OUR OCEAN FUTURE

THEMES AND ISSUES CONCERNING THE NATION'S STAKE IN THE OCEANS

DEVELOPED FOR DISCUSSION DURING 1998, THE YEAR OF THE OCEAN

A MULTI-SECTOR, COLLABORATIVE PROJECT OF

THE H. JOHN HEINZ III CENTER FOR SCIENCE, ECONOMICS AND THE ENVIRONMENT

WASHINGTON, DC
MAY 1998

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The Heinz Center Year of the Ocean project was conducted under the terms of a joint project agreement between The Heinz Center and the National Oceanic and Atmospheric Administration. Funds were provided by the Minerals Management Service, National Oceanic and Atmospheric Administration, U.S. Department of Energy, U.S. Environmental Protection Agency, U.S. Geological Survey, and The Heinz Center. This report does not necessarily reflect the policies or views of The Heinz Center, any individual member of The Steering Group for the Year of the Ocean, or the organizations or agencies that employ these individuals.

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FOREWORD

The purpose of the International Year of the Ocean, 1998, is to raise public awareness about the value of oceans and coasts, celebrate considerable accomplishments in understanding the oceans, and promote learning from past experiences in managing the oceans and their resources. In the United States, the Year of the Ocean also provides a much-needed opportunity to examine national ocean policies and programs as we prepare for the twenty-first century.

The Heinz Center and the National Oceanic and Atmospheric Administration (NOAA) agreed that an examination of the nation's stake in the ocean could best be initiated by convening all major sectors concerned with the oceans—industry, the environmental community, academia, and government. To that end, The Heinz Center and NOAA entered into a joint project. The joint project was implemented by a Steering Group composed of leaders from federal and state governments, ocean industry and business, the environmental community, and academia.

In this, its final report, the Steering Group describes issues affecting the nation's ocean future and, consequently, its economic and environmental future. The report does not offer detailed guidance—that will be the province of those who continue the dialog. However, the work of the Steering Group has convinced us of the need to achieve a better balance between the use and conservation of oceans and coasts.

The Steering Group members gave freely of their time to set the course for, and oversee, the joint project. They invited nearly 200 ocean leaders to meet with them, and to help identify and describe the issues and how they might be addressed. We are deeply indebted to all who participated (these individuals are listed in Appendix A). We also wish to thank our staffs, especially Stanley Wilson and Muriel Cole of NOAA's Office of the Chief Scientist, and Charles Bookman, Marina Guedes and Mary Eng of The Heinz Center, who organized and administered the joint project.

Sincerely,

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EXECUTIVE SUMMARY

The United States is surrounded by one of the largest, richest, and most diverse marine territories of any nation. From the Arctic Ocean bordering Alaska to the Atlantic, Caribbean, and Pacific oceans framing the mainland, Americans enjoy and prosper from an abundance of marine resources and activities, including productive fisheries, global trade, coastal recreation, mineral and energy production, and diverse marine ecosystems. But today these resources and activities face an array of threats, which at best may result in lost opportunities and at worst can cause irreparable damage. Regrettably, the environmental quality of marine areas and resources, and the economic value of vital ocean and coastal industries such as trade, tourism, and fishing (and the communities that depend on these activities), will be in jeopardy unless effective measures are taken immediately to safeguard, protect, and restore America's oceans and coasts.

After consulting with 200 ocean and coastal leaders from industry, government, academia, and environmental organizations, The Heinz Center Steering Group for the Year of the Ocean has concluded that there is an urgent need for a systematic and comprehensive review of ocean and coastal policies and programs. Unless action is taken now, significant benefits to the economy and quality of life will be lost, and the United States will fall behind other nations in using and conserving the oceans and their resources. An integrated vision, and a plan for achieving it, must be developed for U.S. marine areas, resources, and activities. A restructuring of national, regional, and local mechanisms for managing oceans and coasts may be necessary, along with new investments in science, education, and management.

On the positive side, a great diversity of stakeholders, including all levels of government, are interested in helping to develop and implement solutions. Members of the Steering Group believe that an independent commission mandated by the U.S. Congress and supported by the Executive Branch of the U.S. Government offers a means to rethink the nation's stake in the ocean and decide how to address the related challenges and opportunities. The commission would be charged with making recommendations to rejuvenate the nation's ocean and coastal policies and programs and realign them for the future.

OCEAN ISSUES FACING THE NATION

The preeminent challenge for the United States is to achieve integrated management that balances the use of ocean resources with the conservation of those resources. Enormous economic and environmental benefits would result. This challenge can be met if the nation can overcome the obstacles that have blocked progress in the past. The three principal obstacles are the following:

The nation has underinvested in the physical and technological infrastructure necessary for the efficient use of the oceans and coasts. Elements of this infrastructure include ports and waterways, research laboratories and facilities, and marine services.

The national and international institutions and mechanisms for governing and managing ocean and coastal areas and resources are often fragmented and have conflicting mandates.

Insufficient effort has been devoted to developing and applying the knowledge necessary for wise management.

The Steering Group defined the dimensions of these obstacles and explored potential solutions in three national meetings convened to focus on the following broad issues: managing the U.S. coasts for economic and environ-mental prosperity, protecting and restoring fisheries and other living marine resources, and advancing and applying ocean science and technology for the use and conservation of the marine environment.

Managing the Coasts for Economic and Environmental Prosperity

Every American is affected by the oceans. As vast as they are, the oceans can also be harmed by humans. Changes in oceanic conditions in the far Pacific can determine whether the next growing season for Midwestern farmers will be wet or dry. Conversely, agricultural practices, sewage processing, automobile emissions, and other human activities generate by-products that contain nitrogen or other nutrient elements, which eventually find their way into the ocean. Excess nutrients in coastal waters can trigger harmful blooms of marine organisms that adversely affect coastal water quality and fishery resources. Every year, some Americans have to change vacation plans because of beach closures, or endure “fish scares” in the seafood marketplace because of broad-based concerns about environmental quality and public health.

The United States is by far the world’s largest marketplace. American factories and stores depend on imported goods. Approximately 40 percent of the total value of U.S. foreign trade (and a much larger share by weight, including half of the petroleum that fuels the economy) is carried by ship. These goods and products are funneled through ports, which provide an essential link between land and sea. Yet the economic importance of ports is increasingly transparent to the consumer, who does not always appreciate the need to ensure the efficiency and safety of marine transportation. Many other activities, ranging from beachfront development to ocean-dependent industries, also have economic ramifications. All of these vital activities depend on the nation’s capability to manage marine activities, conserve and protect coastal and ocean resources, and, ultimately, understand the sea.

To meet the challenge of protecting and conserving the coastal environment, the United States will need to manage the oceans and coasts in new ways. The economic and other consequences of coastal storms and erosion need to be reduced, and sustainable economic growth needs to be achieved in marine recreation, marine resource development, global trade, and other activities. Progress in these areas

increasingly lies beyond direct federal control. A rich experience base is emerging on partnership approaches that build on the roles and capabilities of the private sector; the knowledge base provided by scientific researchers; and the conservation and economic development tools of local, state, and federal governments. Solutions and innovations today often require the participation of all stakeholders, including every level of government. The process of learning to achieve progress through cooperation more routinely and more effectively will be a major undertaking, with important implications for governing institutions at every level.

Protecting and Restoring Fisheries and Other Living Marine Resources

The nation also faces a difficult challenge in developing a management regime that ensures sustainable fisheries and fishing communities while also protecting and nurturing marine biodiversity. Many U.S. fish stocks are still overutilized despite some successful restoration efforts. Although the commitment to conservation has been strengthened in recent legislation, a great deal of work remains to be done to ensure that this resolve is honored in practice. Fishery managers today need to muster the resources and political will to identify and protect essential fish habitat, address the problems of overfishing and excess fishing capacity, minimize bycatch, address the future of aquaculture and its potential impacts on the marine environment, and apply management techniques that work across jurisdictions and conserve ecosystem values such as the protection of biodiversity.

Advancing and Applying Ocean Science and Technology

Advances in ocean science and technology can be applied to gain important new knowledge that will help build a sustainable future. With new technologies and observing systems, new levels of accuracy are becoming possible in the prediction of natural disasters and climate change. With new knowledge of plate tectonics, scientists have begun to understand the evolution of the Earth and the implications for predicting earthquakes and the distribution of mineral resources. The recent identification of exotic life forms around deep-sea hydrothermal vents suggests that the oceans still harbor many undiscovered treasures, perhaps including clues to the origins of life. The growing understanding of the complexities, fragility, and resilience of ocean ecosystems positions humanity to use the living resources of the sea without adversely affecting their sustainability. But to realize the full potential of ocean science, new investments in research, education, facilities, and international collaboration will be required.

MOVING FORWARD

Americans care deeply about the oceans and coasts. The Year of the Ocean, 1998, provides a unique opportunity to reflect on, and chart, a new and more effective course for managing them. Essential roles in this endeavor are already being performed by industry, government agencies at all levels, research and educational institutions, and nongovern-mental organizations. Buoyed by strong

public interest, all are poised to continue to work together toward America's new ocean future. The best chance for achieving their shared vision lies in the establishment of an independent commission comprised of the nation's ocean leaders, who can recommend the most economically and environmentally beneficial directions for U.S. ocean policy and programs in the next century.

1

OVERVIEW

The bounty and hazards of the oceans that surround the United States make their presence known daily. The fish in the local supermarket, the day at the seashore, the cruise to the Caribbean or Alaska are but part of the ocean's bounty. The national economy and the well-being of citizens depend on ocean-borne trade in fuels, consumer products, and other goods that enhance daily life. On the other hand, the oceans are frequently a cause of devastating hazards. Through their effects on the weather and climate, the oceans influence droughts and floods and are the source of hurricanes, storm surges, and tsunamis. They are also receptacles for the wastes of humanity, sometimes with adverse effects on complex marine ecosystems. Less frequently, and primarily in times of international tension, Americans are reminded of the critical role that the oceans play in protecting national security.

The importance of the oceans has been widely documented. They are an integral part of the hydrological cycle that drives weather and climate. They contain the majority of the Earth's biomass and are a wellspring of ecological diversity. Scientific discoveries in and around the oceans have shed light on the origins of the Earth and even life itself. Human exploration of the ocean, and growing understanding of life and other treasures in the sea, awes and inspires millions. Ecological studies have confirmed that coastal waters are among the most productive and valuable of all habitats. Ocean activities are comparable in economic importance to other sectors of the economy, such as agriculture.

Thirty years have passed since the last comprehensive review of the nation's relationship to the sea (President's Commission on the Oceans, 1969).[1] Since that time, the world has changed so profoundly that a new examination of this relationship is warranted. The Year of the Ocean, 1998, and the prospect of a national commission on the oceans,[2] offer the opportunity to reevaluate the nation's stake in the conservation and use of the oceans.

THE HEINZ CENTER PROJECT ON THE YEAR OF THE OCEAN

As a result of discussions with the Ocean Principals' Group,[3] The Heinz

[1] A brief description of this assessment and its subsequent impact is provided in Appendix B.

[2] S. 1213, 105th Congress, 1st Session. Passed by the Senate in November, 1997. H.R. 3445 was marked up on April 23, 1998, by the House Subcommittee on Fisheries Conservation, Wildlife and Oceans. The bills would require the development of comprehensive ocean policy for the United States. A temporary commission would be established for the purpose of conducting a study and making recommendations concerning national policy for the oceans. S. 1213 would also establish a national marine council to strengthen federal agency coordination and policy implementation.

[3] The Ocean Principals' Group is an ad hoc interagency coordinating committee of federal agencies with ocean missions. Members are agency directors or their principal deputies. The member agencies are the National Oceanic and Atmospheric Administration of the Department of Commerce, the Army Corps of Engineers and Navy of the Department of Defense, Department of Energy, the U.S. Geological Survey and Minerals Management Service of the Department of Interior, Department of State, the Maritime

Center established a 22-member Steering Group to develop themes and issues for the Year of the Ocean. The Steering Group—benefiting from a diverse membership representing industry, government, academia, and environmental organizations—sought to identify what is working well and what is not working with regard to the nation's ocean activities and interests, and also to identify the needs and opportunities. The Steering Group proposed three strategic steps for assessing the nation's stake in the ocean:

> *The first strategic step* was to identify and develop major ocean themes by drafting issue papers and discussing and refining them at national workshops. This step was accomplished by the Steering Group. Approximately 200 ocean, coastal, fisheries, and maritime leaders from industry, government, academia, and environmental organizations participated in three major national meetings in early 1998. Participants in The Heinz Center Year of the Ocean meetings are listed in Appendix A. Background documents contributed by federal agencies (National Oceanic and Atmospheric Administration, 1998) were provided to all participants. This report synthesizes the results of these meetings.
>
> *The second strategic step* is a national conference to highlight the nation's stake in the oceans and build public interest in, and support for, addressing U.S. ocean policies and programs. The U.S. Government plans to convene the National Conference on the Oceans in Monterey, California, on June 11–12, 1998.
>
> *The third strategic step*, not yet realized, is the enactment of legislation establishing a high-level commission to review thoroughly current U.S. ocean policies and programs and the national stake in the oceans (see footnote 2).

The Need to Reassess the Nation's Stake in the Ocean

A remarkable thing happened when 200 leaders from industry, government, academia, and environmental organizations came together under the auspices of The Heinz Center to discuss the nation's ocean future. The four sectors are seldom convened in this way. And yet, despite their diverse backgrounds and interests, these leaders joined together to note the profound changes in virtually every aspect of American life, including the nation's governance structure and environment, in the brief time—just 30 years—since the last comprehensive examination of the nation's stake in the sea. These stakeholders agreed on many points, including the nature of the problems that have arisen over the past several decades and what must be done to address them. The convergence of opinion underscores the urgency of the need to address the nation's ocean future.

This need is driven primarily by changes that have taken place in both the natural environment and approaches to marine governance. Ocean issues also have

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Administration and Coast Guard of the Department of Transportation, the Council on Environmental Quality and Office of Science and Technology Policy of the Executive Office of the President, Environmental Protection Agency, Federal Emergency Management Agency, Federal Maritime Commission, National Aeronautics and Space Administration, National Science Foundation, and Agency for International Development.

important implications for inter-national security and commerce.

Changes in the Natural Environment and Perceptions of It

The quality and well-being of many marine areas and resources have declined over the past several decades, and, partly in recognition of this degradation, there has been a shift in how these areas are perceived. Marine resources are now understood to be finite, even fragile. The interconnectedness of all resources on or near the coast, and even far upstream, is becoming increasingly apparent.

Among the most profound changes has been the encroachment of humanity on the seas. Millions of people take advantage of the amenities found in coastal areas and the economic activities that thrive there. The increase in coastal populations has been accommodated by additional pavement and infrastructure—roads, recreation facilities, residential homes, and businesses—all of which place stresses on the coastal and marine environments. Sensitive habitats, which nurture marine life and buffer the shoreline, are encroached upon, degraded, and sometimes lost. A balance between resource use and conservation is often sought, but rarely achieved.

One of the hopeful trends amid these changes is the growing understanding of ocean and coastal environments and processes. This new knowledge is due in large part to an array of increasingly sophisticated technologies, ranging from remote-sensing instruments on satellites and aircraft to highly equipped underwater platforms and vehicles. The improved observational capabilities, combined with exponential increases in computational power, have reduced the costs of acquiring information and increased the accuracy of weather predictions. Additional investments are needed, however, to exploit fully the potential of these rapidly evolving technologies for ocean science.

Changes in Ocean Governance

Opinion surveys have documented that most Americans care deeply about the environment. The depth of concern and care for the environment has grown and matured over the past 30 years. This concern is now shared by all sectors of society. Environmental organizations on the local, regional, national, and international levels have become a potent political force, perhaps the strongest single political force influencing ocean policy. The rise in influence of the environmental advocacy community is one of the fascinating institutional developments of the past decades. Moreover, these predominantly private-sector interests are willing to work with both landowners and government agencies to conserve and manage the environment, and they have considerable technical and managerial capabilities and resources to offer.

This phenomenon is only one aspect of the growing number and diversity of organizations with roles in managing or using the marine environment. Indeed, the whole approach to marine governance is changing. The traditional players—federal and state governments, industry, and academia—have been joined at the table by regional and local governments as well as the

environmental community. Federal budgets and roles are no longer viewed as the sole answer. Solutions and innovations today may be devised and used by all stakeholders, including multiple levels of government. States are assuming larger roles in planning and managing ocean areas and uses. Still relatively untapped is the private sector's capability to address problems and concerns through market forces. In the future, management programs will increasingly need to recognize the limits of the federal budget, the constraints on states, and the power for change that could be unleashed through market forces.

Building on these new realities, a realigned management framework is emerging that strives to balance ocean uses and conservation. Glimmers of that framework can be seen, for example, in the zoning of the Florida Keys to protect fragile natural resources while guaranteeing the rights of ocean users to continue their activities. It is also evident in habitat protection and species recovery plans developed in many regions and political venues that recognize the linkage between land and water systems and address real problems at the appropriate scales. At the same time, a new vision of innovative partnerships among stakeholders is emerging. But realizing its full potential will involve difficult choices as well as different priorities for fiscal and human resources and realignments of responsibilities among government agencies, between levels of government, and between government and the private sector.

Long-term trends in federal domestic discretionary spending add urgency to the need to develop partnership approaches to governing and managing marine areas and resources. Despite expanding missions and increasing costs, most federal, state, and local agencies involved in ocean management and protection have had flat or declining budgets for years. In virtually every mission area, federal agencies have had to do more with less. For example, in constant dollars, the federal budget for basic research in ocean science grew less than 1 percent between 1982 and 1997, even as the federal budget for basic scientific research overall nearly doubled (in constant dollars). Additional evidence of the budget squeeze can be seen in the backlog of nautical charts that require updating, unmet needs for fishery stock assessments, and many other deficiencies.

While ocean governance structures continue to evolve, an entirely new framework must be devised for vast areas of coastal ocean that at one time were essentially unmanaged. The most significant event in marine governance in the last generation has been the extension of U.S. jurisdiction out to 200 miles off the coast for the purposes of resource management. This Exclusive Economic Zone must be managed wisely and sustainably to preserve resources and values for future generations.

International Security and Commerce

In marked contrast to the 1960s, the United States no longer faces the prospect of war with a military peer. Yet the U.S. military is increasingly called on for peacetime engagement, deterrence, conflict prevention, and the control of regional crises. The capability to sail anywhere and project power remains

important, and knowledge of the ocean, especially the marginal seas and coastal areas, has become increasingly critical to national defense. The military's need for accurate, detailed information is an important driver of the use of advanced technologies in ocean science.

Meanwhile, the globalization of the world economy has intensified the use of the oceans for the transport of goods and services and transformed the shipping industry, heightening the need for modern, efficient ports and waterways. Ships have become critical links in a time-sensitive global distribution chain. Congestion in U.S. ports, the result of continued trade growth with insufficient modernization of the infrastructure, triggers delays in shipping and imposes economic penalties. U.S. ports need to be modernized to the level of the nation's most sophisticated trading partners (and economic competitors), with deeper and wider channels, modern traffic management systems, and improved intermodal connections through the port to highway and rail transportation.

ACHIEVING A BALANCE OF OCEAN USES AND CONSERVATION

The remaining chapters in this report address three broad ocean-related challenges that the nation will face over the coming years. Each chapter is organized somewhat differently, reflecting the dimensions of the particular topic and the nature of the discussions at the national meetings convened by The Heinz Center.

Chapter 2, "The Challenge of Sustainable Coasts," discusses the difficult problem of managing the coast so that both the economy and environment prosper. Topics include enhancing and sustaining coastal environmental quality, shoreline management, producing energy from the ocean, and maintaining and modernizing the nation's ports. The chapter concludes with a discussion of approaches to developing workable, integrated management frameworks for addressing and balancing these diverse coastal issues.

Chapter 3, "Protecting and Restoring Marine Fisheries," identifies the key issues that must be addressed if the management of particular fisheries is to be successful over the long term. These issues include overfishing, over-capitalization, bycatch, habitat protection, aquaculture and its impacts on the environment, managing fisheries across jurisdictions, and the trend toward ecosystem management.

Chapter 4, "Science and Technology—Key to Ocean Understanding," describes some of the many ways in which knowledge of the oceans benefits society, especially the contributions to a productive economy and thriving environment. Other

topics include the national capacity to gain and apply knowledge of the sea, international dimensions of ocean science and technology, research and educational facilities and institutions, and human and fiscal resources.

The following chapters represent the Steering Group's synthesis of the results of the three national meetings convened by The Heinz Center. In addition to outlining what is working and not working today, the chapters identify the major issues and questions that remain to be addressed, important cross-cutting themes, and the organizational structure and fiscal means necessary to achieve national goals. It is hoped that a national commission on the oceans will find this information helpful.

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National Oceanic and Atmospheric Administration (NOAA). 1998. Year of the Ocean Discussion Papers. Washington, D.C.: NOAA Office of the Chief Scientist.

President's Commission on the Oceans. 1969. Our Nation and the Sea: A Plan for National Action. Washington, D.C.: U.S. Government Printing Office.

2 THE CHALLENGE OF SUSTAINABLE COASTS

SUMMARY

The United States benefits from a rich diversity of ocean and coastal resources and activities, which contribute in important ways to the economy and quality of life. But the challenge of preserving the environmental integrity of the coastal region is growing along with the human population and related impacts. To meet the challenge of sustainable coasts, integrated management approaches that serve both economic and environmental purposes will need to be devised and implemented.

A rich experience base on partnership approaches is emerging that builds on the roles and capabilities of the private sector; the knowledge base provided by scientific researchers; and the conservation and economic development tools of local, state, and federal governments. Solutions and innovations today often require the participation of all stakeholders, including all levels of government. Ocean and coastal managers and researchers must share best practices and learn how to encourage and capitalize on the new partnership approaches if they are to protect and conserve the coastal environment; reduce the economic and other consequences of coastal storms and erosions; and meet the challenges of growth in world trade, tourism, and in resource extraction industries.

INTRODUCTION

The majority of the U.S. population lives near the coast,[4] and coastal populations are growing faster than other populations (Culliton et al., 1990; Cohen et al., 1997). Coastal population growth increases demands for food, trade, public health, waste disposal, and protection from natural disasters. Apart from permanent residents, the coasts also attract vacationers, who require additional services and infrastructure. Moreover, increasing affluence leads to different consumption patterns; in the United States, this generally means increased consumption of resources per individual.

Natural coastal resources include biologically and economically important marine life, energy resources, and useful minerals. Perhaps the most important attribute of the coast is the overall ecological system. Thriving coastal areas perform a number of ecosystem functions and have great aesthetic as well as economic importance. Coastal ecosystems support juvenile fish stocks, for example,

[4] The coast is the region in which the land and sea interact as a system. This is a broad definition; the specifics can change, depending on the context. For some purposes, the coast extends from the shoreline seaward 200 miles to the limit of the U.S. Exclusive Economic Zone, and landward from the shoreline to the limit of tidal influence (National Research Council, 1995a). The coast includes the Great Lakes, estuaries, bays, inlets, and other coastal waters. In some contexts, the coast may even include the surrounding lands, watersheds, and even the "airsheds" that influence them.

and provide unparalleled recreational opportunities.

Natural processes sometimes conflict with the activities of humans. Coastal hazards, such as hurricanes, cause record damages to residential and other developed areas. Rising sea levels and beach erosion threaten coastal communities as well as critical natural environments.

The coast is valuable economically for many reasons. Perhaps most obviously, great urban centers are typically found on the coasts, and their ports and harbors provide links to the heartland and gateways to an increasingly global economy. Although comprehensive analyses of ocean-dependent economic activity are not available, the extent and relative economic importance of certain activities have been assessed. For example, one study estimated that selected ocean activities are worth more than $17 billion to California (see Table 2-1).

TABLE 2-1: Contribution of Selected Ocean Industries to the California Economy

Sector	Contribution (in billions)
Tourism	$ 9.90
Ports	6.00
Offshore oil	.86
Fisheries and mariculture	.55
Total	$17.31

Source: Wilson and Wheeler, 1997

These ocean industries account for approximately 2 percent of California's gross domestic product, which is roughly $800 billion. In total, the ocean sector is similar in size to other important sectors of the economy, such as agriculture (Pontecorvo, 1989; Wilson and Wheeler, 1997). Wilson and Wheeler (1997) observed, "These findings are testimony to the concept that ongoing efforts to manage California's ocean resources in a sustainable manner will provide long-term economic, as well as environmental, benefits to the State. In other words, ecosystem management and economic sustainability are not mutually exclusive goals. The State must continue to pursue efficient and effective processes for addressing the protection of ocean resources, while also addressing the legitimate needs of ocean-dependent industries."

Despite their widely recognized intrinsic and economic value, U.S. coasts are threatened. The warnings can be seen in both newspaper headlines[5] and careful studies. Unfortunately, current management approaches may not be adequate to neutralize these threats. A recent report by the National Research Council (1997a) concluded that, "The governance and management of our coastal waters are inefficient and wasteful of both natural and economic resources. The primary problem with the existing system is the confusing

[5] Major coastal news stories of the past year included a toxic bloom of *pfiesteria* in the Chesapeake Bay that caused a public health scare; a "dead zone" of oxygen-depleted water off the mouth of the Mississippi River that raised concerns about regional fisheries and control of nonpoint-source pollution; congestion in West Coast ports that triggered delays in shipping, raised costs, and threatened to disrupt the holiday shopping season; a cyclical change in Pacific Ocean conditions that threatened coastal flooding, storm damage, and large-scale erosion; and production of oil from the deep ocean made possible by advances in marine technology.

array of laws, regulations, and practices at the federal, state and local levels. The various agencies that implement and enforce existing systems operate with mandates that often conflict with each other. In many cases, federal policies and actions are controlled from Washington with little understanding of local conditions and needs."

This chapter summarizes the most significant trends, problems, and opportunities in coastal ocean management, as identified by all four sectors—government, industry, academia, and environmental organizations. The discussion is organized into five sections. The first four sections deal with coastal environmental quality, shoreline management, production of energy from the ocean, and the future of U.S. ports. At the practical level, these subjects may seem to have little in common. From a policy perspective, however, they share a fundamental problem—fragmented governance mechanisms and conflicting mandates. Therefore, the last section discusses governance issues and the need for integrated management.

COASTAL ENVIRONMENTAL QUALITY

"...[M]an's fingerprint is found everywhere in the oceans. Chemical contamination and litter can be observed from the poles to the tropics and from beaches to abyssal depths...But conditions in the marine environment vary widely. The open sea is relatively clean...In contrast to the open ocean, the margins of the sea are affected by man almost everywhere, and encroachment on coastal areas continues worldwide...If unchecked, this trend will lead to global deterioration in the quality and productivity of the marine environment." (Group of Experts on the Scientific Aspects of Marine Pollution, 1990)

Coastal oceans and estuaries are among the most productive and valuable natural systems on Earth. They are also among the most threatened. Coastal areas become more crowded every day; indeed, the rate of population growth is fastest in coastal counties, where population densities are five times the national average (Culliton,1997). Growth brings jobs, creates economic prosperity, adds new industries, improves regional infrastructure, enhances educational opportunities, and increases tax revenues. However, the cost of progress is often the loss or diminishment of the natural features that originally attracted people to the coast. Waste and pollutant loads increase, green space and valuable habitat is paved over or degraded, and water quality deteriorates. The major stresses include pollutants (nutrients, chemicals, and debris); transportation-related activities; and coastal development. Some success has been achieved in mitigating these stresses through mechanisms such as marine protected areas. The stresses and possible solutions are outlined below.

Stresses on the Coastal Environment

Nutrients, Chemicals, and Debris

Oxygen depletion is a severe and growing concern in coastal waters. The growth in human populations, changes in land cover, the loss and degradation of wetlands, and increases in the use of fertilizer and in animal husbandry have resulted in a dramatic increase in nutrient inputs to the coastal ocean from the land. The overenrichment of nutrients, called eutrophication, stimulates the growth of algae and other aquatic organisms and

results in oxygen depletion. This problem particularly plagues large estuaries that are poorly flushed and mix slowly with the coastal ocean.

In the last 50 years, two- to tenfold increases in nutrient enrichment have taken place in coastal waters, with significant seasonal variability in some regions (Culliton, 1997). Many regions are now plagued by both eutrophication and the related problem of "blooms" of algae or tiny toxic animals. In the summer of 1997, newspaper headlines focused on an area of over-nitrification and oxygen depletion that seasonally covers approximately 7,000 square miles of the Gulf of Mexico off the mouth of the Mississippi River. The likely cause is agricultural runoff, which may travel more than 1,000 miles from the Midwest down the Mississippi River before affecting the Gulf of Mexico. In the Chesapeake Bay region, the Governor of Maryland closed fisheries and warned citizens about seafood safety because of a bloom of a tiny toxic organism. The likely cause is the handling of agricultural wastes. These experiences point to a need for more integrated management of land and water in agricultural areas.

The scientific community and coastal managers are just now understanding the role of atmospheric deposition in the contamination of coastal waters. For example, it has been estimated that approximately one-third of the nitrogen that enters the Chesapeake Bay is deposited from the atmosphere. Moreover, in the United States, atmospheric deposition is the predominant source of the mercury that accumulates in fish. Some 40 to 70 percent of atmospheric mercury is believed to originate from anthropogenic sources, with domestic sources releasing approximately 200 tons of mercury into the air each year (U.S. Environmental Protection Agency, 1997).

Chemicals and debris from all sources are also recognized as serious problems in the marine environment. Chemical contamination poses risks of acute and chronic toxicity, threatening predators, and ultimately humans, through uptake (i.e., bioaccumulation) in the food chain. Although many substances that pose health hazards have entered coastal waters, monitoring indicates that chemical pollution is at least not worsening, and that concentrations of some banned chemicals are decreasing. Marine debris, which has been traced to many sources, often harms or kills marine organisms that become entangled in it or ingest it (National Research Council, 1995b). Debris also has economic impacts when it damages fishing gear or reduces the aesthetic appeal of recreational beaches. Communities in New Jersey, for example, spend approximately $1.5 million each summer to keep beaches clean.

Coastal pollution can have a measurable effect on travel and tourism, which is the largest and fastest-growing segment of the U.S. service industry. At ocean, bay, and Great Lakes beaches, there were at least 2,596 individual public-health closings and advisories in 1996; 4 out of 5 were attributed to high bacteria counts, usually the result of storm water overflows from sewage systems or polluted runoff from the land. In any given year, up to half of the estuarine and coastal waters tested do not meet ambient water quality standards (U.S. Environ-mental Protection Agency, 1996). Bac-terial contamination is also a major concern for shellfish harvests. Harvest limitations of

some type have been im-posed on roughly one-third of all shellfish waters because of seasonal health concerns.

Transportation-Related Stresses

Waterborne transportation poses three general risks to the coastal ecosystem. One risk stems from the need to maintain clear, safe navigation channels, a task that requires the management of dredged material. Dredging is commonplace in the United States and is essential to many of the routine activities and services that Americans have come to expect and demand (Interagency Working Group on the Dredging Process, 1994). Approxi-mately 300 million cubic yards of material, on average, are dredged each year from U.S. coastal waters. Although much of this material is clean and can be disposed of safely in dump sites or islands outside of shipping lanes, perhaps 5 to 10 percent of the material does not meet water or sediment quality standards. These materials have to be managed in a manner that protects the environment by containing the potential pollution source, eliminating the pollutants (often an expensive alternative), or reusing the material for some beneficial purpose (National Research Council 1997b).

Ships also pose two other risks to coastal waters. Shipping accidents, although rare events, still occur. Accidental spills represents a small fraction of total pollution of the seas, but shipping accidents can devastate the areas in which they occur, usually in the vicinity of shipping lanes and most frequently near ports (National Research Council, 1995c). Worldwide efforts to improve the safety of shipping and cargo movements, using mechanisms such as treaties negotiated through the International Maritime Organization, help protect the environment but need to be implemented and enforced more comprehensively.

Another well-established risk is the introduction of exotic organisms by ships moving from one region of the globe to another. Unintentional introductions of organisms by ships have altered the ecological balance in the Great Lakes, San Francisco Bay, and other regions and have resulted in large expenditures to control nuisance species (National Research Council, 1996). Air pollution from ships can also be an important local concern.

Development-Related Stresses

Coastal ecosystems are stressed by a variety of human activities, and many areas have experienced widespread degradation. These problems have been extensively documented and are well known. Some of the causes, such as deliberate discharges of wastes, have been effectively controlled. Other causes are equally pernicious but more difficult to control.

Among the most common and serious threats to marine habitat quality are the incremental changes in estuarine watershed function resulting from piecemeal changes in the land use of coastal watersheds. The modification of vegetative patterns (with resulting changes in water balance), installation of impervious surfaces, compaction of soils, elimination of wetlands that retain or detain water, and other changes can greatly modify the way water and associated pollutants move into tidal creeks. Typically, intensified development

results in enhanced average flows and greatly enhanced peak flows, with associated increases in the delivery of sediments and water as well as contaminants (e.g., pathogens, nutrients, toxicants). Small coastal watersheds are particularly vulnerable to the development-related delivery of pollutants associated with storm water. Areas of particular concern include brackish nursery areas, anadromous spawning and nursery areas, and tidal creeks that support shellfish.

The physical alteration or degradation of habitats such as wetlands, sea grass meadows, and coral reefs directly affects the quality of the marine environment and the health of marine living resources. Eight out of 10 commercial fish species use coastal habitats as nurseries, and eight out of ten endangered marine species depend on shallow water habitat. Fully half of all coastal wetlands have been lost or degraded in the United States. At present, coastal wetlands are being lost at an average of 31 square miles annually because of habitat modification, rises in sea level, and other natural and human-induced processes.

Coastal waters are cleaner today as a result of government and industry efforts to reduce the volume of pollutants from point sources, including factories and sewage treatment plants. However, the United States is, at best, holding steady in protecting the coastal environment. The nation clearly needs to reassess its commitment to clean coastal water. The Clean Water Act (33 U.S.C. 1251 et seq.), a fundamental tool for protecting coastal waters, was 25 years old in 1997. Point sources continue to contribute sizable amounts of nutrients and contaminants to coastal waters, partially because of the steady growth in the numbers of people who live in coastal regions and watersheds. Addressing these problems will continue to be a priority for many years.

Nonpoint-source pollution[6] poses an even greater challenge. Runoff from urban and rural areas causes widespread, serious effects, including threats to public health. This problem will be difficult to address because it stems from many sources and cumulative activities across entire watersheds. Moreover, it is aggravated by the widespread alteration of watersheds and water flow and involves significant scientific and technical uncertainty. Marshaling new controls or expenditures to address an identified but diffuse problem has proven to be politically difficult. Adding to the problem is a lack of general public awareness of the sources of the pollution and the contributions that individuals can make to both the problems and the solutions.

Enhancing and Sustaining Coastal Environmental Quality

Solutions to coastal environmental quality problems are difficult to implement, in part because the responsibilities for the watersheds involved typically are shared among multiple governmental jurisdictions and authorities. The management of nonpoint sources, for example, requires

[6] Nonpoint-source pollution is defined as originating from non-distinct sources such as agricultural lands (which are sources of pesticides and fertilizers), roadways and other paved surfaces, soil erosion (which produces silt), septic tanks, and the air.

changes in many behaviors and activities that involve land use and a wide range of social and economic choices. Nonpoint-source pollution remains severe despite expenditures on controls at the state and federal levels through national efforts such as soil conservation programs, the Clean Water Act, and the Coastal Zone Management Act (16 U.S.C. 1451 et seq.). Because of the diffuse nature of nonpoint sources, the most effective approach may be to set national standards and best management practices at the federal level, supported with resources and interagency cooperation, rather than relying on inflexible mandates.

Locally designed solutions are being implemented through the National Estuary Program. Unlike traditional regulatory approaches to environmental protection, this program focuses on protecting not just water quality or individual species, but rather whole ecosystems. It also engages local communities in environmental planning and in protecting estuaries and the species that inhabit them. The national program requires stakeholders to create a comprehensive conservation and management plan for the long-term protection of those resources. Twenty-eight regional programs under the umbrella of the National Estuary Program are endeavoring to safeguard some of the nation's most important coastal waters.

The public's fundamental interest in clean water stems from personal health concerns, which can be expressed in questions such as, "Can I eat the fish?" "Can I swim in the water?" "Is the environment itself healthy?" Monitoring can help assess the well-being of the marine environment and the effectiveness of management policies and actions in maintaining or improving conditions. Although monitoring capabilities have advanced, much more can be done to strengthen the role of monitoring in marine environmental management (National Research Council, 1990). It is important to do so because knowledge is fundamental to any attempt to manage coastal environments in a way that both sustains resources and accommodates multiple uses.

The federal government recently developed a Clean Water Action Plan to chart a course toward fulfilling the original goal of the Clean Water Act—"Fishable and swimmable" waters for all Americans (U.S. Environmental Pro-tection Agency, 1998). The cornerstone of the plan is the watershed approach, which means that increased emphasis will be placed on controlling and preventing polluted runoff within the watershed. This approach is based on the recognition that clean water is a product of a healthy watershed, and that strategies to provide clean water must be built on the foundation created over the past 25 years and tailored to specific watershed conditions. Focusing on the whole watershed helps strike a balance among efforts to control point-source pollution and polluted runoff in the effort to protect drinking water and sensitive natural resources such as wetlands. The watershed approach helps identify the most cost-effective pollution-control strategies to meet clean-water goals. The plan emphasizes new partnerships working at the watershed level to involve the general public and bring together tribal, local, state, and federal programs with the private sector to clean up and protect waters effectively and efficiently.

Marine Protected Areas

A potentially powerful environmental protection measure is to set a region aside for conservation purposes. This approach, used for generations on land, has become widely accepted in marine conservation. Marine protected areas have proliferated around the globe, and a network of marine protected areas is emerging in the United States. Protected areas include national marine sanctuaries, national estuarine research reserves, national estuaries, national wildlife refuges, national parks and related designations, national forests, fishery closure areas, marine reserves, and essential fish habitats. A variety of area set-asides and protections also exist at the state and local levels.

Marine protected areas have proven to be valuable management tools for balancing protection of the environment with traditional uses and navigation freedoms (Roberts and Polunin, 1993). Depending on the management measures taken, marine protected areas can control direct pressures, such as physical alteration of habitats and harvesting of marine species, and also indirect pressures such as pollution and eutrophication, and invasions of exotic species (National Research Council, 1995d). The management measures taken in a particular area may address one or several of these threats; a protected area may be managed for multiple uses or solely for a protection objective. The two approaches are complementary rather than mutually exclusive. The Florida Keys National Marine Sanctuary is an example of combining these approaches.

Protected areas can help conserve ecosystem integrity by providing benchmarks of natural patterns and opportunities to study natural ecosystem function. By contrasting natural and user-induced changes, researchers can improve understanding of the effects of different uses and management approaches. In addition, when used for fisheries management, protected areas can help reduce uncertainty and possibly enhance the yield of fisheries outside the area.

Despite the numbers and diversity of marine protected areas, few provide strong or comprehensive protection for marine resources or effectively address the major threats. In California, for example, the extraction of living resources is prohibited in just nine out of 104 marine protected areas, in areas covering less than 10 square miles (or 0.2 percent of state waters). Resource managers may make greater use of “no take” zones in the future as statutory provisions to designate and protect essential fish habitat are implemented, and, more generally, as additional experience is gained with protected areas.

SHORELINE MANAGEMENT

Thirty of the 50 states have coasts. These states contain approximately 85 percent of the U.S. population. Moreover, about half of the U.S. population lives within 50 miles of the coast. The concentration of the populace on the coasts is expected to continue, resulting in increasing demand for shoreline development.

Much of the U.S. shoreline is sandy. A protective ribbon of islands stretches 2,700 miles from Maine to Texas, one of the longest and best defined coastal barriers in the world (Coastal Barriers Study Group, 1988). Sandy shorelines absorb the constant barrage of the sea. They buffer adjacent wetlands and the mainland from the daily, erosive brunt of waves, currents, and tides. Sandy shorelines, barrier islands, and their associated wetlands are ecologically rich and biologically diverse. People, too, seem drawn to this land-water interface. The sandy shorelines are, in fact, subject to many competing demands from recreational enthusiasts, water-dependent industries, real estate developers, the military, conservationists, and others.

Sandy shores are dynamic. Sand is carried by water and wind between offshore bars and the barrier beach, across the dunes, through coastal inlets, and throughout the entire littoral. Complicating the picture is the projected rise in sea level over the long term (Bijlsma, 1996). The impacts of a rise in sea level include inundation, flooding, erosion, and saline intrusion into coastal aquifers. Clearly, an environment featuring such dynamism and threats so dramatic poses unique problems for those who live or build there. Structures built too close to the shoreline are often threatened by erosion. Hard stabilization (i.e. groins, jetties) to prevent erosion, and soft stabilization techniques (i.e. beach nourishment), must be considered in concert, keeping in mind that shorelines differ and that one or another approach may or may not be successful (National Research Council, 1995e). In addition, whenever the supply of sand to the shoreline is interrupted, it is important to restore the supply to the greatest extent possible.

The degree of protection, management, or human intervention that may be needed depends on the nature of the shoreline and the prevailing uses of the adjacent area. For developed communities with water-dependent economic activities such as harbors and resorts, the strategy of choice is, in all likelihood, to protect the existing infrastructure and maintain beaches. For eroding shorelines that are less developed the decision becomes more difficult (National Research Council, 1985). The choice is either to stabilize the shoreline at some environmental and economic cost or to retreat from the shoreline and let nature take its course, also at some environmental and economic cost. Interestingly, many coastal property owners do not obtain insurance coverage for coastal hazards, especially flooding caused by hurricanes and chronic erosion (Miletti, 1997). In the alternative, property owners in high-risk areas turn to federal disaster relief programs when hit with high flood, wind, and erosion damages, shifting the burden to the nation's taxpayers.

Separate, uncoordinated government programs and practices make choosing stabilization measures more difficult. Sometimes the interests of different agencies come into conflict. For example, the tradition of local and state control of development can sometimes impede federal environmental management efforts. Federal insurance against losses from natural disasters, such as floods, may encourage shoreline development, perhaps promoting the erosion that other agencies seek to combat. Despite the economic and ecological importance of shorelines, the

United States still lacks adequate coordination among the federal agencies that manage shorelines.

To provide a basis for the development of a coordinated national approach to shoreline management, a comprehensive analysis of existing federal and state policies is needed. The analysis should address population and development trends in the context of overall risk, as well as mitigation measures, including the respective roles of hard and soft stabilization techniques versus letting nature take its course. A national approach to shoreline management would need to be implemented through local, state, and federal mechanisms.

OFFSHORE OIL AND GAS DEVELOPMENT

Oil and gas extraction from beneath the seabed is a major marine activity in the Gulf of Mexico, off Southern California, and in some regions of Alaska. Petroleum production from federally controlled offshore lands currently accounts for approximately 19 percent of all domestically produced oil and 27 percent of natural gas, and the percentages are growing. These domestic energy resources are especially important because the United States still depends heavily on imported oil, which supplies about half of the nation's petroleum consumption. The offshore program is also an important source of revenue for the government, generating over $1.4 billion in bonuses, $68 million in rents, and $3.5 billion in royalties in 1997. This industry is also an important employer in the Gulf of Mexico region and elsewhere, with 38,000 workers offshore and another 46,000 onshore support personnel (Gächter, 1997).

Offshore oil production is a major technological triumph. Traditionally a cyclical industry, the offshore oil and gas industry is currently booming. The most challenging and exciting discoveries are far from shore, in water depths ranging from 1,000 to 10,000 feet. Exploratory wells have been drilled in water as deep as 7,600 feet. The MARS project illustrates the scale of offshore activity. Located 130 miles offshore in 3,000 feet of water, the MARS project will produce 100,000 barrels of oil and 100 million cubic feet of natural gas per day. The production platform floats on the sea surface, is tethered by long steel tendons to the sea floor, and stands 3,250 feet tall (nearly three times the height of the Empire State Building). Oil and gas are pumped ashore, or to a gathering platform, through a pipeline that traverses extremely steep and corrugated undersea slopes. Tethered and robotic undersea vehicles play critical roles in the operation of the MARS structure and pipeline. In 1997, the Ram-Powell and Mensa projects in the Gulf of Mexico passed the MARS project in terms

of depth, producing in water 3,214 feet and 5,300 feet deep, respectively.

With the advent of new exploration, drilling, and production-related technologies, interest in the deeper waters has intensified. The MARS project and other deep-water operations are some of the largest, most complex industrial projects ever undertaken and were unimaginable a generation ago. As a result, offshore oil production is projected to increase as much as 70 to 100 percent in the Gulf of Mexico between 1995 and 2000, with exploration pushing beyond the Exclusive Economic Zone and product pipeline networks extending well off the continental shelf and down the continental slope.

The exploration, development, and production of oil and natural gas may affect the marine, coastal and human environments in several ways. Prior to approving any proposal, the Minerals Management Service performs the requisite National Environmental Policy Act (42 U.S.C. 4321 et seq.) analysis to obtain information to support decisions about mitigation of potential impacts, including

- physical disruption of the seafloor habitat and benthic communities;
- discharge of chemicals, drilling muds and cuttings, and produced waters;
- accidental hydrocarbon spills;
- hydrocarbon emissions from facilities, supply vessels, and helicopters;
- exploration and production noise impacts on marine mammals and fisheries stocks;
- impacts of explosive platform removals on fish species; and
- socioeconomic impacts on coastal communities and ports. Of special concern in Alaska are potential impacts on native Alaskan subsistence culture.

The Outer Continental Shelf Lands Act, as amended in 1978 (43 U.S.C. 1331 et seq.), requires the use of the best available pollution-prevention technologies. The Act further requires that research be conducted to assess, manage, and monitor the impacts of oil and natural gas development on the human, coastal, and marine environments. The Minerals Management Service conducts research to evaluate equipment and procedures that could further reduce the risk of environmental impacts. This information is used in making decisions about oil and natural gas activities and in developing appropriate regulations and lease conditions.

The number of significant spills from oil production in state and federal waters has been low, and the volume of oil spilled has declined fairly steadily over the years (Minerals Management Service, 1997). There has not been a spill larger than 1,000 barrels from oil and gas platforms on the outer continental shelf since 1980; in fact, natural seeps introduce approximately 100 times more oil into U.S. marine waters than do spills from offshore development and production activities. Increased precautions by industry, enhanced safety technologies (e.g., blowout prevention systems, shut-in valves), and strict adherence to government regulations most likely have minimized the risk of oil spills from offshore activities.

Although the risk of pollution from oil and gas development appears to be low, land-use decisions remain an ongoing issue. Favorable market conditions and improved exploration techniques have

already revitalized oil and gas exploration and development in the Gulf of Mexico. However, offshore development is not readily accepted by coastal populations in other areas. Local communities and others have blocked such development in many offshore areas because of environmental and land-use concerns. Some stakeholders, for example, are concerned about the adequacy of the local infrastructure to accommodate the growth that might be stimulated by offshore oil and gas development and production. The history of the federal offshore program shows that the successful development of ocean energy and mineral resources requires a shift from conflict to consensus among all stakeholders within the framework of a comprehensive management strategy (Minerals Management Service, 1993).

The need for consensus extends to the different levels of government, because the coastal states play a role in offshore oil and gas development. These states manage and regulate oil and natural gas activities in their waters and the associated onshore facilities. In addition, the Coastal Zone Management Act gives states explicit authority to assure that lease sales and permitting of activities on the outer continental shelf are consistent with state coastal zone management programs (which are federally approved). Federal and state laws related to energy and mineral resources often contain differing policy objectives that must be balanced.

In recent years, the federal government has resolved conflicts to a greater extent and more successfully by working with stakeholders. Efforts have been made to avoid and settle lawsuits concerning the offshore leasing program and to extend leasing more slowly into new areas to provide time for stakeholders to become engaged in the process. There have also been renewed discussions about providing coastal communities with impact assistance funded by revenues from offshore leases, to help offset the associated infrastructure costs and meet additional coastal investment needs. These and other steps have set a new, more conciliatory tone for the offshore leasing program and provide the necessary preconditions for more holistic management of ocean resources. An impact assistance program might strengthen relationships and participation among levels of government concerning offshore development and lead to better planning and impact mitigation.

FUTURE OF U.S. PORTS

The United States is the largest consumer nation, and most of its imports and exports—41 percent of foreign trade by value (and a much larger percentage by weight)—are shipped by sea (National Oceanic and Atmospheric Administration, 1998). In 1995, waterborne commerce totaled 2.24 billion short tons, including 1.09 billion tons in domestic cargo and 1.15 billion tons in foreign trade. The foreign trade alone was valued at more than $600 billion. This trade is expected to triple by 2020, and the U.S. transportation infrastructure must be capable of handling the growth. Domestic marine transportation complements the international trade and serves 47,000 miles of U.S. waterways and 185 major ports.

Oil is by far the most common cargo shipped by water, with 9 million barrels imported every day. Along with oil tankers and barges, many other ships

operate on the waterways. Large containerships striving for tight and reliable transoceanic schedules are essential cogs in just-in-time manufacturing and retail inventory management. Approximately 100 large cruise ships embark frequently from U.S. ports with large numbers of passengers. In all, commercial vessels make roughly 70,000 port calls each year. Approximately 110,000 fishing vessels operate from U.S. ports, and there are more than 20 million recreational craft (National Research Council, 1995b).

The locus of all this activity is the port. Ports are commercial hubs, generating economic vitality and enhancing overall quality of life. Stakeholders in the future of ports are diverse. Commercial stakeholders include waterfront industries, shipping companies, manufacturers of all types, and commodities brokers. State and local governments depend on ports to stimulate regional development. Members of the public enjoy boating and various waterfront activities and want to protect the coastal environment. A number of federal agencies are concerned with the future of ports because of their duties to promote trade, ensure maritime safety, maintain waterways, and enforce environmental regulations.

Ports also provide essential services in national emergencies. Thus, their capabilities and efficiency contribute to national security. The reductions in U.S. forces based overseas, a result of the post-Cold War peace dividend, have increased the nation's reliance on an efficient marine transportation system. For example, during the Persian Gulf War, 95 percent of the supplies for American forces were transported by ship. During the peaks of the Desert Shield logistics buildup, the number of supply ships engaged averaged one every 50 miles between the East Coast and the Persian Gulf. Efficient ports are critical to the nation's stability as well as its capability to respond to world crises with appropriate aid, ranging from food to disaster assistance to military forces.

Despite their importance, many U.S. ports are showing signs of stress, a disturbing prospect as the nation competes in an increasingly dynamic global economy. A study by international tanker operators found that port infrastructure in the United States is being pushed to the limits of its capability, with major decisions about investing in infrastructure renewal on the horizon. The report concludes that, "It is an anomaly that tankers which approach U.S. terminals do so without the support of a modern vessel traffic system, many times base their approach on fifty year old charts, are instructed to approach the berth on less than adequate water draft, and finally moor at a berth which was designed to accommodate ships much smaller than a modern tanker" (INTERTANKO, 1996).

Ports are being affected by important changes in two areas (Bookman, 1996). The first is the rapidly changing intermodal freight transportation market, which moves increasing amounts of cargo on ever-more-demanding schedules. This market has fueled a trend toward larger and faster ships that make precisely timed and efficient port connections to achieve maximum cost effectiveness and competitiveness. The survival of a general cargo port therefore depends on its capability to receive and transfer goods as quickly as possible. A 1991 survey found

that half of public ports and two-thirds of container ports faced growing problems providing seamless links among ports, highways, and railroads (National Research Council, 1993a). There is also a growing need to deepen and widen channels to accommodate the new generation of larger cargo ships.

The second factor is the increasing number and complexity of environmental regulations that pertain to ports (National Research Council, 1997b). In some regions, port maintenance and modernization have been delayed, and costs have been increased, as a result of difficulties in finding acceptable solutions for the disposal or use of dredged material, obtaining land-use approvals for new port facilities and access routes, and resolving other issues. Increasing environmental awareness and mounting environmental problems affecting coastal areas and ocean waters have made dredged material management, in particular, a contentious problem in a number of ports. Many ports are also finding it increasingly expensive and difficult to manage wastes, respond to spills of oil and hazardous substances, control air emissions, and comply with wetlands protection and endangered species legislation. Significant progress is being made to address these problems through cooperative efforts by federal and state governments, local communities, and nongovernmental organizations. Particularly noteworthy are dredged material management planning efforts in the Port of New York/New Jersey, San Francisco Bay, and Galveston Bay.

U.S. ports and waterways are at a critical juncture. Failure to address the need for modernization will adversely affect the economy, environmental security, and national security. On the positive side, a coordinated modernization effort is being launched. The U.S. Department of Transportation recently brought together the many federal agencies responsible for waterways management to discuss issues, coordinate programs and services, and promote efficiency and safety. A national dialog with local stakeholders has also been initiated. Policy coordination at the national level, combined with action at the local port level, can help ensure an adequate infrastructure, including appropriate channel and berth depths, real-time navigation information, modern port facilities, and efficient intermodal connections.

The emerging trend toward vertical and horizontal collaboration among governments and port interests could provide a vehicle for modernization. The Congress could establish a demonstration program to make planning funds available to port regions. These planning funds could be used to forge port modernization partnerships and undertake strategic planning that supports the national interest. For regions and partnerships that successfully undertake such efforts, it might be possible to offer an additional incentive, perhaps expedited federal action on related projects and permits. Such a demonstration program might be established in the normal course of reauthorizing any of several relevant statutes. Coordinated planning may hasten the modernization of safer and more efficient ports, thereby promoting economic growth in an environmentally sound manner.

GOVERNANCE AND MANAGEMENT

Two themes are common to each topic addressed previously in this chapter: inappropriate or inadequate public investment in infrastructure, and fragmented governance and management regimes.

Effective governance of the coastal ocean is difficult at best. Large areas of marine resources are in the public domain. The resources are diverse, as are the resource users. Monitoring and enforcement are especially difficult offshore. These inherent difficulties are compounded by the great number of activities that occur in, on, and under the coastal ocean, and the fractured framework of laws, regulations, and practices that exists at the federal, state, and local levels.

Failures in governance are having increasingly deleterious effects as the marine environment is used more intensely. The biological integrity of the sea has been impaired, as evidenced by depleted fisheries, reductions in marine biodiversity, and the loss of critical coastal habitats. Growing conflicts over the use of marine resources often result in wasted opportunities and unnecessary costs. Delays in dredging harbors, for example, can result in cargo and revenues being shifted to other ports, regions, and transport modes. Problems of this type are bound to become more acute as growing populations exert increasing stresses on the water's edge.

Coastal zones are archetypical complex systems.[7] The interacting forces on coastal areas produce effects that frequently are not intuitively obvious. These multifaceted forces are both natural and anthropogenic and arise both within and outside the coastal areas. The result is management efforts that struggle with diverse goals that sometimes are incompatible. Single-purpose legislation that serves specific goals well has also established multiple modes of management that require great coordination.

Despite the difficulties, examples abound of successful, innovative ocean and coastal management efforts.[8] The 25-year-old Coastal Zone Management Program establishes national policy for coastal areas and empowers states independently to plan and implement programs that meet national policy objectives. In the National Estuary Program, comprehensive planning has been undertaken in 28 estuaries to improve water, sediment, and habitat quality (i.e. overall ecosystems) in a sustainable manner. Although parti-cipating estuaries have been congress-ionally designated, the program is successful because of its strong regional focus. Coastal states are exercising increased control over issues such as ocean pollution, fisheries management, public access, and coastal zone impacts of ocean uses. Although most states manage ocean uses and resources with single-purpose statutes, seven are actively developing or implementing more comprehensive ocean management policies.

The complexity of the management challenge is widely recognized. The

[7] This discussion of integrated coastal management is condensed from the work of Robert M. White, a senior fellow at The Heinz Center, in his paper "Managing Coastal Complexity," which was presented at the Coastal Zone 97 Conference, held in Boston in July 1997.

[8] Detailed examples are provided in a recent report by the National Research Council (1997a).

concept of integrated coastal management is frequently invoked to address the complexity issue (National Research Council, 1993b). Integrated coastal management is a sound concept, but it means different things to different people. There are also formidable obstacles to its practical implementation. There are bureaucratic obstacles in the form of agencies seeking to protect their "turf," economic issues posed by stakeholders who want to advance their own financial interests, and legal concerns created by constituencies who want to achieve their goals through legislative action. There are also political obstacles because the boundaries of cities, counties, and other jurisdictions do not coincide with those of natural coastal zone systems. The core of the conundrum is whether it is possible to manage any coastal activity without managing all coastal activities in an integrated manner.

A fully developed marine governance and management system must necessarily evolve over time and in response to experience gained in managing the coast. However, there seem to be many opportunities to move forward now. Moreover, improvements in governance and management seem to be prerequisites to both productive economic investments and sound environmental stewardship.

General attributes of a successful coastal and ocean governance system, identified during The Heinz Center Year of the Ocean project, are presented in Box 2-1. As the framework for marine area governance and management continues to be developed, it will be important to avoid the tendency to perpetuate the long-standing dichotomy and separation between ocean uses and conservation. The complexity of the existing system of governance often contributes to this polarization. Absent new and innovative ways to bring more cohesiveness to ocean resource management, progress will continue to be hampered by "fragmented and compartmentalized management processes made more complicated by cross-jurisdictional issues and authorities" (Burroughs and Baird, 1995).

Simply put, the policy and legal infrastructure often does not correspond to practical needs. The governance system must place greater emphasis on the use of integrated management approaches to bring together all the stakeholders to address the economic, environmental, and social demands placed on finite ocean and coastal resources. At the same time, focused efforts are needed to harness the expertise and resources of nongovernmental entities, such as private industry, user groups, and nonprofit organizations. Such efforts can help infuse new ideas and resources into a system that has been largely dominated by insiders accustomed to traditional management approaches.

BOX 2-1: ATTRIBUTES OF SUCCESSFUL COASTAL AND OCEAN GOVERNANCE

- overall vision and mechanism for measuring progress
- integrated across all sectors, constituencies, and stakeholders
- decentralized as much as possible but with common goal and objectives
- participatory decision making that promotes good faith, confidence building, and ability to reach closure
- role clarity for participants; there must be a leader, contact, or focal point; someone must have final say
- stakeholders committed to process instead of using political clout to get their own way
- mechanism for conflict resolution
- clear process with a beginning, middle, and end
- adaptive, flexible process that fosters innovation and risk taking
- incentives for collaboration
- cost efficient; considers cost to environment (i.e., external costs) as well as direct internal costs
- realistic, pragmatic programs that use existing capabilities when appropriate
- adequate financial and physical resources to support process and infrastructure as appropriate
- maximizes use of good natural science and social science in decision making
- data on which decisions are based are openly available
- public information and education by government and/or private groups

KEY QUESTIONS

If the United States is to protect and conserve the coastal environment and meet the many other, related challenges of coming decades, then the following key questions must be addressed:

- *What are the priorities among the many environmental threats to the coastal ocean, including estuaries? What steps are necessary to restore, protect and enhance the coastal ocean? What technological, land use, partnership, and public education initiatives can be pursued to reduce nonpoint-source pollution and restore and protect coastal environmental quality? How can the benefits of marine protected areas be assessed and optimized?*

- *Does the United States need a coordinated federal policy concerning management of its shorelines? What steps would lead to the development and implementation of a coordinated national approach to shoreline management?*

- *Has the offshore leasing and development program achieved an acceptable balance between national and local interests, and between resource use and conservation? Would an impact assistance program help achieve a balance between economic and environmental protection?*

- *What steps can be taken to promote U.S. port modernization (and the nation's economic prosperity) while also meeting the many demands on ports to protect the marine environment? How can coordination among port stakeholders, and between regional and port planners, be encouraged?*

- *How do we give operational life to the concept of integrated coastal management? Would a greater degree of coordination or integration of federal ocean programs make it easier to set priorities, or resolve potential use conflicts? How can we achieve a greater degree of effectiveness of federal, state, and local governance approaches? How can the expertise and resources of nongovernmental entities be harnessed in partnership to help set priorities and resolve use conflicts?*

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3

PROTECTING AND RESTORING MARINE FISHERIES

SUMMARY

The 1976 Magnuson Fishery Conservation and Management Act (P.L. 94-265) was highly successful in Americanizing U.S. fisheries, which previously had been dominated by foreign fleets, and in attracting investment in the fishing industry. However, the regional fishery management structure established by the Act has not always succeeded in maintaining uniformly healthy, fully productive fishery resources. Off every shore and in every estuary, the nation faces the difficult challenge of managing its fisheries sustainably. Although the commitment to conservation has recently been strengthened in reauthorized legislation (P.L. 104-297), a great deal of work must be done to ensure that this resolve is honored in practice. Fishery managers today need to muster the resources and political will to identify and protect essential fish habitat, address the problem of excess fishing capacity, reduce bycatch, address the future of aquaculture and its potential impacts on the marine environment, and use manage-ment techniques that conserve ecosystem values such as the protection of biodiversity.

BACKGROUND

Fisheries contribute a significant source of protein to a growing world population[9] and provide a commercial livelihood and recreational opportunities for millions of people across the globe.[10] However, the majority of economically valuable marine fisheries[11] are now at or beyond their limits of sustainability. The United Nations' Food and Agriculture Organization (FAO) (1997) has classified 62 percent of commercial stocks as "in urgent need of management action." Fisheries are in crisis worldwide and fisheries management is at a crossroads.

Since 1977, the marine fisheries of the United States have been managed under the Magnuson Fishery Conservation and Management Act (MFCMA) (16 U.S.C. 1801 et seq.). The MFCMA was designed to eliminate foreign fishing within the U.S. Exclusive Economic Zone and to conserve and manage U.S. marine fisheries. The Act was implemented at a time when the oceans were generally considered to be a limitless source of food and natural resources. The impacts of fishing were not viewed as threatening; indeed, increases in fishing capacity were generally not constrained and were even encouraged.[12]

Commercial landings have tripled since the United States extended its

[9] Sixteen percent of all animal protein consumed worldwide comes from the oceans (Food and Agriculture Organization, 1997).

[10] Worldwide, there are 15 to 20 million fishers (90 percent are small scale), and fisheries provide up to 180 million more jobs in associated sectors (Food and Agriculture Organization, 1997).

[11] The total value of global marine catch is estimated at $80 billion annually (Food and Agriculture Organization, 1997).

[12] For example, fishing was encouraged by the Processors Preference Amendment, Fisheries Promotion Act, and Fishing Vessel Obligation Guarantee Program.

jurisdiction with the enactment of the MFCMA. The annual U.S. catch has fluctuated between 4.2 and 5.0 million metric tons since 1990; it was 4.3 million metric tons in 1996[13]. Fish provide 8 percent of the U.S. animal protein food supply. Consumer expenditures, including retail sales for home consumption, restaurant sales, and industrial fish products, were $41.2 billion in 1996 (U.S. Department of Commerce, 1997). Fishing contributed $21 billion in value added to the 1996 gross national product (U.S. Department of Commerce, 1997).

Estimates of the value of recreational fisheries are incomplete, as are the data related to catch levels and fishing mortality associated with this sector. However, in some fisheries, the value of the recreational sector is equivalent to, or greater, than that of the commercial sector (National Marine Fisheries Service, 1996a). U.S. salt-water anglers number more than 10 million and contribute some $9 billion annually to the economy (U.S. Government, 1997).

The MFCMA established eight regional fishery management councils and assigned them the responsibility for developing fisheries management plans in accordance with national standards. The council system is designed to allow management approaches that incorporate the special characteristics of each fishing region. The councils have developed very different approaches to decision making,[14] which, in turn, have led to different performance outcomes. The variations in management approach and performance reflect, in part, wide disparities in the size and value of the stocks classified as overfished. Fisheries management plans adopted by the regional councils differ with respect to regulatory compliance, adoption of multispecies regulations, approaches to bycatch, stake-holder participation, and social and economic impacts.

Neither the councils, nor the Act itself, have been successful in conserving the nation's fisheries. Over one-third of U.S. fish stocks are overutilized[15] (National Marine Fisheries Service, 1996b).

In 1996, the MFCMA was reauthorized as the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (P.L. 104-297). The MSFCMA provides stronger provisions for fishery management and conservation within the Exclusive Economic Zone by requiring the National Marine Fisheries Service and regional councils to protect essential fish habitat, reduce overfishing and overcapitalization,[16] and minimize bycatch (National Marine Fisheries Service, 1996c).

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[13] The U.S. catch represents 5 percent of the worldwide total (U.S. Department of Commerce, 1997).

[14] There are regional variations in decision procedures, mix of fishery management tools, use of advisory committees, stock assessment procedures, use of economic and social data, and interactions with stakeholders.

[15] "Overutilized" is defined as fished at levels greater than that necessary to achieve the maximum long-term potential yield.

[8] A fishery is overcapitalized when the amount of harvesting capacity exceeds the amount needed to harvest the desired amount of fish at least cost (Organization for Economic Cooperation and Development, 1997).

These changes to the Act create new responsibilities for the regional fishery management councils. These added responsibilities, which in many cases are not yet well-defined, present significant challenges for the already heavily burdened council system. Adequate financial and personnel resources are needed to help the councils meeting the new requirements. Both the U.S. Congress and the Administration will have to maintain a strong commitment if the new provisions in the MSFCMA are to be implemented fully.

The Year of the Ocean provides a timely opportunity to examine national ocean policies and programs as the nation prepares for the twenty-first century. Protection of the nation's marine fisheries and assurance of their long-term sustainability are vital to the economic well-being of the many Americans who depend on fishing for their livelihood. These efforts are also critical to the health of marine ecosystems, which represent an important part of the natural heritage and provide social, economic, and environmental services to all Americans.

KEY ISSUES

A number of key issues must be addressed if U.S. marine fisheries are to be protected and restored. These issues include overfishing, overcapitalization, bycatch, habitat degradation, aquaculture and its impacts on the marine environment, and management of interjurisdictional fisheries. The overarching theme of ecosystem management also demands attention. Marine fisheries are components of ecosystems, and their continued existence at biologically and economically optimal levels depends on the protection of these ecosystems. Unless adequate attention is devoted to the overall environment in which fish populations live, efforts to protect particular fisheries and restore them to sustainable levels are unlikely to be successful.

Each of these issues is discussed briefly in the following sections. Resolution of these issues clearly will require the development of alternative management strategies and the encouragement of effective, streamlined approaches to collaboration among the wide variety of federal, regional, and state authorities that make decisions affecting the marine environment (National Research Council, 1997).

Overfishing

Overfishing is the principal factor contributing to the depletion of U.S. marine fisheries. The National Marine Fisheries Service (1996b) has classified 36 percent of U.S. fisheries as overutilized and 44 percent as fully utilized. Because of current or past overuse, the fisheries are producing only about 60 percent of their estimated long-term potential yield (National Marine Fisheries Service,1996b).

The MSFCMA directs the National Marine Fisheries Service and regional fishery management councils to eliminate overfishing[17] in domestic waters. In the past, uncertainty about the status of fish stocks allowed managers, often succumbing to political pressures, to set

[17] Overfishing is defined as a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis.

quotas at the high end of the estimated range. The revised Act now provides explicit time frames for rebuilding overfished populations. An ongoing problem is the taking of many migratory, straddling,[18] and high seas stocks by individuals from other countries, a practice that limits the capability of U.S. fishery managers to achieve adequate recovery without the active participation of other nations in conservation efforts.

A great deal of work needs to be done to determine how best to eliminate overfishing. For example, should access to fisheries be more strictly regulated, and, if so, how can this be achieved in a manner that is both effective and fair? Given the limitations of fishery science, should regulatory bodies be directed to act conservatively, with a bias toward conservation, when faced with uncertainty regarding the health of fisheries under their jurisdiction? And how might this "precautionary principle"[19] be implemented? The variations in characteristics and conditions of individual fisheries suggest that different strategies, involving both regulatory and market-based approaches, are appropriate for different situations. Greater effort needs to be devoted to identifying alternative approaches to fisheries management and ascertaining their strengths and weaknesses over time.

Overcapitalization

A major driver of overfishing is the overcapitalization of fishing fleets. Over-capitalization creates economic waste and political pressures for increased catch. The Food and Agriculture Organization estimates that global fishing capacity in traditional fisheries is 30 percent greater than that required to take the present world catch. Although no comprehensive estimates are available on the degree of over-capitalization in U.S. fleets, anecdotal evidence indicates that it has reached critical proportions in some fisheries, both com-mercial and recreational. There is broad consensus among experts and fishermen alike that, in many fisheries and regions, the pressure to capture short-term benefits of fisheries at the expense of long-term sustainability cannot be relieved until fishing capacity is reduced.

A key issue is the extent to which fishing capacity must be reduced to manage the resources more effectively. If it is essential to reduce fishing capacity, then considerably more analysis and discussion are needed regarding certain issues, including the role that federal and state governments can and should play in addressing this problem. Specifically, there is a need to examine whether the elimination or reduction of existing subsidy programs, such as the Capital Construction Fund and the Fishing Vessel Obligation Guarantee Program, would prevent future increases in capacity. Also needed is a thorough analysis of the types of market-based incentives and mechanisms that might help reduce overcapitalization and prevent it from recurring, and do so in ways that are acceptable to stakeholders.

Bycatch

[18] Straddling stocks are those whose habitats cross the boundaries of managerial or political jurisdictions.

[19] The precautionary principle calls for conservative action in the face of uncertainty.

Bycatch—the unintended catch of immature fish, unmarketable or protected species, and other nontargeted species—is among the most difficult challenges in fishery management. Furthermore, it is a problem that grows with escalating fishing pressures and declining stocks. Worldwide, an estimated 27 million metric tons of bycatch are discarded each year, an amount equivalent to roughly 25 percent of the global catch (Food and Agriculture Organization, 1997). If those percentages hold for the United States, then bycatch in U.S. fisheries is about 1.8 million metric tons per year, based on 1992–1994 average catch statistics (National Marine Fisheries Service, 1996b). A critical bycatch problem is exemplified in the Gulf of Mexico shrimp fishery, where 4 to 5 pounds of nontargeted species are captured, and mostly discarded, for every pound of shrimp taken. The bycatch problem is not confined to nontargeted species of fish. Each year, large numbers of seabirds and other marine creatures (including whales, dolphins, sea turtles, and marine invertebrates such as crabs, starfish, and sponges) perish in the trawls, nets, and lines of fishers.

Incentives need to be developed to encourage all fisheries to address this problem aggressively. Resources need to be directed toward developing new types of fishing gear that minimize bycatch, promote the survival of nontarget fish and other creatures until they can be released, and enable fishers to return unwanted species alive back to the sea. Finally, although the MSFCMA requires action to minimize bycatch, successful reduction efforts will depend on monitoring and enforcement as well as on the compliance of fishers (Reichert, 1997).

Habitat Protection

Marine fisheries and other living marine resources are dependent on the integrity of the habitats in which they live. Habitats—such as wetlands, coral reefs, oyster beds, kelp forests, and coastal waters that provide essential spawning and nursery grounds for fish and serve as the primary home for a large number of marine species—are being degraded rapidly through a multitude of human activities related to fishing. These practices include bottom trawling, dredging for scallops and clams, coastal development, and the introduction of alien species.

The protection of essential fish habitat is an important new responsibility of the regional fishery management councils. Yet a very small percentage of the National Marine Fisheries Service budget is allocated to the critical role of habitat protection as an essential tool for maintaining and restoring marine fisheries. Furthermore, although the regional councils can take certain actions to minimize the effects of fishing on habitats, they cannot control other important variables, such as nonpoint-source pollution, eutrophication, and physical habitat loss resulting from coastal development or other activities.

To protect essential fish habitat, new mechanisms must be found to streamline and consolidate authority among federal, regional, and state agencies that have jurisdiction over activities that contribute to habitat destruction. Efforts need to be made to identify ways to strengthen both state and federal laws, such as the Coastal Zone Management Act

(16 U.S.C. 1451 et seq.) and the Clean Water Act (33 U.S.C. 1251 et seq.), to reduce habitat destruction caused by land-based pollution. In addition, resources need to be provided to rehabilitate damaged ecosystems and restore estuarine and other habitats that are critical to the reproduction and maintenance of marine fisheries.

Aquaculture

Worldwide, the aquaculture industry is growing rapidly. Total aquaculture production reached a record 25 million metric tons in 1994, with sales of approximately $40 billion in U.S. dollars (Food and Agriculture Organization, 1997). Considering the growing demand, production could reach 39 million metric tons by 2010 (Muir and Nugent, 1995).[20]

In the United States, the aquaculture industry (primarily catfish, cupped oysters, rainbow trout, golden shiner for bait, salmon, and crawfish) is growing more rapidly than any other sector of U.S. agriculture (Electric Power Research Institute, 1995). In 1996, the United States cultured more than 300,000 metric tons of seafood.[21] The industry now exists in virtually every state and territory (Office of Technology Assessment, 1995). Increases in aquaculture are driven by a combination of growing consumer demand, a favorable price differential between aquaculture products and wild catch, advances in aquaculture technology (National Research Council, 1992), and the continuing depletion of popular fish species in the wild.

Aquaculture is often viewed as a source of jobs and revenue for local communities, a promising new food source, and a way to supplement wild fish populations. Yet aquaculture operations can also have significant negative impacts on the marine environment and on fisheries. With the rapid growth and expansion of this industry, special attention must be devoted to environmental concerns. In particular, there is an urgent need to develop standards for aquaculture that minimize pollution, prevent the introduction of alien species and diseases that can seriously threaten wild fish populations, minimize habitat destruction, and protect other wildlife such as seals and fish-eating birds that tend to prey on confined fish stocks.

Interjurisdictional Fisheries

The U.S. government shares jurisdiction over many fisheries with states within its own borders as well as with other nations. Government officials need to be certain that negotiations over management practices and conservation measures do not lead to fishery management outcomes that are weaker than those sought through the MSFCMA.

Domestically, it is important to coordinate conservation standards and guidelines among state, regional, and federal authorities; take steps to eliminate conflicting mandates among different government agencies; consolidate and

[20] This estimate does not include the production of aquatic plants, of which 6.4 million tons were produced by China, Japan, the Republic of Korea, and the Philippines in 1994.

[21] The United States is the world's fifth-largest producer of seafood (U.S. Department of Commerce, 1997).

streamline decision making; and encourage improved collaboration. Internationally, certain fisheries are managed directly under treaties and international agreements. These instruments provide general principles for fisheries management worldwide,[22] but many have yet to enter into force because they have not been ratified by a sufficient number of countries. In particular, high-seas stocks, which live outside the formal jurisdiction of any nation's exclusive economic zone, are vulnerable to overfishing and to the use of destructive fishing practices. Until the United Nations Agreement on Conservation and Manage-ment of Straddling Stocks and Highly Migratory Fish Stocks enters into force, many high seas fisheries are protected only through voluntary agreements, which have proven to be largely ineffective.

Because many fish migrate over long distances and move in and out of U.S. waters, the federal government, to protect domestic fisheries, needs to exert its leadership to encourage other countries to ratify important international agreements aimed at conserving fisheries. The United States also needs to insist that such agreements comply with scientific standards and prevent fishing beyond maximum sustainable yields. In cases where international bodies have failed to establish policies and practices that adequately protect fish that move between national boundaries, the United States must retain the flexibility to establish more rigorous quotas and other management tools aimed at protecting these fish while they are in U.S. waters.

At present, it is clear that many international bodies and individual governments are not equipped to manage across jurisdictions. Techniques must be developed to strengthen capabilities in this area. In addition, new approaches are needed that require compliance of participating nations and systems need to be designed and funded that allow for adequate monitoring and enforcement.

Ecosystem Management

Scientists and fisheries managers worldwide increasingly have recognized that fish are part of a broad ecosystem that contains numerous marine species, all of which are important to the healthy functioning of the system as a whole. With

[22] The Rome Consensus on World Fisheries, adopted by the Food and Agriculture Organization ministerial meeting in March 1995, includes agreement on the need to eliminate overfishing, reduce fishing capacity, reduce bycatch and discards, and strengthen governance. The Code of Conduct On Responsible Fisheries, adopted by the Rome Conference of the Food and Agriculture Organization in October 1995, contains guidelines on fishery management and operations, aquaculture, coastal zone management, trade, and research. The Kyoto Declaration, adopted at the 1995 Conference on the Sustainable Contribution of Fisheries to Food Security, includes agreements on the need to reduce fishing capacity, strengthen the scientific basis for multispecies and ecosystem management, reduce incidental catch, and strengthen institutional coordination. The United Nations Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, adopted in 1995 and ratified by the United States in 1996 but not yet entered into force, represents a consensus among coastal states and distant-water fishing nations concerning the 10 percent of ocean stocks caught on the high seas. The agreement includes provisions for the protection of biodiversity and the use of the precautionary principle. In several cases, these international agreements are leading to national efforts to define and implement the principles embedded in the various actions (Food and Agriculture Organization, 1997).

this recognition has come the need to integrate the management of all marine species, not just individual fish stocks, to protect the overall well-being of the marine ecosystem in which fish live. Successful fisheries management cannot be aimed simply at preserving a single fishery. Rather, it must take into account the maintenance of natural patterns of species composition, or biodiversity, within the broader marine environment.

The MSFCMA contains provisions designed to move U.S. fisheries away from single-stock management and toward ecosystem management. However, numerous challenges need to be addressed before this goal can be accomplished effectively. Greater scientific understanding is needed regarding the complex web of interactions that contribute to ecosystem function. Methods are needed to involve stakeholders representing a broad diversity of commercial, recreational, and conservation interests in research and management. And greater effort is needed to design controlled-access management systems that are fair. The use of maximum sustainable yield as an operational concept needs to be viewed within a larger ecosystem context, so that this approach, which focuses on surplus production, is balanced with requirements for ecosystem function in which "surplus" fish often maintain other species. Finally, improved techniques are needed to ensure that margins of safety corresponding to the degree of uncertainty about the effects of resource use are built into management regimes in such a way as to protect the overall ecosystem.

Marine protected areas are a promising technique for preserving marine ecosystems and protecting fisheries. The protection of specific areas from any direct use offers a number of potential benefits, including the preservation of breeding grounds for threatened or endangered species, assurance that examples of natural ecosystems will exist in the future, and the protection of species with potential biomedical benefits. Protected areas can also serve as controls in research on natural ecosystem function to gain valuable insights into how to improve fisheries management.

As the nation moves forward to take full advantage of the potential benefits of marine protected areas, greater effort needs to be made to understand how best to design these areas to accomplish different tasks, such as the replenishment of fisheries, the protection of endangered species, and the preservation of scenic and other values. It will also be necessary to determine how protected areas can best be incorporated into broader fishery management systems and what criteria should be established for determining their location and size. Finally, considerably more attention needs to be placed on the design and implementation of adequate monitoring and enforcement systems aimed at ensuring that these areas actually accomplish what they are intended to do.

KEY QUESTIONS

If the United States is to build and maintain sustainable fisheries, protect other marine resources, and conserve and restore living marine resource habitat (U.S. Department of Commerce, 1996), then it will be necessary to answer these important questions:

- *What steps can be taken by the National Marine Fisheries Service and the regional fisheries management councils to facilitate the swift and effective implementation of laws that are designed to eliminate overfishing, reduce bycatch, and protect essential fish habitat?*

- *What steps need to be taken to reduce fishing capacity and prevent the recurrence of overcapacity to restore fish populations to—and maintain them at—levels that are commercially and ecologically sustainable? How can this be accomplished in an equitable manner, taking into account the interests of all sectors and parties?*

- *What management strategies might better protect habitat that is critical to fisheries and other living marine resources? How can these strategies be implemented?*

- *How can marine aquaculture evolve in the United States in a manner that does not adversely affect the environment?*

- *How can coordination be improved among state, regional, and federal authorities whose mandates and jurisdictions affect areas that are important to the conservation of marine fisheries?*

- *What role should the United States play in encouraging the design and imple-mentation of international agreements and treaties that protect fisheries and other living marine resources?*

Marine resources are vital to the American economy and environment. All stakeholders at The Heinz Center's national conference on fisheries recognized the need to restore depleted fisheries, protect marine ecosystems, and manage the future use of marine resources in ways that are sustainable and do not threaten marine biological diversity. The Year of the Ocean provides a timely opportunity to strengthen the commitment to protect the nation's marine fisheries and other living marine resources and ensure that future generations of Americans will be able to enjoy the numerous social, economic, environmental, and aesthetic benefits provided by the oceans. A sustained political commitment will be needed among policy makers at both the federal and state levels to address these issues. Fishers and other stakeholders will need to work alongside government in a vigorous effort to develop more effective ways to manage marine resources in ways that accommodate uncertainty, value sustainability, and preserve viable commercial and recreational fisheries for the benefit of all Americans.

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4

SCIENCE AND TECHNOLOGY—KEY TO OCEAN UNDERSTANDING

SUMMARY

By enhancing capabilities to observe and understand the physics, chemistry, and biology of the oceans and their dynamics, the United States can help improve both the economy and the environment. During the last half of the twentieth century, investments in ocean science and technology have been driven largely by national defense needs. The focus is now shifting to sustainability. Just as the Cold War provided a strategic vision for the postwar era, it is necessary today to develop a compelling vision that encompasses both a productive economy and thriving environment.

Additional investments in ocean research and the development of new technologies and observing systems may lead to new levels of prediction of natural disasters and climate change. With the maturation of knowledge of plate tectonics, scientists will better understand the evolution of the Earth and its implications for predicting earthquakes and the distribution of mineral resources. An enhanced understanding of the complexities, fragility, and resilience of ocean ecosystems may help humanity manage these ecosystems wisely in ways that maximize the use of living marine resources without adversely affecting their sustainability. The discoveries of exotic life forms in extremely hot deep-sea vents suggests that the oceans may harbor new clues about the origins of life. To make this vision a reality, investments must be made in education, technical assistance, and facilities for ocean research. In addition, the knowledge gained through investments in ocean research needs to be made available to coastal and ocean managers and to industry.

INTRODUCTION: THE OCEANS AND SOCIETY

The oceans are ubiquitous in their effects on society.[23] They are the source of the rainfall that sustains humanity's agricultural food supply. They are a treasure trove of living and nonliving resources. They are global avenues of commerce and arenas for worldwide military presence. They shape the pathways of the planet's most destructive storms, such as hurricanes, even as they regulate the climate. They bathe the Earth's coasts, home to an expanding population. The oceans are also the receptacle for much of the world's wastes.

If the oceans are to be managed and conserved amid growing use of their resources, then a greater understanding is needed of their dynamics and changing chemical composition, interaction with the atmosphere, living and nonliving resources, tolerance for and response to pollution, and effects on society. The acquisition of such knowledge requires systematic, long-term investments by both the government and the

[23] This chapter focuses on the open ocean, but many of the topics addressed are also pertinent to coastal areas, bays, estuaries, and the Great Lakes. Coastal zone and fisheries science and technology issues are discussed in Chapter 2, "The Challenge of Sustainable Coasts," and Chapter 3, "Protecting and Restoring Marine Fisheries."

private sector in ocean research and the development and application of technologies that can probe a vast and mysterious domain that is difficult to study.

The present national ocean sciences enterprise comprises a diverse set of disciplines and myriad technologies for exploring, monitoring, observing, and predicting the state of the oceans. Many of these systems rival space technologies in terms of complexity. Some eight federal agencies spend a combined total of approximately $500 million annually on ocean science and technology. Although serious efforts are under way to coordinate the diverse ocean science and technology efforts, no comprehensive national strategy guides them. The overall result is essentially the sum of the individual parts rather than a cohesive program in which projects are designed to leverage others.

Any ocean science and technology strategy must follow from the important national interests in the seas. The national investment strategy must address the major knowledge gaps and develop the means necessary to close them. This chapter discusses these gaps in three sections: the relationship between the oceans and the concept of sustainability, ocean facilities and technologies and access to them, and human and fiscal resources. [24]

[24] The discussions at The Heinz Center's national meeting on ocean science and technology were based in part on a report by the National Research Council (1992). Although somewhat dated, this report provides a comprehensive assessment of the state of ocean science and technology and identifies important research directions for the future.

THE OCEANS AND SUSTAINABILITY

During the Cold War, U.S. national defense requirements provided the impetus for dramatic advances in every field of ocean science and technology. With the end of the Cold War less than a decade ago, the nation's stake in the oceans needs to be redefined.

In shaping a national ocean strategy, perhaps the most critical challenge is to respond to the widely recognized need for both a productive economy and a thriving environment. Sustainable development has been characterized as meeting the needs of the present without compromising the ability to meet the needs of the future. To achieve this goal, humanity needs adequate knowledge for making the appropriate choices. The following sections describe the types of information needed and how it might be obtained.

The Oceans and the Global Environment

The oceans and the atmosphere form the thin fluid envelope of the Earth. The two fluids, one liquid and one gaseous, interact on all time and space scales, resulting in a range of natural phenomena whose formation, development, and life cycles have widespread social and economic consequences. Improved detection, monitoring, and prediction of hurricanes, storm surges, ocean temperature anomalies, and global climate perturbations will help protect lives and property and minimize the economic consequences of these phenomena.

The United States and other nations have, over the years, developed a useful, but limited, global system for monitoring the physical state of the seas. The present system is based largely on observations from ships at sea, satellite measurements of sea state and sea surface temperature, and supplementary observations from island locations. Special campaigns to study specific ocean and atmospheric processes use a wide range of other tools, such as buoys, submersibles, and various expendable measurement systems.

In recent years the nations of the world have devoted increased intellectual and financial resources to the study of oceanic and atmospheric circulation. Observations of ocean conditions are intrinsically valuable. However, they yield their greatest benefits as the basis for the prediction of future oceanographic and atmospheric conditions on all time scales, from fast-developing hurricanes to seasonal phenomena such as El Niño to climate changes over long periods of time. Capabilities for numerical modeling of the coupled ocean-atmosphere system have advanced substantially in recent years. These models have enabled improved predictions of oceanic phenomena such as El Niño and atmospheric phenomena such as hurricanes. The resulting warnings have yielded enormous economic benefits in many parts of the world and have been responsible for the improved protection of life and property.

Ongoing international programs such as the Global Change Research Program, Global Ocean Observing System, and World Ocean Circulation Experiment are coordinated efforts to improve scientific capabilities to understand and predict ocean and atmospheric conditions. Special regional observing efforts such as the Tropical Atmosphere Ocean buoy array have already proved their worth by enabling improved understanding of El Niño conditions in the Pacific Ocean. The United States participates actively in all of these efforts. Continued participation will likely provide benefits that far exceed the costs.

The Oceans and Marine Life

The encroachment of humans on the marine environment has had significant effects on coastal and oceanic ecosystems. These effects have ranged from the destruction of the great whales to the depletion of global fisheries. Pollutants from land, air, and marine sources have adversely affected habitats. Widespread degradation of coastal waters endangers many marine living resources, threatens the viability of coral reef systems in subtropical regions and triggers periodic outbreaks of microfauna that affect both fish and humans.

Scientists have yet to catalog all the life forms in the ocean or explore in detail the natural cycles and habitats that sustain them. An improved understanding of marine ecosystems is indispensable to the prevention of irreversible damage and the loss of valuable organisms and resources before they are even identified. Recent explorations of hydrothermal vents in the sea floor have yielded an almost continuous string of discoveries of previously unknown biota. The wonders still to be discovered may help answer some of the fundamental questions about the origins of life.

The Oceans and the Earth's Life-Support Systems

The Earth's life-support systems depend on the circulation of chemicals through the oceans, atmosphere, solid earth, and terrestrial and marine biosphere. The role of the oceans in these transfers is believed to be critical but remains poorly understood. The global cycles of important elements such as carbon, nitrogen, and oxygen—and the ways in which the oceans participate in these cycles through the physical transport of water or the biological processes in marine ecosystems—are of great importance in climate change and the population dynamics of marine organisms. The oceans, for example, are a significant sink in the global carbon cycle. As a result, they exercise important controls on the buildup of carbon dioxide in the atmosphere and the resulting projected climate warming. Carbon dioxide is removed from the atmosphere by organisms in the upper part of the ocean, and these organisms subsequently settle to the abyss in the form of dead organic matter. The marine food web plays a critical role in this process.

Additional, highly sophisticated research on biochemical cycles is needed to enhance understanding of these complex processes and the role of the oceans in sustaining the Earth's life-support systems. This understanding will help provide a basis for wise decision making.

The Oceans and Continental Origins

Among the most profound discoveries of ocean science of the past several decades has been the verification of the processes of plate tectonics. Plate tectonic theory and related observations have broad practical implications. For example, scientists now understand the causes of the distribution of the global earthquake zones. The theory also has shed light on the location and formation of the Earth's mineral resources.

The present knowledge base was developed through the international Ocean Drilling Program sponsored by the National Science Foundation and agencies of other nations. This program provides an excellent example of the dividends of investments in basic science. Among the many other benefits of the ocean drilling effort, recovered deep-sea cores have contributed much of the information that has revealed the extent and nature of climate change. Based on these discoveries, a framework has been developed for understanding climate change, including the possible range of natural variations.

The Oceans and National Security

Knowledge of the oceans is an element of national security because the oceans are an important military operating environment. The ocean environment affects all aspects of naval operations, and timely ocean data are increasingly critical to the operation of high-technology military systems. The capability of naval forces to train and operate on and in the oceans around the world supports global peace and security. Exercising and preserving the traditional navigational rights and freedoms codified in the 1982 Law of the Sea Convention is one of the United States' highest ocean policy priorities. Recognizing that national defense and environmental protection are compatible goals, the U.S.

Navy has developed sophisticated new approaches to mitigate the effects of naval operations on the environment. Many of the Navy's science and technology advances developed for tactical use and environmental protection of the ocean are also offered for public use.

OCEAN FACILITIES AND TECHNOLOGIES

Technology provides the means for monitoring and exploring the oceans. It provides the modes of access and the analytical capabilities for assessing present conditions and predicting future changes. In recent decades, there has been an explosion of new ocean technologies as well as advanced systems that were designed for other research fields but can also be applied to ocean science. In addition to the traditional systems consisting of fixed platforms, ships, buoys, and undersea vehicles, ocean scientists now command a diverse arsenal of new technologies that promises new and expanded modes of access to the oceans.

Space technology makes it possible to observe surface oceanic and atmospheric phenomena on a global basis. New remote acoustic or electromagnetic sensing technologies and unmanned, remotely piloted undersea and aerospace vehicles provide new observational capabilities. Advances in computing technology now make it feasible to model the ocean-atmosphere system mathematically, in considerable detail. The ability to acquire, transmit, process, and interpret data from the oceans has taken a quantum leap forward with modern communications and computers.

Because of the increasing costs of developing and operating technological facilities—ships, submersibles, satellites, and computers—a coherent national strategy is needed for developing and operating ocean technology. Such a plan might include facilities that are shared by the scientific community and joint funding provided by multiple agencies. As in the case of the Ocean Drilling Program, international funding and management of some facilities is desirable. Expanding the international character of ocean science and technology efforts is a fiscal necessity in some instances, and it makes good programmatic sense in others. This is especially so because the Law of the Sea Convention, ratified by 124 nations and now in force, provides favorable treatment for research programs conceived and undertaken with international cooperation.

International Dimensions of Ocean Science and Technology

The study of the seas is an international enterprise. Over the last several decades, progress in ocean science and technology has benefited from the collaborative research that takes place between individual investigators and within large global programs such as the Ocean Drilling Program and the World Ocean Circulation Experiment. The broader access, greater resources, and intellectual stimulation afforded by international cooperation has enabled scientists to achieve objectives that otherwise would have remained out of reach. Moreover, although the United States is one of the dominant intellectual powers in this field, other nations play important roles. For example, each nation tends to dominate the

work that takes place within its own exclusive economic zone.

Over the coming decades, the further internationalization of the ocean sciences needs to be encouraged, where appropriate. There are many opportunities for international collaboration in global observations of the oceans; monitoring and management of fisheries and marine ecosystems; renewal and expansion of research infrastructure; and broad public education, a major objective of the International Year of the Ocean.

Until recently, ocean science programs, even those of international scope, have been driven primarily by the research interests of individual investigators. This model will continue to be important, but future global programs increasingly will be addressed through worldwide oceanographic operations directed to meet well-defined management goals and needs. Management goals include observing and predicting changes in ocean conditions that can influence worldwide weather, and monitoring the well-being of coastal oceans and marine living resources. These operational oceanographic programs will rely to a great extent on the collection of long-term, real-time, routine (often synoptic) observations, in a manner analogous to the ongoing worldwide collection of atmospheric observations now used as the basis for operational atmospheric weather forecasting. Because the scope of these programs will greatly exceed the capabilities of any one nation, they will by necessity be organized, managed, and operated through international collaborations.

The development of future international agreements and arrangements must be closely associated with the process of defining and organizing these global programs. The capabilities of the U.S. Government and scientific community to effect the necessary international agreements and make the associated institutional arrangements will be important factors shaping the future of these collaborations. The present level of sophistication and effort directed to these matters is not sufficient. Building a capacity to address these issues is a matter of some urgency because the needs for global operational oceanographic programs are emerging rapidly, and the programs are already being developed.

Needs for New Facilities and Institutions

The United States has been well served by its oceanographic facilities and institutions. However, as a new national vision and strategy emerge for ocean science and technology, the needs for, and roles of, the various facilities and institutions need to be reevaluated. For example:

Global Ocean Observing System. An international global ocean observing system has been planned to tackle complex and interesting questions concerning the vitality of the oceans and climate change. A prototype system would combine existing sensors and data. To move this concept forward, an integrated strategy is needed to complete the development and testing of observing systems and then establish operational networks.

Seafloor Observatories. Ocean observatories would improve data sampling over space and time; provide

time-series data sets to address problems in the study of climate, biogeochemical cycles, and ecology; and provide information about infrequent events, such as volcanic eruptions. The observatory system would be composed of various elements, such as buoys, undersea vehicles, and seafloor instrument packages.

Oceanographic Ships. The research ship is evolving from an isolated data-acquisition platform to a multipurpose platform for launching and operating various data-acquisition systems and analyzing the data. This shift implies dramatically different requirements for future oceanographic ships. Although U.S. oceanographic research fleets are modern and well maintained, planning needs to begin now for the building of new ships, a process that requires long lead times. There is a need to continually reassess requirements for research vessels and platforms and the changing demand for undersea vehicles.

Facilities for Data Assimilation and Integration.. As oceanographic platforms and sensors proliferate, new methods are needed to assimilate and integrate data from different sensors working on different time and space scales. The success of a global ocean observing system will depend in part on advances in capabilities to assimilate and integrate diverse data sets.

Institutions. The last major change in federal institutions dealing with ocean affairs was the establishment of the National Oceanic and Atmospheric Administration, as recommended by the 1969 Stratton Commission. The name and duties of this agency recognize the interaction between the oceans and atmosphere. Since that time, this coupling has proven to be a valid concept, as the nation has grappled with the effects of phenomena such as El Niño. It is now time to review the institutional structure once again to determine whether, in light of present knowledge and national needs for a sustainable future, a new institutional approach is warranted to address the Earth's physical and biological systems as a whole.

HUMAN AND FISCAL RESOURCES

The most comprehensive analysis of the human and fiscal resources required for the U.S. ocean science and technology efforts covers the time period 1982 to 1992 (National Research Council, 1992). The study provides a status report and projections for human resources, including the demand through the year 2000 for oceanographers with advanced degrees. It also describes the existing oceanographic facilities, including ships, submersibles, satellites and computational facilities, and details agency funding for ocean science (see Box 4-1).

In constant dollars, federal funding for ocean science and technology changed less than 1 percent between 1982 and 1997 (Watkins, 1997), while the total federal science and technology budget nearly doubled. If the United States had followed the fiscal recommendations of the President's Commission on the Oceans (1969), then the current federal investment in ocean science and technology investment would be approximately $925 million—85 percent more

than it actually is. This extra funding would augment the considerable private-sector investment in tools and technology for performing research and the collection of the environmental data needed for engineering and operations.

BOX 4-1: STATUS OF HUMAN AND FISCAL RESOURCES FOR OCEAN SCIENCE AND TECHNOLOGY

- Approximately 55 percent of the more than 3,000 oceanographers with Ph.D.s are employed in educational and research institutions, 15 percent in the federal government, 10 percent in industry, 10 percent in nonprofit organizations, and the rest in other organizations.
- The oceanographic fleet managed by the University National Ocean Laboratory System (UNOLS) consists of some 28 vessels. Other vessels are owned and operated independently by the Navy and National Oceanic and Atmospheric Administration. Many smaller vessels and facilities are owned and operated by regional institutions, some with state support. Fifty-seven academic institutions help manage the UNOLS academic fleet.
- The submersibles in the federal fleet consist of *Alvin* (which can operate in waters 4,000 meters deep), operated by the Woods Hole Oceanographic Institution; and *Sea Cliff* and *Turtle* (6,000 and 3,000 meters, respectively), which were operated by the Navy but are now being mothballed; and two Johnson Sealink submersibles (1,000 meters), operated by the Harbor Branch Oceanographic Institution. There is growing use of remotely operated vehicles.
- The drilling vessel *Joides Resolution* is operated by the United States for the Ocean Drilling Program.
- A variety of ocean-sensing satellites are operated by three federal agencies.
- Funding for ocean research, in current dollars, increased from $364 to $518 million between 1982 and 1992. In constant 1982 dollars, funding decreased from $364 million to $348 million during the same time period. About 72 percent of the funding is provided by the National Science Foundation, Office of Naval Research, and National Oceanic and Atmospheric Administration. As a percentage of total U.S. government science and technology funding, ocean science funding shrank from 7 percent of the total in 1982 to 4 percent of the total in 1995.

Sources: National Research Council, 1992, 1996; Consortium for Ocean Research and Education, 1996; CORE home page, http//core.cast.msstate.edu/corehmpg1.html

The federal government is currently implementing a new effort designed to strengthen ocean science and technology and its usefulness to society. The U.S. Congress established the multi-agency National Oceanographic Partnership Program in 1997 to promote the national goals of assuring national security, advancing economic development, protecting quality of life, and strengthening science education and communication through improved knowledge of the ocean. The program also is intended to coordinate and strengthen oceanographic efforts in support of those goals by identifying and carrying out partnerships among federal agencies, academia, industry, and other members of the scientific community.

The International Year of the Ocean provides an opportunity to focus attention on the past and future contributions of ocean science and technology to society's welfare, as well as on the needs and mechanisms for strengthening national and international programs and integration of disparate elements into a coherent whole.

KEY QUESTIONS

If the United States is to maintain an ocean science and technology enterprise that can meet the challenges of the coming decades, then the following key questions must be addressed:

- *The vision of a sustainable future holds implications for the present portfolio of ocean science and technology initiatives. Can a national strategy be developed for ocean science and technology that supports the transition to a sustainable future? Should this strategy become the central driver for investment in ocean science and technology for the next generation?*

- *Ocean science is becoming increasingly dependent on facilities, both shore and sea based, that enable new types of data acquisition and analysis. Is the present governmental and institutional framework for funding and managing the nation's ocean science and technology program adequate, efficient, and sufficiently cost-effective to meet the needs of the next decade?*

- *Advancing technology offers new capabilities for monitoring and probing the oceans. Are sufficient funds being invested in new technology development? Where should efforts be focused?*

- *The vigor of the national ocean science and technology program depends directly on the availability of a well-educated and trained pool of talent, ranging from technicians to Ph..D. Is the present institutional framework adequate to educate and retain the necessary talent? Are the resources available to those institutions to meet the broader educational needs of the country?*
- *The roles of the various stakeholders in ocean science and technology are evolving. What should the relative roles be of the government and the private sector in the development of ocean technologies? In what areas of the ocean enterprise will it be valuable to strengthen ties among the private, governmental, and academic sectors?*

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APPENDIX A

PARTICIPANTS IN THE HEINZ CENTER YEAR OF THE OCEAN WORKSHOPS

1998 YEAR OF THE OCEAN WORKSHOP
OCEAN SCIENCE AND TECHNOLOGY:
MEETING THE NEEDS OF SOCIETY
OVER THE NEXT 25 YEARS
IRVINE, CALIFORNIA
FEBRUARY 6-7, 1998

Anders Andren, University of Wisconsin
Ronald Baird, NOAA Office of Sea Grant
Richard Barber, Duke University Marine Laboratory
Robert Bourke, U.S. Naval Postgraduate School/U.S. Navy
Kenneth Brink, Woods Hole Oceanographic Institution
Warner Chabot, Center for Marine Conservation
Charles Cook, The Nature Conservancy
John Dickson, California Coastal Commission
Sylvia Earle, Deep Ocean Exploration and Research
Edward Frieman, Science Applications, Inc.
John Halkyard, Deep Ocean Technology
Ed Horton, Deep Ocean Technology
Kenneth Johnson, Moss Landing Marine Laboratory
Kristina Katsaros, Atlantic Oceanographic and Meteorological Laboratory/NOAA
John Knauss, University of Rhode Island
Marsha McNutt, Monterey Bay Aquarium Research Institute
Walter Munk, Scripps Institution of Oceanography
Fred Piltz, Minerals Management Service/ DOI
Shirley Pomponi, Harbor Branch Oceanographic Institution
Michael Purdy, National Science Foundation
Steven Ramberg, Office of Naval Research/ U.S. Navy
Terry Schaaf, Consortium for Oceanographic Research and Education
Richard Spinrad, Consortium for Oceanographic Research and Education
John Steele, Woods Hole Oceanographic Institution
Kenneth Tenore, Chesapeake Biological Laboratory and National Association of Marine Laboratories
Paul Tobin, Oceanographer of the Navy/ U.S. Navy
James Watkins, Consortium for Oceanographic Research and Education
Stephen B. Weisberg, Southern California Coastal Water Research Project
Robert White, Washington Advisory Group
Dennis Whitford, U.S. Naval Academy
Stanley Wilson, National Oceanic and Atmospheric Administration
L. Donelson Wright, Virginia Institute of Marine Science

Staff

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1998 YEAR OF THE OCEAN WORKSHOP
THE CHALLENGE OF SUSTAINABLE COASTS
CHARLESTON, SOUTH CAROLINA
FEBRUARY 11-12, 1998

Anne Aylward, Volpe Trans-portation Systems Center
Donald Boesch, University of Maryland Center for Environmental Studies *(by telephone)*
Lillian Borrone, Port Authority of New York/New Jersey
Thomas Campbell, Coastal Plan-ning and Engineering Inc.
Thomas Chase, American Associa-tion of Port Authorities
Jessica Cogan, U.S. Environmental Protection Agency
Penelope Dalton, Professional Staff, Senate Subcommittee on Fisheries and Oceans
Margaret Davidson, NOAA Coastal Services Center
Rick DeVoe, South Carolina Sea Grant Program
William Eichbaum, World Wildlife Fund
John Fisher, North Carolina State University
Anna Maria Frankic, Office of Senator Akaka, U.S. Congress
James Good, Oregon State Univer-sity and NOAA Coastal Services Center
Fred Holland, South Carolina Marine Resources Department
James Houston, U.S. Army Corps of Engineers
Robert Huggett, Michigan State University
Wesley Jordan, BBN Technologies
Paul Kelly, Rowan Drilling Co.
Robert Kifer, National Ocean Service/NOAA
Thomas Kitsos, Minerals Manage-ment Service/DOI
William Klesch, Coastal America
John Knott, Dewees Island Project, S.C.
Stephen Leatherman, Florida Inter-national University
Richard Lee, Skidaway Institute of Oceanography
Tom Leschine, University of Washington
Douglas Logan, Charleston Branch Pilots
James Loy, U.S. Coast Guard
Anthony MacDonald, Coastal States Organization
Orville Magoon, Coastal Zone Foundation
Howard Marlowe, American Coastal Coalition
Roger McManus, Center for Marine Conservation
Richard Mosteller, Fort Sumter Tours, Inc.
James Murley, Florida Department of Community Affairs
Robert North, U.S. Coast Guard
William Oakerson, Boat U.S.
Michael Orbach, Duke University
Jeff Payne, NOAA Coastal Services Center
Nina Petrovich, NOAA Coastal Services Center
Margaret Podlich, Clean Water Trust
Alan Pulsipher, Louisiana State University
Douglas Rader, Environmental Defense Fund
James D. Reilly, Duke University Marine Laboratory
Joseph P. Riley, Mayor of Charleston, S.C.
William “Quin” Robertson, Woods Hole Oceanographic Institution
William Robertson, Andrew Mellon Foundation
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Paul Sandifer, South Carolina Department of Fisheries and Wildlife
Roger Schecter, North Carolina Division of Coastal Management
Kenneth Smith, Coastal Advocates, Inc.
Whit Smith, Charleston Branch Pilots
James Spitzer, U.S. Coast Guard
Robert Stewart, National Ocean Industries Association
William Stronge, Regional Re-search Associates

Dennis Suszkowski, Hudson River Foundation
Gerald Talbert, Southeast Conservation Buffer Campaign
James Tripp, Environmental Defense Fund
Rod Vulovic, Sealand Service Co.
Douglas Wheeler, California Resources Agency
Richard Worthington, Office of the Chief of Engineers, U.S. Army Corps of Engineers
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1998 YEAR OF THE OCEAN WORKSHOP
FISHERIES AND OTHER LIVING MARINE RESOURCES
WASHINGTON, D.C.
MARCH 3-4, 1998

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Edward P. "Ted" Ames, fisherman, Stonington, Maine
Lee Anderson, University of. Delaware
John Aquilino, Global Aquaculture Alliance
Jesse Ausubel, Alfred P. Sloan Foundation
Stephanie Bailenson, Subcommittee on Fisheries and Oceans, U.S. Senate
Robert A. Bachman, Maryland Fisheries Administration
James Baker, National Oceanic and Atmospheric Administration
Nelson Beideman, Bluewater Fisherman's Association, Barnegat Light, N.J.
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Paul Brouha, American Fisheries Society
Ralph Brown, Oregon groundfisher; member, Pacific Fisheries Management Council
Scott Burns, World Wildlife Fund

Julius Collins, J. Collins Trawlers, Brownsville, Texas
Penelope Dalton, professional staff, Subcommittee on Fisheries and Oceans, U.S. Senate
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Craig Dorman, Office of Naval Research/U.S. Navy
David Evans, National Marine Fisheries Service/NOAA
Hon. Sam Farr, U.S. House of Representatives
John Field, Subcommittee on Fisheries, Wildlife and Oceans, U.S. House of Representatives
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Patricia Kurkul, National Marine Fisheries Service/NOAA
Mary Langlais, National Marine Fisheries Service/NOAA
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Bonnie McCay, Rutgers University
Morgan McCosh, U.S. Fish and Wildlife Service/DOI
Roger McManus, Center for Marine Conservation
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APPENDIX B

COMMENTARY ON THE MARINE RESOURCES AND ENGINEERING DEVELOPMENT ACT OF 1966 (P.L. 89-454), THE STRATTON COMMISSION, AND THE REPORT, *OUR NATION AND THE SEA*[25]

The Marine Resources and Engineering Development Act of 1966 led directly to the establishment of the National Oceanic and Atmospheric Administration (NOAA), laid the groundwork for enactment of many pieces of legislation, and set priorities for federal ocean activities that have guided this nation for almost 30 years. Much of this was possible because the 1966 Act established a Presidential commission on marine science, engineering, and resources. The commission was chaired by Julius A. Stratton, a former president of the Massachusetts Institute of Technology and then chairman of the Ford Foundation. The commission became known as the Stratton Commission.

The number of accomplishments achieved in marine legislation and activities in the late 1960s and 1970s is truly remarkable. In 1966, the Sea Grant Program was established and the Marine Resources and Engineering Development Act was passed; in 1970, NOAA was formed and the International Decade of Ocean Exploration and World Weather program began. In 1972, when the Coastal Zone Management Act (16 U.S.C. 1451 et seq.); Clean Water Act (33 U.S.C. 1251 et seq.); Marine Protection, Research, and Sanctuaries Act (33 U.SA.C. 1401 et seq.); and Marine Mammal Protection Act (16 U.S.C. 1361 et seq.) were all passed. Then, in 1973, the Endangered Species Act (16 U.S.C. 1531 et seq.) was passed, giving NOAA and the U.S. Fish and Wildlife Service the authority to manage marine and other species faced with extinction. Finally, in 1976, the Magnuson Fisheries Conservation and Management Act ((16 U.S.C. 1801 et seq.) was enacted.

The commission members were from federal and state governments, industry, universities, and laboratories, and also included bipartisan congressional advisors. While commission members all were accomplished individuals, the diversity of appointed, advisory bodies was not yet a concern. This illustrates an important point: that the Stratton Commission, for all its acknowledged brilliance and foresight, was very much a product of the thinking of the 1960s. The environmental movement was a nascent political force in marine policy at that time, and it was not specifically represented in the membership of the commission. Nor were the coastal states accorded a seat at the table.

Policy is now informed by a wider range of viewpoints. Americans also look at marine issues differently. In the late 1960s, marine resources were viewed as essentially infinite, and efforts were made to expand their use and accelerate development to grow the economy. This attitude is expressed within the Marine

[25] Condensed from a presentation by Mary Hope Katsouros of The Heinz Center, delivered at the February 1998 annual meeting of the American Association for the Advancement of Science, held in Philadelphia, Pennsylvania.

Resources and Engineering Development Act itself, as evidenced by this quotation from the Act regarding its purpose: "Develop, encourage, and maintain a coordinated, comprehensive, and long-range national program—to protect health and property and enhance commerce, transportation, and national security—and to *increase utilization* of these resources." This paradigm is also reflected by the charges to the Stratton Commission, which was called upon to maintain the expanding national economy and obtain the needed resources from the marine environment.

The Stratton Commission published *Our Nation and the Sea* in January 1969. The report included 126 recommendations in 17 categories. Without discussing all of the recommendations and activities of the commission, it should be sufficient to note that the Stratton Commission has had far more impact on marine sciences and policy than any other commission, board, or committee—before or since. As noted earlier, those recommendations led directly to the establishment of NOAA in 1970, laid the groundwork for enactment of the Coastal Zone Management Act in 1972, and set priorities for federal ocean activities that have guided this nation for almost 30 years.

The commission of the 1990s may not look much like Stratton's, but it can be as wise and forward looking. If it fulfills this role, then the early years of the new millennium will be a marine watershed—like the 1970s. But the new paradigm will not reflect a movement toward increased development. Instead, it will reflect a movement toward balancing use and conservation; movement towards the sustainability of marine resources.