected Technology Issues in U.S. Aquaculture (1995)

[1] National Research Council. *Abrupt Climate Change: Inevitable Surprises*. Washington, DC: National Academy Press, 2002.
[2] Social Science Review Panel. *Social Science Research within NOAA: Review and Recommendations.* Washington, DC: National Oceanic and Atmospheric Administration, Science Advisory Board, 2003.
[3] National Marine Protected Areas Center. "Social Science Research Strategy for Marine Protected Areas." Internal draft. Silver Spring, MD, June 11, 2003.
[4] The Interagency National Survey Consortium. *National Survey on Recreation and the Environment (NSRE), 2000*. Silver Spring, MD: National Oceanic and Atmospheric Administration, May 2001.
[5] National Sea Grant College Program. *NOAA Sea Grant Strategic Plan for FY 2003–2008 and Beyond: Science for Sustainability in the 21st Century*. Silver Spring, MD: National Oceanic and Atmospheric Administration, November 4, 2003.
[6] Cruickshank, M.J., and S.M. Masutani. "Methane Hydrate Research and Development." *Sea Technology*. August 1999, pp. 69–74.
[7] U.S. Commission on Marine Science, Engineering and Resources. *Our Nation and the Sea: A Plan for National Action*. Washington, DC: U.S. Government Printing Office, 1969.
[8] National Advisory Committee on Oceans and Atmosphere. *The Need for a National Plan of Scientific Exploration for the Exclusive Economic Zone*. Washington, DC, 1986.
[9] President's Panel for Ocean Exploration. *Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration*. Washington, DC: National Oceanic and Atmospheric Administration, 2000.
[10] National Research Council. *Exploration of the Seas: Voyage into the Unknown*. Washington, DC: National Academy Press, 2003.
[11] Office of Coast Survey. *National Survey Plan*. Sliver Spring, MD: National Oceanic and Atmospheric Administration, November 2000.
[12] Center for Coastal and Ocean Mapping/Joint Hydrographic Center. *The Compilation and Analysis of Data Relevant to a U.S. Claim under United Nations Law of the Sea Article 76*. Durham, NH: University of New Hampshire, 2002.
[13] National Research Council. *A Geospatial Framework for the Coastal Zone: National Needs for Coastal Mapping and Charting*. Washington, DC: National Academy Press, 2004.