# *Year of the Ocean*

## *Discussion Papers*

*March 1998*



*Prepared by the U.S. Federal Agencies with ocean-related programs*

**UNITED STATES DEPARTMENT OF COMMERCE**
**The Under Secretary for**
**Oceans and Atmosphere**
Washington, D.C. 20230

Dear Colleague:

The United Nations has declared 1998 as the International Year of the Ocean, and the Federal agencies with ocean-related programs have been planning activities in honor of this occasion. One such activity is the preparation of the enclosed set of discussion papers which address a variety of themes and issues--what is working well and what is not working well, needs, and opportunities for the future. They are intended to provide background information needed to assist the private and the public sectors to work together to promote the conservation, exploration, and sustainable use and national security interests of the ocean. On behalf of all of the participating agencies, I hope you will find this volume of interest.

Sincerely,

D. James Baker

Enclosure

# YEAR OF THE OCEAN
## *Discussion Papers*

*March 1998*

***Prepared by the U.S. Federal Agencies with ocean-related programs***

*For additional copies, please contact:*

Office of the Chief Scientist, NOAA
U.S. Department of Commerce
14th Street and Constitution Avenue, N.W.
Washington, D.C. 20230

Telephone: (202) 482-3385
Facimile: (202) 482-5231

Funding for the publication of this document was provided by the Department of Energy, the Environmental Protection Agency, the Minerals Management Service, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey.

# FOREWORD

The United Nations has declared 1998 as the International Year of the Ocean. This declaration represents an opportunity to raise public awareness about the value of the ocean to all Americans, to celebrate our considerable accomplishments in understanding the ocean, and to learn from our experiences in managing ocean resources to assure that our children have a healthy and productive ocean to enjoy.

<u>The Value of the Ocean to All Americans</u>

All Americans are affected by the ocean (including coastal waters, estuaries, and the Great Lakes). And we all affect it. The United States has more than 95,000 miles of coastline and more than 3.4 million square miles of ocean within its territorial sea. The ocean's living resources provide food on our plates, raw materials for industry, new medicines to improve health, and unparalleled recreational experiences. Historically, the ocean has buffered the U.S. from conflicts overseas and foreign invasion. Our national security and our interests in enhancing global peace and stability are absolutely dependent on preserving high seas freedoms of navigation for military and commercial vessels. In 1996 approximately $590 billion of goods (41 percent of the total value of United States foreign trade, and a much larger share by weight) were carried on the ocean and passed through American ports. By comparison, air and overland transportation accounted for 27 and 31 percent respectively, by value. U.S. residents ate an average of 15 pounds of fish and shellfish last year. The ocean is also an important source of energy - about 18% of our oil and 27% of our natural gas are produced from the Outer Continental Shelf. Leading-edge anti-inflammatory drugs and potentially life-saving cancer treatments contain ingredients from fish and marine organisms. Finally, about 180 million people visit our coastlines each year, and most Americans spend at least 10 days a year near a coast. Travel and tourism is the largest and the fastest growing segment of the U.S. service industry.

The ocean regulates the world's climate. The effects of the ocean on the atmosphere control our daily weather. This year's El Niño event has changed dramatically weather patterns in the US and around the world. The ocean provides natural services such as carbon storage, atmospheric gas regulation, nutrient cycling, and waste treatment. Coral reefs, mangroves, and kelp forests protect coastal areas from storms. Marine algae contribute nearly 40 percent of global photosynthesis.

The ocean provides many Americans with their livelihood. One out of six jobs in the U.S. is marine-related and one-third of our GNP is produced in coastal areas. Today, over half of our population lives and works in coastal areas adjacent to the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Great Lakes. Over the past three decades, coastal population has grown faster than the population of the country as a whole. The U.S. coasts are among the most densely populated areas in the world. By the year 2025, close to 75 percent of our people will live in coastal areas, the majority in sprawling, interconnected metropolitan centers. One concern about our burgeoning coastal population is the increased risk of coastal hazards and hurricanes, which have accounted for almost $50 billion in coastal damages over the past decade.

The oceans play an important role in enabling the United States to project military power, when necessary, to troubled regions of the world. Freedom of the seas provides U.S. policy-makers with flexible options in dealing with challenges to international peace and security.

Finally there is a very personal value to the ocean. Often, we are drawn to the ocean only to stand and stare and listen. The ocean is beautiful to almost everyone, for reasons each of us understands and none of us knows. It has inspired some of the world's finest paintings, poetry, stories, and music.

Preserving Ocean Resources

Although some progress is evident, signs of trouble in the seas should continue to concern us. Over-fishing, changes in coastal habitat, and pollution have combined to impact dramatically living resources in our marine waters. In both the United States and globally, with few exceptions, stocks are declining and the majority of fisheries are thought to be fully or over-utilized. Some species (cod, haddock, and flounder, for example) have nearly disappeared off the New England coast. Recent trends in catches, trade, contribution to food supplies, and overall economic viability of the fishing industry are not encouraging. As a result of effective conservation practices, a few marine mammals and sea turtles in U.S. waters appear to be recovering after years of declining numbers, but habitat loss and human activities are jeopardizing other species, such as salmon. Less-studied marine organisms are probably being lost before ever being identified, much less protected. We continue to lose important habitats such as wetlands, sea grass beds, and coral reefs. These are more than just environmental issues. The serious decline of fisheries have sparked confrontations in the past, and environmental degradation has created situations of friction, dislocation, and mass migration in various regions of the world.

Concerns about ocean pollution also are warranted. About 40% of our estuarine and coastal waters are not fishable or swimmable - primarily because of excess nutrients and bacteria from agricultural runoff and municipal wastewater discharges. Although the quality of our shellfish harvesting waters has improved over the past five years, 30% of these areas still have some form of harvest restrictions. In 1996 over 2,500 closings and advisories were issued for coastal bathing beaches due to bacterial contamination. Sediments in coastal areas near industrial facilities and ports, especially in areas where water circulation is slow, show elevated concentrations of chemical contamination. Concerns about dredging contaminated sediments in port areas have delayed the maintenance of major ports and waterways. Oil contamination, not only from tankers, but from municipal and industrial operations on the land, continues to be a problem. Major tanker spills contribute only about five percent of the oil contaminating the ocean. In fact, at least 75% of all pollutants that contaminate the ocean are from land-based sources.

Despite these very real concerns, there is much to be optimistic about with respect to the future of the ocean. The ocean remains a largely unexplored frontier that represents a critical source of food, energy, and other natural resources for the next millennium. Only recently have the seas yielded their secrets of the deep ocean floor, home to communities of organisms whose productivity is based on chemosynthesis instead of photosynthesis. Whole new ecosystems have been discovered within the last year, some of which might be the basis of new drugs and medical treatments.

Opportunities for New Partnerships

Ocean policy is such a large, cross-cutting field that no single agency of the Federal government, on its own, has the necessary legal authorities, human and financial resources, and experience to move the country ahead in ocean science and management. As a result of the Stratton Commission, the National Oceanic and Atmospheric Administration of the Department of Commerce was formed almost 30 years ago to unify many ocean-related functions in one agency. At that time other agencies also expanded their ocean missions. New partnerships among agencies with responsibilities for ocean issues, such as the Department of Transportation, the Department of the Interior, the U.S. Environmental Protection Agency, the Department of Defense, the Department of State, the U.S. Agency for International Development, the Department of Justice, and the National Oceanic and Atmospheric Administration, are beginning to show results. For example, experiments in the civil use of advanced technologies in the military and intelligence communities promise new insights into environmental problems in coastal areas and the ocean.

The Federal government, however, cannot do it alone. Renewed cooperation with our counterparts in state and local governments will be critical in order to solve problems of coastal pollution, habitat loss, hazards mitigation, and other areas. Federal agencies have a growing experience base in working with colleagues in state and local governments through programs such as the Coastal Zone Management Program and the National Estuary Program that can serve as models for future cooperation.

Moreover, the Federal government doesn't have all the answers. Federal agencies, private industry, state and local governments, and academic institutions are strengthening and improving their cooperative activities, including the sharing of human resources, experience, data, equipment, instrument development, and facilities. Nurturing existing partnerships, such as the National Oceanographic Partnership Program, can help build support for oceanographic research.

In a time of shrinking budgets, the public sector at all levels will never have adequate resources to do all that needs to be done. Investments in coastal and marine areas by the private sector far outweigh public investments, and the experience base of the private sector is often untapped in public decision making. Real opportunities exist to develop public-private partnerships with the insurance industry to deal with concerns about climate change, with the tourism industry to deal with the environmental quality of coastal areas, and with the fishing industry to deal with issues related to essential fish habitat.

Finally, the United States cannot move the country ahead in ocean science and management in isolation. The ocean and its resources are inherently international. Even within our own waters, the health of the fish we eat and the waters in which we swim are affected by activities in other countries. The elements of effective management -- public participation, scientifically-sound decision making, governmental coordination and integration, the need for creative financing for programs -- are similar in all nations. The threats to ocean ecosystems -- over-fishing, destruction of habitat, nutrient and toxic pollutants, non-indigenous species, and pathogens -- are also global.

Although we should celebrate recent improvements of marine environments in the U.S., it is important to remember that coastal areas in the developing world are under severe pressures that few nations are equipped to manage. U.S. international development programs, in partnership with non-governmental organizations, universities, and the private sector, work with foreign governments, community groups, and international institutions to build local capacity to protect and use marine resources more sustainably. Principles that were established first in the U.S. are being adapted for use in Latin America, the Caribbean, Southeast Asia, East Africa, and the Middle East. As a nation, we can also learn through our attempts to help others deal with similar problems. Building capacity for sustainable management on distant shores will enhance our own efforts.

## Current Developments

The ocean has already begun to receive new attention in other countries, the academic community, and the Congress. One of the Administration's highest priorities this year is accession to the Law of the Sea (LOS) Convention. The LOS Convention restrains excessive maritime claims and codifies key legal provisions in the areas of navigational freedoms, ownership of non-living resources, environment, fisheries, and public vessel sovereign immunity in a way that balances the vital interests of maritime and coastal states.

In May 1998, Lisbon, Portugal, will open EXPO98, an international world's fair focusing on the importance of the ocean in our lives. This event will be an opportunity to raise public awareness world-wide since over 20 million people are expected to attend. The ocean will also be a key issue at the 1998 G-8 Environmental Ministerial meeting that will be held in April, 1998, in the United Kingdom.

In recent years, many reports have concluded that domestic ocean management in the United States is fragmented. Most recently, a report entitled Striking a Balance: Improving Stewardship of Marine Areas, authored by the Marine Board of the National Research Council, concluded that our existing domestic management system is characterized by a confusing array of laws, regulations, and practices at the federal, state, and local levels. Further, it concluded that the various agencies that implement and enforce existing legal regimes operate with mandates that often conflict with each other, and that no mechanism exists for establishing a common vision and set of objectives. To begin correcting this situation, the Marine Board recommended the creation of a "National Marine Council" to define national objectives and improve coordination among federal and state agencies and other interested parties in the private sector. It also considered whether a domestic ocean management regime would be an effective structure for planning and decision-making, since most ocean management issues cross state boundaries. Congress is considering legislation this year to develop and maintain a coordinated, comprehensive, and long-range national policy with respect to domestic ocean and coastal activities.

The Federal agencies with ocean-related programs have been planning activities for the Year of the Ocean. In addition, these agencies have prepared the following set of discussion papers on a variety of themes and cross-cutting issues. They discuss what is working well and what is not in ocean resource management, and identify needs and opportunities for the future. They are intended to provide some of the background information needed to enable both the public and private sectors to work together to promote the conservation, exploration, and sustainable use of the ocean.

# ACKNOWLEDGEMENTS

*Many individuals contributed to the preparation of these papers over many months. Particular appreciation goes to those listed below, with apologies to others whose names may have been inadvertently omitted. The asterisk identifies the individual(s) with lead responsibility in each area.*

**Overall Guidance and Coordination**

W. Stanley Wilson *
Office of the Chief Scientist, NOAA

Charles Bookman
The H. John Heinz III Center for Science, Economics and the Environment

Muriel Cole
Office of the Chief Scientist, NOAA

Marguerite Danley
National Ocean Service, NOAA

Steve Dunn
The H. John Heinz III Center for Science, Economics and the Environment

Marina Guedes
The H. John Heinz III Center for Science, Economics and the Environment

Steve Morrison
National Ocean Service, NOAA

Harrison Pannella (Editor)

Terry L. Schaefer
Office of the Chief Scientist, NOAA

---

**The U.S. Marine Transportation System**

Norman Lemley *
U.S. Coast Guard

Captain Charles Allen, USN
U.S. Department of Defense

Charles Chesnutt
U.S. Army Corps of Engineers

Margie Hegy
U.S. Coast Guard

John Heisler
Environmental Protection Agency

Millington Lockwood
National Ocean Service, NOAA

Paul Mentz
Maritime Administration

Stephen Miller
U.S. Department of State

Kennard Potts
Environmental Protection Agency

Captain Mark Rosen, USN
U.S. Department of Defense

Captain David VanOss, USN
U.S. Department of Defense


---

**The Oceans and National Security**

Captain Mark Rosen, USN *
U.S. Department of Defense

John H. Noer
Center for Naval Analyses

U.S. Department of Defense
- Office of the Secretary of Defense
- Office of General Counsel, Department of Defense
- Office of the Chief of Naval Operations
- Office of General Counsel, Department of the Navy
- Office of Secretary of the Navy
- Office of Oceanographer of the Navy
- Office of Naval Research

Center for Naval Analyses

Environmental Protection Agency

U.S. Department of Commerce
- National Oceanic and Atmospheric Administration

U.S. Department of Energy

U.S. Department of Justice

U.S. Department of State

U.S. Department of Transportation
- U.S. Coast Guard
- Maritime Administration

---

**Ensuring the Sustainability of Ocean Living Resources**

Sari J. Kiraly *
National Marine Fisheries Service, NOAA

Charles Chesnutt
U.S. Army Corps of Engineers

Jerome Erbacher
National Marine Fisheries Service, NOAA

Anne Gore
Environmental Protection Agency

Judy Gray
Coastal Ocean Program, NOAA

Lieutenant Commander Gregory Hitchens, USCG
U.S. Coast Guard

Thomas F. Hourigan
National Marine Fisheries Service, NOAA

Suzanne Iudicello
National Marine Fisheries Service, NOAA (Contractor)

Karen Koltes
U.S. Geological Survey

Gary Matlock
National Marine Fisheries Service, NOAA

Matteo Milazzo
National Marine Fisheries Service, NOAA

Kenneth W. Osborn
National Marine Fisheries Service, NOAA

Brady Phillips
National Ocean Service, NOAA

Barbara Schroeder
National Marine Fisheries Service, NOAA

Allen Shimada
National Marine Fisheries Service, NOAA

---

**Ocean Energy and Minerals: Resources for the Future**

Ken Turgeon*
Minerals Management Service

Jonathan Amson
Environmental Protection Agency

Charles Chesnutt
U.S. Army Corps of Engineers

Susan Gregersen
U.S. Department of Energy

Terry Holman
Minerals Management Service

Jim Magill
U.S. Coast Guard

Elliot Spiker
U.S. Geological Survey

*With assistance from the following Minerals Management Service staff:*
*Roger Amato, Kim Coffman, Keith Meekins, Jim Price, and Robert W. Smith*

---

**Coastal Tourism and Recreation**

Biliana Cicin-Sain *
Center for the Study of Marine Policy
University of Delaware (on behalf of National Sea Grant College Program, NOAA)

Robert Knecht*
Center for the Study of Marine Policy
University of Delaware (on behalf of National Sea Grant College Program, NOAA)

Miriam Balgos
University of Delaware

Nigel Bradly
University of Delaware

Charles Chesnutt
U.S. Army Corps of Engineers

Macara Lousberg
Environmental Protection Agency

Al Marmo
U.S. Coast Guard

Bill Price
National Marine Fisheries Service, NOAA

Fritz Schuler
National Sea Grant College Program, NOAA

Trevor Spradlin
National Marine Fisheries Service, NOAA

Joseph Uravitch
National Ocean Service, NOAA

Kenneth Walker
National Ocean Service, NOAA

*Thanks are due to the following members of the Sea Grant network for providing useful information:*
*Jan Auyong (Oregon Sea Grant Program), Robert Bacon (South Carolina Sea Grant Consortium), and James Falk (Delaware Sea Grant College Program)*

---

**Impacts of Global Climate Change - With Emphasis on U.S. Coastal Areas**

Richard W. Reynolds *
National Weather Service, NOAA

Ben Mieremet
National Ocean Service, NOAA

Steve Morrison
National Ocean Service, NOAA

Stephen Piotrowicz
Office of Oceanic and Atmospheric Research, NOAA

Ellen Prager
U.S. Geological Survey

Kathryn Ries
National Ocean Service, NOAA

Jim Titus
Environmental Protection Agency

S. Jeffress Williams
U.S. Geological Survey

---

**Mitigating the Impacts of Coastal Hazards**

Margaret Davidson *
National Ocean Service, NOAA

Richard Krimm *
Federal Emergency Management Agency

S. Jeffress Williams *
U.S. Geological Survey

Charles Chesnutt
U.S. Army Corps of Engineers

Sandy Ward
National Ocean Service, NOAA

---

**Opportunities and Challenges for Marine Science, Technology and Research**

Richard Spinrad *
Consortium for Oceanographic Research and Education

Captain Daniel Schwartz
Consortium for Oceanographic Research and Education

The Interagency Working Group of the National Oceanographic Partnership Program

- Defense Advanced Research Projects Agency
- Environmental Protection Agency
- Minerals Management Service
- National Aeronautics and Space Administration
- National Oceanic and Atmospheric Administration
- National Science Foundation
- Office of Management and Budget
- Office of Naval Research
- Office of the Oceanographer of the Navy
- Office of Science and Technology Policy
- U.S. Coast Guard
- U.S. Department of Energy
- U.S. Geological Survey

---

**A Survey of International Agreements**
U.S. Department of State *

**Marine Education U.S.A.: An Overview**

Dale Ingmanson *
San Diego State University (on behalf of National Sea Grant College Program, NOAA)

Barbara Elkus
Coastal America

Melissa Gordon
Office of the Chief Scientist, NOAA

Joyce Gross
Office of Public and Constituent Affairs, NOAA

Ellen Prager
U.S. Geological Survey

Sarah Schoedinger
Consortium for Oceanographic Research and Education

David Smith
U.S. Naval Academy

William Wallace
San Diego State University

**The Legendary Ocean - The Unexplored Frontier**

Barbara Moore *
National Undersea Research Program, NOAA

Al Kalvaitis
National Undersea Research Program, NOAA

Julie Zeidner
National Undersea Research Program, NOAA

David Stein
Office of Oceanic and Atmospheric Research, NOAA

**Domestic Legal Regimes (included as Appendices where applicable)**

Margo Jackson *
Office of General Counsel, NOAA

Stephanie Campbell
Office of General Counsel, NOAA

Roger Eckert
Office of General Counsel, NOAA

Pamela Lawrence
Office of General Counsel, NOAA

Brandy LeGrande
Office of General Counsel, NOAA

Mary O'Brien
Office of General Counsel, NOAA

Constance Sathre
Office of General Counsel, NOAA

Michael Weiss
Office of General Counsel, NOAA

# CONTENTS

# 1998 Year of the Ocean

## THE U.S. MARINE TRANSPORTATION SYSTEM

**Contents**

## EXECUTIVE SUMMARY

The U.S. marine transportation system encompasses a network of navigable waters, publicly and privately owned vessels, port terminals, intermodal connections, shipyards, vessel repair facilities, and a trained labor pool operating and maintaining this infrastructure.

The United States is the world's largest trading nation, accounting for over one billion metric tons or nearly 20 percent of the world's oceanborne trade. Nonetheless, with international trade projected to triple by 2020, and with over 90 percent of this trade (by weight) projected to move by ocean, the capacity of the U.S. marine transportation system must increase. This includes bringing the physical infrastructure of the system, such as charts, vessel traffic services, and berths, up to world-class standards.

The larger vessels being built to accommodate increasing demands require deeper channels. Dredging operations that are necessary for the safe operation of vessels and port facilities raise environmental concerns regarding the disposal of dredged material. Additional environmental challenges include control of non-indigenous species, intentional and non-intentional emission of petroleum and other toxins, and physical damage to marine habitats caused by vessel and port operations.

Technological developments in shipbuilding, navigation information, communications, sensors, and cargo handling will improve safety and efficiency and allow smaller crews. As ships and transportation systems become more complex, training requirements will grow. Crews must be qualified and operate in accordance with international standards.

Regulatory authority already exists to manage and maintain the marine transportation system. However, the scope of improvements needed to remain globally competitive forces consideration of the need for better coordination among the many stakeholders, new funding mechanisms, and development of a Federal Waterways Management Plan.

## INTRODUCTION

Marine transportation is an integral component of the U.S. transportation system and is essential to the nation's economy. By 2020, international trade will triple, with over 90 percent (by weight) moving via the ocean. Accordingly, the entire U.S. transportation infrastructure, including ports and waterways, must be able to handle this projected increase. The nation needs to plan for and manage future growth of marine transportation on its waterways.

The importance of waterways tends to be overlooked by the public when compared to air, rail, and highway systems. This can be attributed to the general lack of understanding of the contribution of ports and the waterways system to people's daily lives as well as to national security. In many cases, as in international commerce, there is no alternative to moving goods by water. Thus, formal coordination and planning of marine transportation infrastructure improvements are needed as competition for use of the waterways and vessel size and complexity increase. For example, one consequence of inefficient waterway use would be an inability to meet "just-in-time" delivery requirements, resulting in higher costs for consumer goods.

Increasing the efficient use of waterways has additional economic and environmental benefits. The marine transportation system can relieve congestion in other transportation modes. Waterborne transportation is more fuel-efficient than other transportation modes and reduces propulsion emissions by one-third or more. Transporting bulk goods by water results in a 35 percent reduction in transportation costs, when compared to other modes.

Technological advances offer opportunities to counter the challenges that increasing trade and the continued growth in the length, width, and draft of ships present for the nation's economy, environment, and port communities. In combination with computer and communication technology to integrate and deliver the data to mariners, the following advances will significantly reduce the risk of serious accidents and spills:

- full-bottom coverage survey equipment;
- electronic chart display and information systems;
- electronic charting systems;
- vessel traffic services;
- vessel transponders;
- real-time acquisition and delivery of data; and
- the differential global positioning system.

One study by the Woods Hole Oceanographic Institute estimates that an effective electronic charting system alone could do as much to reduce risks of oil and chemical spills as requiring tankers to have double hulls.

Marine safety will also benefit from improved communications and cooperation among federal, state, local authorities, and private interests.

## THE CURRENT U.S. MARINE TRANSPORTATION SYSTEM

The U.S. marine transportation system encompasses a national and global network of navigable ocean, lake, river, and inland waterway routes; the vessels that carry waterborne commerce; a complex of ports and terminals serving as intermodal points of transfer between the water system and the land-based transportation modes; ship operators; an extensive supplier base; and shipboard, shipyard, and longshore labor forces. The system includes over 3,500 bulk oil transfer facilities, 10,000 marinas, 18,000 bridges, a network of locks and dams, and 97,000 aids to navigation. Diverse groups of waterway users—commercial vessels making 70,000 port calls annually, 110,000 fishing vessels, and 20 million recreational vessels—vie for access to our waterways often with conflicting interests and purposes. Additionally, the general public is concerned about the waterways' environmental health and esthetics.

### The Merchant Marine Fleet

As of October 1, 1997, the U.S. merchant marine—the fleet of privately owned, U.S.-registered ships, in foreign and domestic trades—totaled 356 vessels (286 oceangoing ships and 70 large Great Lakes vessels) with a capacity of approximately 15 million deadweight tons (dwt). In 1996, approximately 33,000 cargo carrying vessels and 8,000 tugs, ferries, passenger, and supply boats served the inland waterways, Great Lakes, and coastal trades. Overall, the U.S. water transportation industry employs 170,000 people on board ships and in supporting shoreside occupations. An additional 34,000 production workers are employed in the major shipyards, and thousands more work in smaller-shipbuilding and ship repair facilities.

### Foreign Trade

The United States is increasingly enjoying the benefits of growing international trade as trade barriers are eliminated. Currently, trade flows are growing faster than the gross domestic product. In 1996, approximately $590 billion of goods (41 percent of the total value of U.S. foreign trade, and a much larger share by weight), were carried on the ocean and passed through our ports. By comparison, air and overland transportation accounted for 27 and 31 percent, respectively, by value. Comparable statistics on the weight of truck, rail, and pipeline traffic between the United States and Canada/Mexico are not available.

The United States is the world's largest trading nation, accounting for over one billion metric tons or nearly 20 percent of world oceanborne trade. The nine million barrels of oil the United States imports daily, the majority by water, is by far the largest single commodity handled anywhere. In fact, excluding Mexico and Canada, over 95 percent of overseas trade by tonnage is shipped by sea.

Despite the growth in U.S. foreign trade and numerous promotional programs designed to subsidize U.S.-flag operations, the U.S. maritime industry has struggled to compete effectively in the international shipping market. U.S.-flag ship operators continue to face substantial competition from foreign operators who have achieved equal or better productivity. Foreign operators enjoy substantially lower operating and capital costs with less stringent safety, construction, and environmental requirements. They also benefit from more modern shipyards, and less expensive labor from developing countries. Given these conditions, the role of the federal government in defining and protecting U.S. national interests will need to be addressed in the years ahead. The U.S. merchant fleet currently carries three percent of U.S.-foreign waterborne trade, with the remaining 97 percent hauled by foreign-flag operators.

Even though its share has declined, the quantity of cargo carried by the U.S. fleet generally has increased—from 25.2 million long tons in 1970 to 28.3 million long tons in 1996, a 12.5 percent increase. The absolute increase in cargo carried on U.S.-flag vessels reflects the deployment of larger, more productive U.S.-flag vessels since the 1970s.

### Domestic Shipping

Domestic shipping includes commerce on the Great Lakes, the inland waterways, and in the domestic ocean trades. Annually, over one billion short tons of cargo move in the domestic trade (24 percent of all U.S. cargo on a ton-mile basis) at less than 2 percent of the entire domestic freight bill ($422 billion in 1995). U.S. domestic waterborne shipping generates $8 billion in annual freight revenue. Domestic shipping serves over 90 percent of the U.S. population, and carries approximately 65 million passengers each year on domestic vessel cruises and passenger ferries. Approximately 124,000 people are engaged in a variety of domestic shipping-related activities, including an estimated 80,000 employed in seafaring and non-seafaring positions on board U.S.-flag vessels operating in the coastwise and inland waterway trades. Long-standing U.S. law limits commerce between U.S. ports to U.S.-flag vessels.

### Ports

There are 355 ports in the United States that handle cargoes at some 4,000 marine terminals. Ports and marine terminals are intermodal transfer points where cargo is moved from one mode of transportation to another. While the surface transportation is generally efficient, improvements are needed at the transfer points in our ports. The importance of these intermodal interchange points is recognized in the National Highway System Designation Act of 1995. The Act identifies 240 connectors between the nation's highway system and the 150 port and marine terminals that handle nearly all U.S. waterborne freight.. Predicted growth in international waterborne commerce will increase the demands on U.S. ports' infrastructure, intermodal connectors, and the entire transportation system. The infrastructure of U.S. ports is critical for national economic health and protection of U.S. national security interests.

Ports must be able to accommodate the larger vessels coming into service. Ports must also upgrade cargo-handling equipment and operational procedures to increase the speed and volume of cargo throughput. In general, larger and faster ships and advanced port container-handling equipment will enable terminal operators to move more cargo and increase labor productivity. The labor force of the future will have to be highly skilled to operate the equipment and systems needed for tomorrow's ports. Unless necessary port infrastructure improvements are completed in a timely and cost-effective manner, some major ports could lose business to other U.S. or non-U.S. ports.

To exploit fully the cost efficiencies of the new "mega" ships, large carriers will limit vessel calls to major load center ("hub") ports. Some hub ports exist today, but by 2020, they will become the preferred distribution points on high-volume trade routes fed by domestic coastal "relay" operations. Smaller ports will take on a new role as they become part of a network of coastal trade facilities.

The deployment of larger ships will increase dredging concerns—both the physical capability to handle large ships and the environmentally sound and cost-effective disposal of dredged material. Large vessels (6,000 twenty-foot equivalent units (TEUs)) require a minimum channel depth of 15 meters (49 feet), increasing only marginally to 15.3-15.5 meters (to 51 feet) for 8,000-10,000 TEU ships.

In addition to the growth in trade, environmental concerns and a need to relieve road and rail congestion will drive coastwise expansion of markets for movement of freight and passengers.

### Shipbuilding and Repair

The United States shipbuilding and repair industry is an aggregate of more than 280 privately owned facilities. These facilities are located in more than 150 cities, in 30 states and Puerto Rico. Eighteen of the U.S. facilities comprise the Major Shipbuilding Base (MSB). The MSB includes shipyards having at least one shipbuilding position consisting of an inclined way, a launching platform, or a building basin capable of accommodating a vessel of at least 122 meters in length. With few exceptions, these shipbuilding facilities are also major repair facilities with drydocking capability. As of January 1, 1997, the total production workforce in the MSB was 34,591—of which 3,974 were engaged in constructing vessels for commercial operations. Second-tier shipyards, comprised of small or medium size facilities, engage primarily in the construction of vessels for use on the inland and coastal waterways as well as for foreign markets.

Around 2020, shipyards will begin building vessels to replace those being built today. Sufficient capacity will be available. The integration of ship design and production processes, and the use of robotics and electronically controlled assembly will result in more efficient, cost-effective and timely ship construction. While Far East shipyards will continue to dominate shipbuilding, Japan and South Korea are expected to be less dominant, as China, India, Malaysia and Singapore capture increased market share. Pacific Rim shipyards are also expected to enter markets for more sophisticated vessels.

## IMPORTANCE TO THE U.S. ECONOMY AND NATIONAL SECURITY

Transport by water is generally the most economical and efficient means to move goods. Efficient, well managed ports and waterways benefit every American by keeping waterborne commerce flowing. This, in turn, keeps shipping costs down and ultimately makes products more affordable.

The demand for waterborne cargo initiates a chain of economic activity, which contributes to the overall national economy. This activity generates 15.9 million jobs throughout the country and contributes $78.6 billion to the GDP. For example, with increased farm production, for U.S. farmers to be competitive globally, there must be low-cost and efficient marine transportation to deliver their products to overseas markets.

Marine transportation, including ports and waterways, is vital to our national security. With the recent reduction of U.S. forces and forward basing of equipment overseas, the ability to rapidly deploy troops and material worldwide is even more critical. During the Gulf War, for example, 95 percent of the supplies for U.S. forces went by ship.

## GLOBAL TRENDS THAT WILL AFFECT MARINE TRANSPORTATION

### Shifts in Trade Patterns

Shifts in trade patterns will have direct impacts on shipping demand. Trade routes will change in response to available labor pools and markets. As labor-intensive manufacturing continues to migrate from North to South America and eastern to western Asia in search of lower-cost labor, shipping from U.S. East Coast ports via the Suez Canal may become more attractive than trans-Pacific routing. This could reverse the current west-to-east flow of Asian imports.

Within the United States, domestic waterborne commerce may benefit by a shift in dry cargo shipments from congested highway and rail corridors to coastal waterways. Development of effective intermodal interfaces could also promote domestic trade growth. For example, domestic tug-barge service throughout the Great Lakes, inland waterways, and coastal ocean trades, could provide an integrated water route for Canada-U.S.-Mexico trade.

### Capital Requirements

Substantial capital investment—both private and public—in new ships, related equipment, and physical intermodal infrastructure, will be required to meet growing transportation demands. New financing mechanisms will be needed to meet the unique requirements of ports and waterways which do not benefit from direct public use and attention. Future capital requirements and priorities must be set for the allocation of available funds. Increased congestion on the interstate highway system, for example, will provide an incentive to shift investment toward maritime and rail service; however, without greater public appreciation of the importance and value of marine transportation, public funds will continue to be directed towards the immediate needs of land transportation. The increased globalization of the U.S. economy and increased demand for transportation services must be factored into transportation investment decisions.

### Vessel Technology

New vessel designs and propulsion and energy sources will produce larger, faster, more efficient ships, particularly in the high-volume line-haul trades from the Far East to Europe and the United States. Containerships introduced into service in the 1960s with capacities of less than 500 TEUs, have been replaced by ships that can carry approximately 6,000 TEUs. Carriers planning for increased cargo volume have ordered vessels that can carry over 8,000 TEUs. By 2010, ships carrying 13,000 TEUs are possible. However, this prospect raises concerns about port capacity and the ability of intermodal connections to move cargo away from a port to its destination. The limited channel depth of many ports will create more demand for vessels with smaller draft, including tug-barges, to transship cargo to final regional distribution ports.

Component miniaturize has applications in vessel technology. The capability to produce higher amounts of power with smaller generators will result in a significant fuel savings and a reduction in noxious emissions. Fuel cell development could lead to an environmentally friendly propulsion alternative for the future.

Integrated navigation and communications systems utilizing global positioning, electronic chart display, improved data and voice transmission capabilities, and the military's "glass cockpit" technology[1] will improve safety. Onboard automation will further increase productivity. A ship with a crew of 50 seafarers in 1960 and 8, 16, or 21 today could have as few as 4 by 2020.

### Human Resources/Training

Even as ships become larger and average crew sizes smaller, the current shortage of adequately trained mariners will continue worldwide as trade triples by 2020. As ships and transportation systems become more complex, training requirements will grow. Advances in human factors technology and applications of system safety principles will demand better training and performance testing of personnel. Highly trained people will be required for most positions and this will result in a demand for skilled U.S. seafarers, especially as the difference between U.S. and foreign wages decreases.

[1] Heads-up display where information is projected or appears on the glass window or cockpit through which the operator is looking.

Increased public concern for safety and protection of the environment will accelerate the movement toward enhanced international requirements for vessel safety, environmental protection, and crew qualifications.

## MARITIME POLICY AND KEY STRATEGIC ISSUES

There are many laws and international treaties that govern our waterways and their use. Although many federal agencies exercise specific authorities, section 101 of Title 49 United States Code (U.S.C.) gives the Department of Transportation the responsibility to oversee the national transportation system. Other authorities relevant to marine transportation can be found in U.S.C Titles 14, 16, 19, 33, 46 and 49, and in international treaties.

### International Standards

Under International Maritime Organization (IMO) resolutions to become effective in 2002, the United States and the member nations of the European Union (EU) have pledged to verify that ships calling in ports under their jurisdiction are in compliance with international standards of ship safety, training, operation, and construction. The uniformity and enforcement of these regulations will ensure that carriers have equitable safety and training costs. With U.S. leadership, operational safety in U.S. and EU ports should improve significantly; efforts will need to be directed to worldwide acceptance of these standards among all maritime nations.

The use of double-hulls and other design features will decrease the possibility of an oil spill if a vessel goes aground or is involved in a collision. The Oil Pollution Action of 1990 requires all oil tankers and barges calling at U.S. ports to have double-hulls by 2015. In addition, under IMO regulations, newly constructed tankers must have a double hull or equivalent protection.

### Need for greater policy coordination and integration

Although the U.S. marine transportation system is extensive and currently capable of handling vast amounts of cargo, it is not without problems. Investment and technological deficiencies hinder growth, and a variety of users have expressed their concerns. For example, Intertanko, an organization of foreign-flag tanker owners and operators whose members' ships carry 60 percent of oil and petrochemical shipments to and from the United States, notes that U.S. ports are being pushed to the limits of their capability. They further contend that it is an anomaly that tankers that approach U.S. terminals do so without the support of a modern vessel traffic system. These tankers must often base their approach on 50 year old charts, are instructed to approach a berth on less than adequate water draft, and finally moor at a berth that was designed to accommodate ships much smaller than a modern tanker.

The President of Sea-Land, a major U.S. and global liner and shipping company, has stated that successful U.S. ports of the future will be those that have appropriate road and rail connections and deep harbors to accommodate the larger, newer vessels. He warns that the Port Authority of New York/New Jersey could lose 20 percent of its international cargo by 2015 unless its channels are deepened beyond 40 feet.

The Center for Naval Analysis notes that responsibility for managing U.S. ports and its waterways system is spread among various federal agencies and stakeholders. Management is fragmented and there is no mechanism for coordination. The Center further indicates that unless all entities work together in unison, it will not be possible to ensure that all ships and cargoes can move efficiently into and out of U.S. ports, global prices will rise, and U. S. global competitiveness will drop.

Actively involving waterway users and stakeholders in comprehensive planning will aid in consensus building that balances the needs of all. Waterways management is currently the product of a loosely coupled system of customers and stakeholders. Analyses show that waterways management policies, procedures, and standards are inconsistent from port to port, from region to region, and from nation to nation. Waterway users want a seamless transportation system from the point of origin to destination. Waterway managers, speaking with one voice and working together, can achieve this objective. At the local level, ports need to be more customer-focused to give waterway users a greater degree of consistent, "one stop-shopping" for port information, services and to satisfy all regulatory requirements.

As demand for use of limited waterway space increases, the public expects the government to ensure the safety of the marine transportation system and to protect the marine environment. The public also expects an infrastructure that adequately meets the nation's needs, even though much of the landside facilities are provided by non-federal entities. Coordination of public and private efforts is needed to meet this challenge.

## Marine Transportation and National Defense

As a military and economic superpower, the United States must be prepared to respond to regional conflicts around the globe that threaten U.S. national security or economic interests. The Department of Defense (DoD) will deploy smaller, but more efficient, military forces to protect vital national interests and rely on "just-in-time" logistics for improved defense equipment inventory management and force projection capability.

To maximize DoD's logistics capability and minimize its cost, future defense transportation requirements will be met by increased reliance on the U.S. commercial transportation sector. As security threats or natural disasters occur, the United States will use not only sealift, but the entire intermodal transportation system, to deploy quickly and sustain its forces.

For general (dry) cargoes, the Maritime Security Program, and the Voluntary Intermodal Sealift Agreement program, assure a cost-effective way to provide DoD with a worldwide network of container ships, terminals, and experienced personnel for sealift requirements.

For petroleum cargoes, the Voluntary Tanker Agreement that provides a mechanism for U.S. tanker owners to make their vessels available to DoD for point-to-point transport of military fuels and lubricants. This agreement is designed to meet contingency or war requirements, it is not applicable to peacetime re-supply operations normally addressed by commercial type charters.

Complementing these resources are the vessels and crews employed in the domestic waterborne trades. Under section 27 of the Merchant Marine Act of 1920, known as the Jones Act, coastal and inland trades are reserved for U.S.-citizen owned vessels built in the United States, which meet U.S.-citizen crew requirements. Over 75 percent of the oceangoing Jones Act vessels are militarily useful, as defined by DoD, and the pool of seafarers with experience on these vessels has been relied upon to operate government-owned reserve fleet vessels for many missions.

## Marine Transportation and the Environment

The immense size of the marine transportation infrastructure and the fact that much is located in sensitive coastal environments raise concerns over possible environmental impacts to marine ecosystems. Dredging operations that are necessary for the safe and operational function of port facilities raise environmental concerns regarding the disposal of dredged material. The purpose of many statutes and regulations is to prevent environmental damage when building or utilizing the marine transportation system.

Dredging is necessary for many ports to remain operational and accommodate a wide diversity of transport vessels. However, deeper dredging may expose concentrated toxins that are currently sealed by a layer of silt and clay. An example of this is the ketones disposed of by old industrial processes at the mouth of the James River. Dredging in this area would create an environmental disaster. The disposal of dredge spoils has become a major environmental concern in conflict with port and waterway development.

In response to environmental concern over the ocean disposal of material, the United States Congress enacted the Marine Protection, Research, and Sanctuaries Act (MPRSA) to address and control the dumping of materials into ocean waters. As a result, all operations involving the transport and disposal of dredged material are evaluated, disposal sites are designated and selected to reduce environmental impacts, and monitoring programs are established by the Environmental Protection Agency and the U.S. Army Corps of Engineers to ensure unnecessary environmental degradation.

Plants, animals, and microorganisms are incidentally transported through ballast water from their natural habitats to other areas of the globe. Without local predators, they can become an invasive nuisance and overwhelm indigenous populations. Zebra mussel larvae, introduced to the United States waters, have become widespread and can clog the water intake pipes of plant operations. Control and eradication efforts are costly. San Francisco Bay is home to some 230 invasive species, the largest introduced population in the nation.

Marine paints incorporate biocides to inhibit corrosion and colonization and growth of marine sessile organisms. These paints reduce hull maintenance downtime, increase vessel speed by reducing drag, and improve fuel consumption. The biocides that make marine paints effective can damage non-target aquatic species. The "Organotin Paint Control Act of 1987" has greatly reduced levels of the toxin TBT in waterways, while still making marine paints with biocides available for the commercial fleets.

Petroleum products spilled into waterways can have both short and long term effects on water quality. Massive oil spills can be very damaging; however, it is the collective contribution of small amounts of petroleum products due to leakage, accidents, and runoff from roadways, rail yards, and parking lots that introduce a large amount of oil and petroleum products into the marine environment. Much effort and regulatory attention has been made to prevent the large spills, but much needs to be done to prevent the many small pollution sources.

Physical damage to sensitive aquatic habitats from vessel groundings is another concern. The recovery of lost and damaged corals due to a recent grounding of a large commercial vessel in the Florida Keys National Marine Sanctuary (FKNMS), is a long and slow process. Recovery from the incidental damage to local fisheries and tourism can also be slow. Establishing marine protected areas such as the FKNMS will help to keep vessels clear of these sensitive areas.

Marine transportation activities come under an environmental regulatory framework that is both national and international in scale. Most of these regulations are directed at controlling or preventing water pollution. As science better understands the movement, fate, and effects of a wide variety of pollutants, additional control policies will be created. Marine transportation must facilitate commerce without damaging marine ecosystems.

## TECHNOLOGY

The U.S. maritime industry has been a leader in developing and applying technology to lower transportation costs, improve service to shippers, increased safety, ensure environmental protection, and provide sealift to the U.S. armed forces in times of national emergency. It has dramatically improved productivity through innovative and creative application of technologies.

Technology offers tools to increase safety and efficiency. By 2020, advances in computer information and communications technologies will further change the way transportation and business activities are organized.

### Navigation Information

Critical to safe and efficient movement of marine traffic is a modern navigation information infrastructure. This infrastructure includes accurate electronic charts, reliable positioning systems, real time environmental information (winds, waves, tides, water levels) and a vessel traffic management system. Developing accurate charts will require a comprehensive bottom survey program using state-of-the-art technology. There are many areas of U.S. coastal waters and harbors that have not been surveyed in 50 years. The introduction of deeper draft ships as well as facilities' construction, channeling, and natural silting justify newer surveys. This is especially critical in areas where there is minimal under-keel clearance available to ships.

The Differential Global Positioning System) and the Electronic Charting Display and Information System are replacing traditional navigational methods. Electronic navigation systems are likely to improve safety overall, but may introduce new complexities and new opportunities for human error. These systems will require new training and qualification programs for mariners. Looking back historically to the introduction of radar, one might also expect that some of the safety advantages of electronic navigation systems will translate into increased transportation throughput.

Automatic identification system transponder capability will improve mariners' and ashore managers' job performance by providing more comprehensive information frequently and unobtrusively. Digitized communications on demand will lessen reliance on traditional VHF voice communications, which are reaching airwave saturation. Sensing communications and information technologies offer big improvements in how things are done in the marine industry. "Smart" systems can tell mariners what is happening with their ship, independent of their own observation. Many traditional systems, like stability books, can be enhanced with updated technology.

Advances in marine technology will change vessel design, operating procedures, and manning levels. These advances will offer the potential for rapid increases in transportation throughout and highlight the need for streamlined, responsive, performance-oriented regulations. Industry will demand greater involvement in the policy-making and regulatory processes to take advantage of innovative approaches and to stay competitive.

Effective use of technology can increase the capacity of marine transportation while maintaining safety and protecting the environment. To that end, the development and effective use of risk assessment techniques are essential. Coordinated research and development to assess the complexity and coupling of systems is important.

In general, technological advances will be critical factors in ensuring that the overall transportation system is brought to its full potential in terms of life-cycle economics (the cost of acquisition, operation, maintenance, and disposal of an item), energy efficiency, and minimal societal impacts. The rapid advance of technological capabilities has not been matched by the government's ability to establish standards that deploy its use, nationally and internationally. When the marine industry is ready to use a technology, such as the Electronic Charting Display and Information System, it expects there to be a national standard in conformity with international conventions. A national policy and mechanism for better coordination on issues such as these would represent a giant step toward providing the technology wanted by the maritime industry. Federal resources for maritime research and development have declined significantly, leading to a reduction in important R&D activities and elimination of some crucial programs at the very time that R&D is needed to meet the challenges.

### Human Factors

As technological advances become more sophisticated, the interface between man and machine becomes increasingly complex. In considering this human element interface, one must recognize that to achieve the world's safest, most cost-effective, and environmentally sound maritime transportation system, the role of people in preventing casualties and pollution must be emphasized. Advances in technology on board vessels and in the marine transportation infrastructure have reduced the number of casualties due to engineering or structural failures to less than 20 percent.

Studies of recent casualties show that human factors cause 75-95 percent of all marine accidents. This indicates an engineering success story; however, it also indicates that to make additional gains, the issues involving the role and impact of people must be addressed. Management, training, work environment, behavior, and technology are all elements that influence how people will perform. Future improvements to the U.S. marine transportation system must include human element considerations.

## OPTIONS FOR CONSIDERATION

Improving marine transportation will require a number of actions to improve the focus, coordination, planning, research, and management for ports, waterways, and their intermodal connections. Investment in the marine transportation system should take several forms:

- technology assessment and application
- risk management development and application
- active involvement at all levels with the user community, environmental interests, Congress, states, and other federal agencies.

Federal agencies need to take an active role in marine transportation and waterways management at the local and national levels. They need to work with industry and other affected stakeholders to resolve problems and, where appropriate, provide federal funding for projects and services.

In light of budget cutbacks, the maritime industry, local governments, and the Federal Government should explore partnership funding arrangements to:

- Recognize the marine transportation system as a critical element in transportation legislation (such as ISTEA or subsequent legislation).
- Develop federal ports and waterways.
- Implement pollution prevention and response initiatives recommended by the Interagency R&D Committee established under the Oil Pollution Act of 1990.
- Conduct research and development in areas where commercial interests alone are not sufficient to justify work in the private sector.
- Develop a long-term comprehensive dredged material management plan for the U.S.
- Develop a "model port" concept.

## CONCLUSION

Marine transportation is one of the more important uses of the ocean. There will be increased demand on U.S. ports and waterways, which are already reaching maximum capacity. Increased use of waterways and port facilities must be achieved while still protecting human health and the environment. National leadership, in partnership with private and public stakeholders, can help to ensure that the marine transportation system meets the nation's needs into the 21st Century.

## DOMESTIC LEGAL REGIME

### Contents

- Shore Protection Act of 1988 (33 U.S.C. §§ 2601 et seq.)
- U.S. Public Vessel Medical Waste Anti-Dumping Act of 1988 (33 U.S.C. §§ 2501 et seq.)

The legal regime covering this topic is based on a collection of important federal statutory authorities. The following is a brief description of some of those authorities relating to maritime transportation. The list is selective and is designed to illustrate some major maritime transportation acts. The list is not meant to be comprehensive.

## I. PORTS AND WATERWAYS

**Deepwater Port Act of 1974**, as amended, 33 U.S.C. §§ 1501 et seq.

The Act creates the regulatory regime for the location, ownership, construction, and operation of deepwater ports in waters beyond the territorial limits of the United States. The Act provides for the protection of the marine and coastal environments and the rights and responsibilities of states and local communities. Deepwater ports are non-vessel, fixed or floating manmade structures that are used as a port or terminal for the loading, unloading, or handling of oil for transportation to a state. The Secretary of Transportation issues deepwater port permits; however, the National Oceanic and Atmospheric Administration advises the Department of Transportation on the environmental review criteria for deepwater port applications, the site evaluation and preconstruction testing at potential locations, and the designation of "adjacent coastal state" status (in other words, if the state is subject to equal or greater risk than the state directly connected to the port by pipeline).

**Ports and Waterways Safety Act of 1972**, as amended, (PWSA), 33 U.S.C. §§ 1221-1236

The PWSA, as amended by the Port and Tanker Safety Act of 1978, P.L. 95-474, and the Oil Pollution Act of 1990 (OPA), is designed to promote navigation, vessel safety, and protection of the marine environment. Generally, the PWSA applies in any port or place under the jurisdiction of the United States, or in any area covered by an international agreement negotiated pursuant to section. 33 CFR 2.05-30 defines waters subject to the jurisdiction of the U.S. as navigable waters, other waters on lands owned by the U.S., and waters within U.S. territories and possessions of the U.S.

The PWSA authorizes the U.S. Coast Guard (USCG) to establish vessel traffic service/separation schemes (VTSS) for ports, harbors, and other waters subject to congested vessel traffic. The VTSS apply to commercial ships, other than fishing vessels, weighing 300 gross tons (270 gross metric tons) or more. The OPA amended the PWSA to mandate that appropriate vessels must comply with the VTSS.

The PWSA was amended by the Port and Tanker Safety Act of 1978 (PTSA), P.L. 95-474. Under the PTSA, Congress finds: that navigation and vessel safety and protection of the marine environment are matters of major national importance; that increased vessel traffic in the Nation's ports and waterways creates substantial hazard to life, property or the marine environment; that increased supervision of vessel and port operations is necessary in order to (1) reduce the possibility of vessel or cargo loss, or damage to life, property or the marine environment; (2) prevent damage to structures in, on, or immediately adjacent to the navigable waters of the United States or the resources within such waters; (3) insure that vessels operating in the navigable waters of the United States shall comply with all applicable standards and requirements for vessel construction, equipment, manning and operational procedures; and (4) insure that the handling of dangerous articles and substances on the structures in, on, or immediately adjacent to the navigable waters of the United States is conducted in accordance with established standards and requirements; and that advance planning is critical in determining proper and adequate protective measures for the Nation's ports and waterways and the marine environment, with continuing consultation with other federal agencies, state representatives, affected users and the general public, in the development and implementation of such measures.

The PTSA provided broader regulatory authority over regulated and non-regulated areas. The PTSA provided for improvements in the supervision and control of all types of vessels operating in navigable waters of the United States, and in the safety of foreign or domestic tank vessels that transport or transfer oil or hazardous cargoes in ports or places subject to United States Jurisdiction. The PTSA also reflects certain tank vessel standards and requirements accepted internationally, specifically those developed by the International Conference on Tanker Safety and Pollution Prevention.

**Rivers and Harbors Act of 1899**, as amended, (RHA), 33 U.S.C. § 401 et seq.

The RHA prohibits the unauthorized obstruction of navigable waters of the United States. The construction of any structure or the excavation of or deposit of fill in the navigable waters of the United States is prohibited without a permit from the Army Corps of Engineers. The Act also prohibits the discharge of refuse and other substances into navigable waters, but this aspect of the RHA has been largely superseded by the Clean Water Act.

## II. NAVIGATION

**Bridges over Navigable Waters**, 33 U.S.C. §§ 491-535

The sections within Title 33 between sections 491 and 535 area a collection of several bridge laws that are intended to prevent any interference with navigable waters of the U.S. whether by bridges, dams, dikes or other obstructions to navigation except by express permission of the U.S. The Secretary of Transportation's authority has been delegated to the Commandant of the Coast Guard. There is, however, an advance approval category where the Commandant has given his advance approval for bridges over waters navigable in law but not navigable in fact. See 33 CFR 115.70.

**Coast and Geodetic Survey Act**, as amended, 33 U.S.C. §§ 883a-k

The Secretary of Commerce is authorized to conduct hydrographic and topographic surveys, tide and current observations, geodetic-control surveys, field surveys for aeronautical charts, and geomagnetic, seismological, gravity, and related geophysical measurements to provide nautical and aeronautical charts and other information for safe marine and air navigation. Also, these charts and information have commercial and industrial uses and fulfill engineering and scientific purposes. This information is collected, assimilated, and distributed by the National Oceanic and Atmospheric Administration under its authority in the Act.

**Inland Navigational Rules**, as amended, 33 U.S.C. §§ 2001-2073

The Inland Navigational Rules provides regulations that govern ship navigation for vessels upon the inland waters of the United States, and to U.S. vessels on the Canadian waters of the Great Lakes to the extent there is no conflict with Canadian law.

**International Regulations for Preventing Collisions at Sea**, as amended, (72 COLREGS), 33 U.S.C. §§ 1601-1608

The International Regulations for Preventing Collisions at Sea provides binding comprehensive regulations for the prevention of collisions on the water. The 72 COLREGS apply beyond established demarcation lines. In the United States, the 72 COLREGS govern ship navigation on non-internal waters. The scope of the 72 COLREGS include Steering and Sailing Rules, e.g., conduct of vessels in sight of one another, conduct of vessels in restricted visibility; Lights and Shapes, and Sound and Light Signals. The statute also contains special provisions for ships of war, vessels proceeding under convoy, and fishing vessels engaged in fishing as a fleet. Civil penalties may be assessed for violations of the 72 COLREGS.

**Wreck Act**, as amended, 33 U.S.C. § 409 et seq.

The Act prohibits the anchoring or tying of vessels or other craft in navigable waters in a manner that prevents or obstructs passage of other vessels or craft. Also, the Act places a duty on an owner, lessee or operator of a vessel, raft or other craft that has sunk in a navigable channel to mark the wreck with a buoy or beacon and to maintain such marker until the wreck is removed or abandoned. The owner, lessee, or operator has the duty to commence the immediate removal of the wreck.

III. VESSELS, CARGO, PASSENGERS

**Title 46 United States Code**

Title 46 of the United States Code is integral to maritime transportation as it comprehensively addresses shipping. Title 46 is broken down into three general subtitles:
(I) General; (II) Vessels and Seamen; and (III) Maritime Liability. Subtitle II contains laws governing vessels, cargo and passengers including, for example, laws pertaining to design and construction of vessels, vessel manning and pilotage, and carriage of cargo or passengers.

**Subtitle II - Vessels and Seamen** (Chapter 21 through Chapter 147)

**Part A—General Provisions** (Chapters 21 and 23)

Part A provides general and limited definitions applicable to sections within Subtitle II; provides the basic authority and responsibility for enforcement and administration of the subtitle. Secretary is defined as the "head of the department in which the U.S. Coast Guard (USCG) is operating"; presently the Secretary of Transportation. The Secretary has general superintendence authority over the U.S. merchant marine and its personnel (section 2103). Chapter 21 provides authority for the Secretary to delegate to the USCG the duties and powers conferred by subtitle II (section 2104). The chapter also provides that when a vessel in liable *in rem*, the vessel may be libeled and proceeded against in the U.S. district court where the vessel is found (section 2106). Civil penalty procedures are provided in sections 2107-2108. Section 2109 expressly exempts that application of subtitle II to a public vessel of the United States although it does apply to Department of Transportation vessels, except USCG and Saint Lawrence Seaway Development Corporation vessels. Section 2110 authorizes fees for services or other things provided by the Secretary under the subtitle, with procedures therefor and limitations thereon. Section 2113 provides authority for the Secretary to exempt certain vessels from the application of provisions of subtitle II. Section 2114 provides protection for any seaman who reports a violation of the subtitle.

Chapter 23 (Operation of Vessels Generally; sections 2301-2306) provides for penalties and injunctive relief for negligent operation of vessels (section 2302, 2305); duties related to marine casualty assistance and information and providing assistance at sea (section 2303-2304); and vessel reporting requirements (section 2306).

**Part B - Inspection and Regulation of Vessels** (Chapters 31 through 47)

Part B provides authority and responsibility for the inspection and regulation of vessels by the U.S. Coast Guard. Part B specifies vessels subject to inspection and inspection procedures, as well as vessels exempt from inspection.

Chapter 31 (General; sections 3101-3102) provides authority for the President to suspend inspection requirements for foreign flag vessels registered in the United States. It also provided for immersion suits.

Chapter 32 (Management of Vessels; sections 3201-3205) requires the Secretary to prescribe regulations which establish a safety management system addressing, for example, safety and environmental protection, and procedures for safe operation of vessels in compliance with U.S. and international law, for responsible vessels and persons subject to the chapter. The Secretary shall issue Safety Management Certificates and a Document of Compliance to requesters complying with safety management plans.

Chapter 33 (Inspections Generally; sections 3301-3318) provides the requirements and procedures for inspection of vessels. Vessels subject to inspection include freight vessels, nautical school vessels, passenger vessels, seagoing barges, and tank vessels. Vessels exempt from inspection in certain circumstances include fishing vessels and certain fish processing vessels (sections 3301-3302). Reciprocity for foreign vessels is provided in section 3303. The Secretary is directed to issue regulations for proper execution of Part B. Certificates of inspection are issued to vessels successfully meeting inspection requirements and are required to be on board the vessel to operate; compliance with certificates of inspection is required (sections 3309-3314). Penalties may be assessed for violation of Part B (section 3318).

Chapter 35 (Carriage of Passengers; sections 3501-3506) governs the carriage of passengers. Certificates of inspection shall include the number of passengers a vessel is authorized to carry and liability may result for exceeding that number (section 3501). Persons in charge of specified vessels must keep a correct list of passengers, including a correct count (section 3502). Persons selling passage to a ship with accommodations of 50 or more passengers must notify prospective passengers of the vessels safety standards; violations are subject to civil penalties (section 3504). Foreign vessels are prohibited from departing a U.S. port with passengers who embarked at that port if the Secretary finds that the vessel does not comply with the standards in the International Convention for the Safety of Life at Sea (SOLAS) (section 3505).

Chapter 37 (Carriage of Liquid Bulk Dangerous Cargoes; sections 3701-3718) governs the carriage of liquid bulk dangerous cargoes such as oil or hazardous materials. The chapter applies to any tank vessel operating in U.S. navigable waters or transferring oil or hazardous materials in any port subject to U.S. jurisdiction, with exemptions for certain vessels (section 3702). The Secretary is required to issue regulations for the design, construction, alteration, repair, maintenance, operation, equipping, personnel qualification, and manning of vessels subject to the chapter, necessary to protect life and property, for navigation and vessel safety, and protection of the marine environment (section 3703; regulations are found in 33 CFR and 46 CFR). Minimum standards for tank vessel construction are provided (section 3703a); requirements for coastwise trade vessels (section 3704); as well as minimum standards for crude oil tankers, product carriers, tankers, and self-propelled tank vessels, with certain exemption as authorized by the Secretary (sections 3705-3709). The Secretary is directed to establish a marine safety information system to contain information about vessels subject to the chapter (section 3717). Civil or criminal penalties may be assessed for violations of the chapter, including revocation of Customs Service clearance (section 3718).

Chapter 39 (Carriage of Animals; sections 3901-3902) provides authority for the Secretary of Agriculture to prescribe regulations governing the accommodations for the export of animals, and provides for penalties for violations of such regulations.

Chapter 41 (Uninspected Vessels Generally; sections 4101-4106) applies to vessels not subject to inspection and certification requirements of chapter 33. Such vessels must comply with certain minimum safety requirements (section 4102). Uninspected passenger vessels are subject to the requirements of chapter 43 pertaining to recreational vessels (section 4105).

Chapter 43 (Recreational Vessels; sections 4301-4311) contains the laws applicable to recreational vessels. The Secretary is authorized to issue regulations establishing, for example, minimum safety and equipment standards (section 4302; regulations are found in 19 CFR, 33 CFR, 46 CFR). The chapter expressly preempts state law establishment of a recreational vessel or associated equipment performance or other safety standard that is not identical to a regulations under section 4302 (section 4306). Persons are prohibited from manufacturing, constructing, offering for sale or introducing into interstate commerce, or import into the United States a recreational vessel, associated equipment, or component thereof unless it conforms with the chapter and regulations thereunder, does not contain an identified defect creating a substantial risk of personal injury to the public, or is intended only for export and is so labeled. Nor may a person operated a vessel in violation of the chapter or regulations thereunder (section 4307). Recreational vessel manufacturers subject to the chapter must maintain record and reports and provide information to the Secretary to enable the Secretary to identify whether the manufacturer has acted in compliance with the chapter or regulations thereunder (section 4309). Recreational vessel and associated equipment manufacturers must provide notification of a defect or failure of compliance if discovered (section 4310). Criminal and civil penalties, including injunction, for violations of the chapter (section 4311).

Chapter 45 (Uninspected Commercial Fishing Industry Vessels; sections 4501-4508) provides requirements, standards and procedures applicable to uninspected fishing vessels, fish processing vessels, or fish tender vessels. The chapter also directed the Secretary to establish a Commercial Fishing Industry Vessel Advisory Committee.

**Part C - Load Lines of Vessels** (Chapter 51)

Chapter 51 (Load Lines; sections 5101-5116) provides for the assignment of load lines and issuance of load line certificates to vessels. The chapter also requires certain classes of vessels (e.g., vessels of the U.S., vessels on the navigable waters of the U.S., public vessels of the U.S. (except vessels of war)) to be marked with load lines. A vessel may be operated only if it has been assigned load lines (section 5103). The chapter provides reciprocity for foreign vessels under certain conditions (section 5109). A vessel may not be loaded in a way that submerges the assigned load line or the place at which the load line is required to be marked on the vessel (section 5112). The

Secretary is authorized to detain a vessel from leaving a place in the United States in violation of the chapter or regulations thereunder (section 5113), and may, with the approval of the Secretary of the Treasury, use a Customs Service officer to enforce the chapter (section 5114). Civil and criminal penalties may be assessed for violations of the chapter (section 5116).

**Part D - Marine Casualties** (Chapters 61 and 63)

Chapters 61 (Reporting Marine Casualties; sections 6101-6104) and 63 (Investigating Marine Casualties; sections 6301-6307) govern procedures and requirements for reporting and investigating marine casualties. Chapter 61 provides for reporting of marine casualties (e.g., death or serious injury, material loss of property, significant harm to the environment). Penalties may be assessed for failure to report a marine casualty (section 6103). The Secretary is directed to issue regulations for a uniform state marine casualty report system for vessels (section 6102). Chapter 63 directs the Secretary to issue regulations for the immediate investigation of marine casualties. Marine casualty regulations are found 46 CFR.

**Part E - Merchant Seamen Licenses, Certificates, and Documents** (Chapters 71-77)

Part E established the U.S. Coast Guard's authority to issue, suspend and revoke licenses, certificates of registry, and merchant mariner's documents for individuals engaged on U.S. vessels. Chapter 71 (sections 7101- 7114) governs licenses and certificates of registry; chapter 73 (sections 7301- 7319) governs merchant mariners' documents; chapter 75 (7501-7506) provides general procedures for licensing, certification, and documentation; and chapter 77 (7701-7705) provides procedures for suspension and revocation.

**Part F - Manning of Vessels** (Chapters 81-93)

Part F provides the requirements for manning of vessels, including the number of individuals required, qualifications and conditions of employment, and duties for: masters and officers (chapter 83); pilots (chapter 85); unlicensed personnel (chapter 87); small vessels (chapter 89); tank vessels (chapter 91); and Great Lakes pilotage (chapter 93).

**Part G - Merchant Seamen Protection and Relief** (Chapters 101-115)

Part G contains provisions for the protection and relief of merchant seamen. Part G generally does not apply to fishing vessels, whaling vessels or yachts. Chapter 103 requires certain contractual arrangements between charterers, masters, or individuals in charge and seamen employed on the vessel, with certain minimum conditions. The chapter applies to U.S. vessels on a voyage between a U.S. port and a foreign port (excluding Canada, Mexico, or the West Indies); or U.S. vessels of at least 75 gross tons on a voyage between a U.S. port on the Atlantic ocean and a U.S. port on the Pacific (chapter 103). Chapter 105 addresses coastwise voyages; chapter 106 addresses fishing voyages. Chapter 107 provides procedures for when a seaman dies during a voyage, and chapter 109 provides procedures for when a vessel is suspected to be unseaworthy. Logbooks are required to be kept by the master of a vessel (chapter 113), and chapter 115 provides for penalties for specified offenses.

**Part H - Identification of Vessels** (Chapters 121-125)

Part H provides the procedures for documentation of vessels of five net tons or greater not registered under the laws of a foreign country if certain ownership conditions are met. Under chapter 121, the Secretary issues certificates of documentation. A vessel titled in the U.S. is not entitled to be documented. The effect of documentation is that it is conclusive evidence of nationality for international purposes, although not in proceedings conducted under U.S. law. Documentation is also conclusive evidence of qualification to be employed in a specific trade (excepting recreational endorsement). Documentation is not conclusive evidence of ownership in a proceeding where ownership is at issue. Chapter 121 also provides that certificates of documentation can be endorsed with a registry, coastwise, Great Lakes, fishery, or recreational endorsements, which allow the vessel to be employed in certain types of activities (e.g., foreign trade, coastwise trade). Chapter 121 provides procedures for surrender or invalidation of certificates of documentation. The Secretary and the Secretary of State, jointly, may provide for the issuance of certificates of registry for vessels procured outside the United States meeting the ownership requirements chapter. The Secretary is required to publish a list of all documented vessels. Civil penalties may be assessed for violation of chapter 121; as well as forfeiture of the vessels. Chapter 123 provides requirements and procedures for numbering of undocumented vessels. The Secretary is directed to prescribe a standard numbering system, and to approve state applications for state numbering systems. Chapter 125 provides the establishment of a vessel identification system for all U.S. vessels.

**Part I - State Boating Safety Programs** (Chapter 131)

Part I establishes a recreational boating and safety program administered by the U.S. Coast Guard, the purpose of which is to encourage states participation and uniformity in boating safety efforts. States with recreational boating safety programs approved by the Secretary are eligible for federal funding.

**Part J - Measurement of Vessels** (Chapters 141-145)

Part J contains procedures applicable to the measurement of a vessel to determine its tonnage and for obtaining an International Tonnage Certificate. Part J implements the 1969 International Convention on Tonnage Measurement of Ships

**Harter Act**, 46 App. U.S.C. §§ 190-195

The Act requires owners, masters or agents of any vessel transporting merchandise or property from or between U.S. ports and foreign ports to issue to shippers a bill of lading, or shipping document, stating, among other things, the number of packages, or quantity, condition of merchandise, and weight. Such document shall be prima facie evidence of receipt of the merchandise. It allows vessel owners limitation of liability for losses resulting from errors in navigation, dangers of sea and acts of God. Similar to the Carriage of Goods by Sea Act, except that the Harter Act: does not allow for relieve the owner for errors in navigation if there was failure to exercise due diligence to provide a seaworthy vessel; has no statute of limitations; and does not provide a limit of liability for loss or damage of cargo.

**Carriage of Goods by Sea Act**, 46 App. U.S.C. §§ 1300-1315

The Carriage of Goods by Sea Act governs every bill of lading or similar document of title which is evidence of a contract for the carriage of goods by sea to or from U.S. ports, in foreign trade. Provides for the duties and rights of carrier. The Act provides for the responsibilities and liabilities of the carrier and ship regarding, for example, seaworthiness, cargo and contents of a bill, as well as rights and immunities of the carrier and ship.

## IV. COMMERCE

**Interstate Commerce Act**, as amended, (ICA), 49 U.S.C. §§ 10101 et seq.

The ICA provides for the regulation of rates and services of competing interstate carriers. Part B (chapters 131-149) addresses water carriers, defined as a person providing water transportation for compensation (section 13102(22)). The transportation policy of part B is to "ensure the development, coordination, and preservation of a transportation system that meets the transportation needs of the United States." In overseeing the modes of transportation, the United States will, among other things, recognize and preserve the inherent advantage of each mode of transportation; promote safe, adequate, economical, and efficient transportation; encourage the establishment and maintenance of reasonable rates for transportation, without unreasonable discrimination or unfair or destructive competitive practices; and in overseeing transportation by water carrier, to encourage and promote service and price competition in the noncontiguous domestic trade (section 13101). The Secretary and the Surface Transportation Board (formerly the Interstate Commerce Commission) have jurisdiction over transportation by water carrier section 13521). Amendments to the ICA repealed provisions of the Shipping Act of 1916, and Intercostal Shipping Act.

**Intermodal Surface Transportation Efficiency Act of 1991**, P.L. 102-240.

The purpose of the Act is to develop a national surface transportation system that is economically efficient and environmentally sound, provides the foundation for a global economy, will move people and goods in an energy efficient manner. The Act provides that the system will consist of all forms of transportation in a unified, interconnected manner, including transportation systems of the future, to reduce energy and air pollution while promoting economic development and supporting the national preeminent position in interstate commerce.

## Merchant Marine Acts

Merchant Marine Act of 1920, 46 App. U.S.C. §§ 861 et seq.
Merchant Marine Act of 1928, 46 App. U.S.C. § 891
Merchant Marine Act of 1936, 56 App. U.S.C. §§ 1101 et seq.

The Merchant Marine Acts sought to promote the continued development of the American Merchant Marine. The purpose as stated in the Act of 1920 is that it is necessary for the national defense and proper growth of foreign and domestic commerce that the United States shall have a merchant marine of the best equipped and most suitable types of vessels sufficient to carry the greater portion of its commerce and serve as a naval or military auxiliary in time of war or national emergency, ultimately to be owned by U.S. citizens (section 861). The Act of 1928 provided the Secretary of Transportation authority to remodel and improve the fleet. The Act of 1936 sought to foster continued development and maintenance of the merchant marine. The Act also prevents unjust discrimination by carriers.

## Shipping Acts

Shipping Act of 1916, 46 App. U.S.C. §§ 801 et seq.
Shipping Act of 1984, 46 App. U.S.C. §§ 1701-1720

The Shipping Acts are intended to establish a non-discriminatory regulatory process for the common carriage of goods by water in the commerce of the United States. The Shipping Acts were modeled on the Interstate Commerce Act. The Act of 1916 governs transportation by water of passengers and property on the high seas or Great Lakes between states, territories, districts or possessions. Carriers are required to establish and file "joint and reasonable rates" with the Federal Maritime Commission. The Act of 1984 governs foreign commerce (repealing provisions of the Act of 1916 re: foreign commerce), and has as its purposes: to establish a non-discriminatory regulatory process for the common carriage of goods by water in foreign commerce of the United States; to provide efficient and economic transportation system in the ocean commerce of the United States, that is responsive and in harmony to international shipping practices; and to encourage development of an economically sound and efficient U.S. flag liner fleet capable of meeting national security needs. The Act allows ocean carriers the right to establish intermodal or through rates in agreements that must be filed with the Federal Maritime Commission.

V. LIABILITY

**Admiralty Extension Act (AEA)**, 46 U.S.C. § 740

The AEA (or Extension of Admiralty Jurisdiction Act) expressly defines the scope of admiralty and maritime jurisdiction of the United States. Such jurisdiction included all cases of damage or injury to person or property, caused by a vessel on navigable water, notwithstanding that such damage or injury be done or consummated on land. Suits under the AEA may be brought *in rem* or *in personam*. However, the AEA provides that any suit brought against the U.S. Public Vessels Act, or Suits in Admiralty Act shall constitute the exclusive remedy, for all suits not otherwise filed under the Federal Torts Claim Act. The AEA was enacted to eliminate the confusion over the lines between land and water, e.g., those cases where persons or property on land was damaged by ships.

**Death on the High Seas Act**, as amended, (DHSA), 46 U.S.C. § 761

For deaths caused as a result of wrongful act, neglect, or default occurring on the high seas beyond a marine league from shore, the personal representative of the decedent may bring a suit for damages in U.S. District Court, in admiralty, for the exclusive benefit of decedent's wife, husband, parent, child, or dependent relative. Suits under the DSHA may be brought against the vessel, person, or corporation which would have been liable if death had not ensued. The statute of limitations for suits brought under the DHSA is 3 years. Contributory negligence of the decedent does not bar recovery, although damages may be reduced accordingly. Further, the DHSA expressly ensures state remedies will not be affected, nor does the DHSA apply to the Great Lakes, any waters within the territorial limits of any state, or any navigable waters in the Panama Canal Zone.

**Jones Act**, 46 App. U.S.C. § 688

The Jones Act provides that any seaman who suffers personal injury in the course of his employment may, maintain an action for damages, with the right of trial by jury. In the case of death of a seaman, the personal representative may maintain such action.

**Limitation of Shipowner Liability Act**, 46 App. U.S.C. §§ 181-185

The Limitation of Shipowner Liability Act provides procedures for the limitation of liability for vessel owners. The Act provides a procedure in admiralty whereby a vessel owner may petition a U.S. district court for limitation of liability. Liability for losses may be limited to the value of the owner's vessels and freight.

**Longshore and Harbor Workers Compensation Act**, 33 U.S.C. §§ 901 et seq.

The Longshore and Harbor Workers Compensation Act provides a comprehensive worker's compensation scheme for certain maritime workers who do not qualify as seamen.

**Public Vessel Act**, as amended, (PVA), 46 U.S.C. §§ 781-790

The PVA provides authority for bringing an admiralty cause of action against the United States for damages caused by U.S. public vessels. Thus, the PVA waives sovereign immunity by the U.S. in cases involving public vessels. Public vessel is not defined in the PVA, but case law provides direction. The PVA contains provisions for the venue of suits brought thereunder, counterclaims, suits by nationals of foreign governments, and exemptions and limitations of liability. The PVA also expressly provides it shall not be construed to recognize the existence of or as creating a lien against any U.S. public vessel.

**Suits in Admiralty Act**, as amended (SAA), 46 U.S.C. §§ 741-752

The SAA provides the authority to bring admiralty suits against the United States. Such suits may be brought *in personam*, and no U.S. vessel or cargo may be seized under the SAA. If a suit is brought under the SAA, it is the exclusive remedy available to a claimant. The SAA provides a statute of limitations (2 years) after the cause of action arises. The United States is entitled to all exemptions and all limitations of liability accorded by law to owners, charterers, operators or agents of vessels. The SAA also provides procedures in the event a vessel within the scope of the SAA is seized by foreign jurisdictions. The SAA authorizes arbitration, compromise, or settlement of claims. The SAA also provides that a crew of a U.S. vessel may recover compensation for salvage services. Finally, any money recovered by a suit brought by the United States shall be deposited in the U.S. Treasury to the credit of the department having control of the vessel or cargo with respect to such cause of action.

**Title 46, U.S.C., SUBTITLE III—Maritime Liability**

Subtitle III (chapters 301 and 313) of title 46 contains provisions related to commercial instruments and liens and public vessels and goods. Chapter 301 provides general terms and definitions. Chapter 313 governs commercial instruments (subchapter II) and maritime liens (subchapter III).

## IV. ENVIRONMENTAL

**Act to Prevent Pollution from Ships**, as amended, (APPS), 33 U.S.C. §§ 1901 et seq.

The APPS is the federal legislation implementing the International Convention for the Prevention of Pollution from Ships, as modified by a Protocol of 1978 (MARPOL).

a. Oil and Noxious Liquid Substances.

The Act to Prevent Pollution from Ships as originally enacted implemented Protocols I and II, and Annexes I and II, of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL). Annex I of MARPOL establishes requirements to prevent the discharge of oil except in accordance with specific conditions. Annex II provisions cover the discharge of noxious liquid substances.

APPS applies to all U.S. flag ships anywhere in the world and to all foreign flag vessels operating in the navigable waters of the United States or while at a port or terminal under the jurisdiction of the United States. The oil and noxious liquid substances provisions apply only to seagoing ships. The regulations implementing Annex I and Annex II of MARPOL limit discharges of oil and noxious substances, establish report requirements for discharges, and establish specific requirements for monitoring equipment and record keeping aboard vessels. In particular, the regulations require that vessels covered by APPS and MARPOL keep Oil Record Books in which all discharges, disposal and transfers of oil are kept.

b. Garbage and Plastics.

APPS was amended by the Marine Plastic Pollution Research and Control Act of 1987, which implemented the provisions of Annex V of MARPOL relating to garbage and plastics. Annex V of MARPOL and the regulations implementing it apply to all vessels, whether seagoing or not, regardless of flag on the navigable waters of the United States and in the exclusive economic zone of the United States. It applies to U.S. flag vessels wherever they are located.

Under the regulations implementing APPS, the discharge of plastics, including synthetic ropes, fishing nets, plastic bags and biodegradable plastics, into the water is prohibited. Discharge of floating dunnage, lining and packing materials is prohibited in the navigable waters and in areas offshore less than 25 nautical miles from the nearest land. Food waste or paper, rags, glass, metal, bottles, crockery and similar refuse cannot be discharges in the navigable waters or in waters offshore inside 12 nautical miles from the nearest land. Finally, food waste, paper, rags, glass, and similar refuse cannot be discharged in the navigable waters or in waters offshore inside three nautical miles from the nearest land. There are some exceptions for emergencies. Under APPS, the definition of ship includes fixed or floating platforms. There are separate garbage discharge provisions applicable to these units. For these platforms, and for any ship within 500 meters of these platforms, disposal of all types of garbage is prohibited. Additionally, all manned, oceangoing

U.S. flag vessels of 12.2 meters or more in length engaged in commerce, and all manned fixed or floating platforms subject to the jurisdiction of the United States, are required to keep records of garbage discharges and disposals.

**Clean Air Act, as amended (CAA)**, 42 U.S.C. §§ 7401 et seq.

The CAA establishes national guidelines and ambient air quality standards to protect and enhance the quality of the Nation's air resources. The Environmental Protection Agency (EPA) is responsible for implementing the CAA. The EPA determines the appropriate level of technology and emission reduction required in order to achieve improved air quality. Prevention of Significant Deterioration (PSD) provisions of the CAA apply to new sources on the Outer Continental Shelf (OCS) adversely affecting air quality; these regulations supplement air quality regulations administered by the Department of the Interior in its activities related to the OCS.

The CAA required the EPA, in consultation with the Department of Transportation, to issue standards applicable to the emission of VOCs and other air pollutants from loading and unloading of tank vessels which the EPA finds causes, or contributes to, air pollution that may be reasonably anticipated to endanger public health or welfare.

The CAA establishes a great waters program, which looks specifically at the impacts of air deposition or nutrients and toxics in coastal waters.

**Clean Vessel Act of 1992**, subtitle F, §§ 5601 to 5608, of Title V of Pub. L. 102-587, amending 16 U.S.C. §§ 777c and 777g and enacting 33 U.S.C. §1322 note

The purpose of the Clean Vessel Act is to provide funds to states for the construction, renovation, operation and maintenance of pumpout stations and waste reception facilities. The Act requires the Department of the Interior (DOI) to issue guidance on what constitutes adequate and reasonably available pumpout facilities and waste reception facilities. Each coastal state is then to conduct a survey to determine the number and location of such stations and facilities and the number of recreational vessels in its coastal waters with toilets and develop and submit to the DOI for approval a plan for any construction or renovation necessary to ensure that there are adequate and reasonably available stations and facilities.

**Comprehensive Environmental Response, Compensation, and Liability Act of 1980**, as amended, (CERCLA), 42 U.S.C. §§ 9601 et seq.

Hazardous substances that are toxic to living organisms result from industrial processes and are released into the environment either intentionally or by accident. CERCLA is designed to respond to these releases and protect public health and environmental quality including natural resources.

CERCLA provides for the following three possible actions to protect the public and the environment from the harmful effects of a hazardous substance spill. Any combination of these three may be used at a particular spill.

1) Removal—CERCLA authorizes the Environmental Protection Agency (EPA) to clean up the spilled substance either at the expense of the responsible party or with funds from the Superfund. CERCLA § 104(a)(1).

2) Remedial action—CERCLA authorizes EPA to take steps to protect public health and the environment from exposure to the hazardous substance. Example of steps: dredging contaminated sediments, repairing leaking containers, collecting rain water runoff and relocating displaced residents. CERCLA § 104(a)(1).

3) Damages for natural resource injuries—When the removal and or remedial action will not remedy all injuries to natural resources, CERCLA authorizes the trustees for natural resources, to seek damages from responsible parties to restore or replace natural resources injured by exposure to hazardous substances beyond the scope of EPA's removal and remedial action. CERCLA §§ 107(a)(4)(C) and 107(f).

**Federal Water Pollution Control Act**, as amended, also called the **Clean Water Act**, as amended, 33 U.S.C. §§ 1251 et seq.

The CWA establishes the basic scheme for restoring and maintaining the chemical, physical, and biological integrity of the waters of the United States. The primary mechanism in the CWA regulating the point source discharge of pollutants is the National Pollutant Discharge Elimination System (NPDES), which is administered by the Environmental Protection Agency (EPA). Under the NPDES program, a permit is required from EPA or an authorized state for the discharge of any pollutant from a point source into the waters of the United States. This includes discharges associated with oil and gas development on federal leases beyond state waters. An NPDES permit for certain stormwater discharges also is required. Permit discharge limits are technology-based and, where technology-based limits would not protect desired water quality for a particular water body in which the discharge takes place, based on state water quality standards which are developed by the states using EPA guidance and are intended to protect the designated uses of the water body. In the case of discharges to the territorial sea or beyond, permits are also subject to the ocean discharge criteria developed under section 403 of the act. Permits for discharges into the territorial sea or internal waters may be issued by states following approval of their permit program by EPA; in the absence of an approved state permit program, and for discharges beyond the territorial sea, EPA is the permit-issuing authority.

The CWA was amended in 1987 to include the current nonpoint source (NPS) program. Under this program (section 319), states must develop management programs to address NPS runoff, including the identification of best management practices and measures. In addition, section 319 authorizes grants to assist the states in implementing their approved management programs.

The CWA generally prohibits discharges of oil and hazardous substances into coastal or ocean waters except where permitted under the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships. The U.S. Coast Guard (USCG) investigates and responds to discharges of oil and hazardous substances into coastal or ocean waters in accordance with the National Contingency Plan (NCP). The USCG, with the cooperation of EPA, generally administers the NCP when oil or a hazardous substance is discharged into coastal or ocean waters. Regional contingency plans and area contingency plans are developed to implement the NCP.

The CWA (section 312) requires vessels with installed toilet facilities and operating on the navigable waters of the U.S. to contain operable marine sanitation devices certified as meeting standards and regulations promulgated under section 312. Section 312 also allows establishment of zones where discharge of sewage from vessels is completely prohibited. Amendments made to section 312 in 1996 will require, where appropriate, the use of marine pollution control devices for operational, non-sewage, discharges from vessels of the Armed Forces.

Publicly owned sewage treatment facilities must, at a minimum, meet effluent reductions by secondary treatment, except for certain facilities discharging to coastal waters for which EPA has approved a waiver under section 301(h).

The Army Corps of Engineers (COE) implements the section 404 permit program. Under section 404, a permit is required for the discharge of dredged or fill materials into the waters of the U.S. that lie inside of the baseline for the territorial seas and fill materials into the territorial seas within three miles of shore. Although COE has responsibility for the section 404 program, EPA is authorized to review and comment on the impact of proposed dredge and fill activities and to prohibit discharges that would have an unacceptable impact on municipal water supplies, shellfish beds and fishery areas, wildlife and recreational areas. EPA, in consultation with COE, is charged with developing guidelines to be used in evaluating discharges subject to section 404. (<u>See</u> 40 C..F.R. Part 230.) The section 404 permit requirement is the cornerstone for the current wetlands regulatory program. If COE or EPA determines that a certain property is a jurisdictional wetlands, no one can discharge dredged or fill materials into it without a section 404 permit. COE and EPA also have cooperative agreements with the Natural Resources Conservation Service and rely on its determinations as to the presence of wetlands on agricultural lands.

Section 320 of the CWA establishes the National Estuary Program, which uses a consensus-based approach for protecting and restoring the estuary. There are currently 28 NEPs.

**<u>Florida Keys National Marine Sanctuary Act (FKNMSA)</u>**, P.L. 101-605

On November 16, 1990, Congress designated an area of the marine environment surrounding the Florida Keys as a National Marine Sanctuary in order to protect its unique, nationally significant natural resources including seagrass meadows, mangrove islands, and coral reefs. The FKNMSA expressly prohibits operating a tank vessel or a vessel greater than 50 meters in registered length in designated Areas to be Avoided, except if such vessel is a public vessel and its operation is essential for national defense, law enforcement, or responses to emergencies that threaten life, property, or the environment.

**Hazardous Materials Transportation Act**, 49 U.S.C. §§ 1801-1813

Authorizes the Secretary of Commerce to regulate the transportation of hazardous materials within the jurisdiction of the United States, including the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa and Guam.

**National Marine Sanctuaries Act (NMSA)**, 16 U.S.C. §§1431 et seq.

The NMSA provides the Secretary of Commerce with the authority to designate and manage nationally significant marine areas as national marine sanctuaries. The NMSA's stated purposes and policies include comprehensive and coordinated conservation and management; enhancing public awareness, understanding, appreciation and wise use of the marine environment; and facilitating, to the extent compatible with the primary objective of resource protection, all public and private uses of resources not prohibited pursuant to other authorities.

Among the factors the Secretary must consider in determining whether an area merits designation as a national marine sanctuary are present and potential uses of the area that depend on maintenance of the area's resources, including commercial and recreational fishing, other commercial and recreational activities, and research and education; the public benefits to be derived from sanctuary status, with emphasis on the benefits of long-term protection of nationally significant resources, vital habitats, and resources which generate tourism.

The NMSA prohibits the destruction, loss of, or injury to any sanctuary resource managed under the laws or regulations for the sanctuary; the possession, delivery, sale, transport, or shipment of any sanctuary resource taken in violation of the NMSA; interference with law enforcement under the Act; and any violation of the Act, any regulations, or permits issued pursuant to the NMSA. NOAA has the authority to board and search any vessel suspected of violating the NMSA and to execute warrants issued by a court of competent jurisdiction. Any person who destroys, causes the loss of, or injures a sanctuary resource can be found liable for a maximum fine of $100,000 per violation; response costs; damages including replacement cost, restoration cost, or acquisition of an equivalent sanctuary resource, and lost-use value of that resource; and interest.

Sanctuaries have site specific regulations which include a narrow range of prohibited activities, including for example, those that pertain to discharges, alteration of the seabed, and vessel operations.

**Ocean Dumping Act** (Titles I and II of the Marine Protection, Research, and Sanctuaries Act of 1972), 33 U.S.C. §§ 1401 et seq.

The Act provides the basic authority for the Environmental Protection Agency (EPA) and the Corps of Engineers to regulate ocean dumping (Title I) and for the Department of Commerce, through the National Oceanic and Atmospheric Administration, to carry out research on the effects on ocean systems of ocean dumping and other man-induced changes (Title II). The Act prohibits (1) the transportation of any material from the United States; and (2) the transportation of any material by U.S. flagged vessels and by U.S. departments, agencies, or instrumentalities, for the purpose of dumping it into ocean waters, without a permit. The Act also prohibits any person from dumping, without a permit, any material transported from a location outside the United States into the U.S. territorial seas or into the U.S. contiguous zone, to the extent it may affect the territorial seas or the territory of the U.S. EPA may issue permits regulating the ocean dumping of all material except dredged material, which is permitted by the Corps of Engineers, using EPA environmental criteria..

The ocean dumping of sewage sludge and industrial waste is prohibited. In addition, no radiological, chemical, and biological warfare agents; high-level radioactive waste; or medical waste. States may adopt and enforce requirements for ocean-dumping activities that occur in their jurisdictional waters.

Title II of the ODA requires the DOC, in coordination with the department in which the U.S. Coast Guard is operating and EPA, to conduct a comprehensive and continuing program of monitoring and research on the effects of dumping of material into ocean or other coastal waters or into the Great Lakes. The title further requires the DOC, in close consultation with other appropriate departments, to conduct a comprehensive and continuing program of research into the possible long-range effects of pollution, overfishing and man-induced changes of ocean ecosystems. The title specifies that the program must include continuing monitoring programs to assess the health of the marine environment, including but not limited to the monitoring of bottom oxygen concentration contaminant levels in biota, sediments and the water column, diseases in fish and shellfish, and changes in types and abundance of indicator species.

**Oil Pollution Act of 1990 (OPA)**, 33 U.S.C. §§ 2701 et seq.

OPA amends section 311 of the Federal Water Pollution Control Act (the Clean Water Act or CWA), 33 U.S.C. 1321 et seq., to clarify federal response authority, increase penalties for spills, establish U.S. Coast Guard response organizations, require tank vessel and facility response plans, and provide for contingency planning in designated areas. OPA, however, does not preempt states' rights to impose additional liability or other requirements with respect to the discharge of oil within a state or to any removal activities in connection with such a discharge.

OPA is a comprehensive statute designed to expand oil spill prevention, preparedness, and response capabilities of the federal government and industry. OPA establishes a new liability regime for oil pollution incidents in the aquatic environment and provides the resources necessary for the removal of discharged oil. OPA consolidates several existing oil spill response funds into the Oil Spill Liability Trust Fund (Trust Fund), resulting in a $1-billion fund to be used to respond to, and provide compensation for damages caused by, discharges of oil. In addition, OPA provides new requirements of response planning by both government and industry and establishes new construction, manning, and licensing requirements for tank vessels. OPA also increases penalties for regulatory noncompliance and broadens the response and enforcement authorities of the federal government.

Title I of OPA contains liability provisions governing oil spills modeled after the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601 et seq., and section 311 of the CWA. Specifically, section 1002(a) of OPA provides that the responsible party for a vessel or facility from which oil is discharged, or which poses a substantial threat of a discharge, is liable for:

- certain specified damages resulting from the discharged oil; and
- removal costs incurred in a manner consistent with the National Contingency Plan.

The scope of damages for which there may be liability under section 1002 of OPA includes:

- natural resource damages, including the reasonable costs of assessing these damages;
- loss of subsistence use of natural resources;
- real or personal property damages;
- net loss of tax and other revenues;
- loss of profits or earning capacity; and
- net cost of additional public services provided during or after removal actions.

**Organotin Anti-Fouling Paint Control Act of 1988**, 33 U.S.C. §§ 2401 et seq.

Organotin biocides are added to paints to protect the bottom of boats from encrusting organism buildup. Because organotin has been shown to be toxic, it may pose unreasonable risks to marine and freshwater organisms. The Act's purpose is to protect the aquatic environment by reducing the quantities of organotin entering the waters of the United States. The Environmental Protection Agency (EPA) is primarily responsible for the administration and enforcement of this statute.

The Act generally prohibits boats less than 25 meters in length from using anti-fouling paint containing organotin. Aluminum hulls and lower drive shaft units of marine engines (outboard motors) are excepted from this Act and allowed to use this paint. Penalties are available for violations. The EPA, in consultation with the National Oceanic and Atmospheric Administration, is directed to monitor the ecological effects of organotin in estuaries and coastal waters for ten years beginning in 1988.

**Shore Protection Act of 1988**, 33 U.S.C. §§ 2601 et seq.

Municipal or commercial waste cannot be transported by a vessel in coastal waters without a permit from the Department of Transportation. Municipal or commercial waste includes solid waste as defined by the Resource Conservation and Recovery Act (RCRA), but does not include hazardous wastes regulated under RCRA, waste generated by the vessel during normal operations, construction debris, dredged or fill material, and sewage sludge regulated under the MPRSA. The loading, securing, and off loading of wastes subject to the SPA must assure that any waste deposited into the coastal waters is minimized.

**U.S. Public Vessel Medical Waste Anti-Dumping Act of 1988**, 33 U.S.C. §§ 2501 et seq.

This Act prohibits public vessels from discharging medical waste except in extremely limited circumstances, because of the serious and widespread risks to public health and to the welfare of coastal communities. Potentially infectious medical waste may only be discharged by a public vessel if: 1) the health or safety of individuals on board the vessel is threatened or during a time of war or national emergency; 2) the waste is released at least 50 nautical miles from the nearest land; and 3) the waste is sterilized, properly packaged, and sufficiently weighted to prevent it from coming ashore.

## LIST OF ACRONYMS

| | |
|---|---|
| DoD | Department of Defense |
| GDP | gross domestic product |
| ISTEA | Intermodal Surface Transportation Efficiency Act |
| MSB | Major Shipbuilding Base |
| R&D | research and development |
| TEU | twenty-foot-equivalent unit |
| VOC | volatile organic compound |
| U.S.C. | United States Code |

# 1998 Year of the Ocean

## THE OCEANS AND NATIONAL SECURITY

Contents

## INTRODUCTION

The United Nations has designated 1998 as the "International Year of the Ocean." This reflects a growing international awareness of the paramount importance of the oceans. For the United States, the oceans are important for both their global economic and military security.[1] Public policy in the United States, along with private enterprise, have long been shaped by a keen appreciation of the strategic importance of the seas to the nation's economic well-being and global security.

Oceans, seas, and waterways connect most of the nations and people of the world, either directly or indirectly. As modern communications and transport bring the world's population closer together, the oceans become more important as avenues of connectivity than as barriers of separation. Throughout the nation's history, the seagoing members of U.S. armed and auxiliary forces,[2] and a wide variety of civilian maritime participants,[3] have been involved in operations at sea and have assisted in articulating U.S. national security interests in matters pertaining to the oceans. It is on behalf of all those seagoing professionals who are deployed on U.S. flagged vessels around the globe that this paper is offered to promote a greater understanding of the relationship between the oceans and national security.

## NAVAL OPERATIONS

### Global Mobility and Access

The role of naval power in U.S. military strategy is in transition. With the end of the Cold War, the United States is much less likely to face the prospects of a world war. However, uncertainty remains over when, where, and how future conflicts involving U.S. armed forces will occur. Draw-downs in the size of U.S. forces maintained, and a more diffuse and complex political environment, have put a premium on flexible forces that can quickly move anywhere and remain there for a long time. These forces must function without undue logistic strain to respond to threats to international peace or security. There is also a premium on flexible forces that are capable of multiple missions. Maritime forces have inherent strengths which make them America's best tool to effectively meet most emergent and changing military situations.

Through the use of the world's oceans by U.S. forces, the advantage of on-scene capabilities for simultaneously executing all three components of the National Military Strategy is possible without infringing on any nation's sovereignty. According to the Chief of Naval Operations: "The Navy contribution to our national security objectives is defined by the major

1 Whereas other Year of the Ocean discussion papers have used the singular form *ocean*, this paper uses the plural form as a means of acknowledging the importance of specific locations within a military context.
2 Includes uniformed members of National Oceanographic and Atmospheric Administration (NOAA) Seagoing Commissioned Officers Corps.
3 Includes the men and women who command and crew ships which are either owned by or under charter to the Military Sealift Command, the U.S. Maritime Administration, and the U.S. Army Corps of Engineers.

components of the National Military Strategy: peacetime engagement, deterrence and conflict prevention, and controlling crises."[4] This role is rooted in the fundamental ability of the Navy-Marine Corps-Coast Guard Team to maneuver independently of the control of other nations and win. This is done through an ability to operate in international waters with forward deployed forces in the highest possible state of readiness.

Modern military systems allow the United States to hold potential adversaries at risk at ever greater distances. As technologies shrink the globe, the United States is effectively closer to potential enemies who also have long-distance military capabilities. To counter these capabilities, U.S. forces must be prepared to use the oceans to meet potential adversaries on their home ground or on waters far from U.S. coasts. In this very important way, the oceans can buffer North America from conflict overseas.

Key to the ability to provide trained, ready forces anywhere in the world at any time to meet our national security objectives is freedom of navigation. U.S. public vessels provide a forward U.S. presence to protect our own and allied interests. Freedom of the seas also ensures that commercial and military cargoes can move freely by sea. The U.S. has a special interest in maintaining secure, stable lines of communication at sea throughout the world. As the 21st century approaches, the United States can look back at fifty years of relative peace on the high seas. Maintaining this combination of security and navigational freedom of the seas is a fundamental condition for global peace, security, and prosperity.

## Overflight Freedom

Freedom of navigation applies not just to the oceans but to the airways above, and ensures that aircraft are free to move passengers and cargo over the oceans to their destinations. Freedom of overflight, like freedom of navigation, permits military forces to respond in times of crisis and is essential to free trade. No one can legally deny anyone the right to fly over the oceans in international airspace, and no landing rights are required for military flight operations at sea. The fact that aircraft operating independently or in conjunction with warships may operate up to 12 nautical miles from any littoral (coastal) state eases access ashore.

Both maritime and airborne freedom of navigation require assured safe passage, free from the threat of harm. Both require provisions for safety, rescue, and navigational assistance. Freedom of overflight above the oceans is as important as the freedom of maritime navigation, in both commercial and military terms.

## Power Projection

The oceans provide access to littoral states. Military presence on the high seas provides the United States with the capability to project power to areas of international tensions, to help friends and allies, and to preserve international peace and stability. A range of options is thereby

[4]Department of the Navy, *Forward from the Sea*, p.1. (1997).

available to U.S. foreign policy makers. Military power may be projected symbolically as a diplomatic goodwill gesture or to deter war.

Mobility, endurance, lift, and response are the components of global projection of military power over the oceans. Sealift and airlift can transport land forces and materiel across the oceans to most trouble spots worldwide. Naval forces have the unique ability to remain at their stations for months, ensuring continued presence on the oceans wherever trouble may arise.

### Deterrence

Naval forces are among the most useful of diplomatic tools. Policy makers can send them to over two-thirds of the world's surface at any time without having to obtain advance basing rights or prior permission to conduct naval movements. Having a sound capability for deploying military forces to almost any coastal (littoral) area makes it possible for the United States to provide the tangible leadership that is necessary to facilitate the assembly of coalition forces, or negotiate forward basing rights should the circumstances so require.

While U.S. maritime forces may not be immediately visible offshore, they are a potent deterrent to potential adversaries since such forces can arrive quickly and remain indefinitely. Routine forward deployment provides the President of the United States with "on-call military presence" almost anywhere in the world and furnishes the capability to project military power and show credible resolve without provoking war. This presence also reminds potential adversaries of U.S. military capability and resolve to enforce international law. In this regard, the oceans and U.S. naval forces provide the United States with unparalleled peacemaking capability and promote the rule of law.

### Sea Denial and Operations Other Than War

As world attention turns from the old ideological East-West confrontation of the Cold War to the economic disparity between developed free market societies and developing nations, there has been a re-emergence of maritime interception operations in situations short of hostilities. There has been no decrease in crises that require military operations other than war. Transoceanic operating and logistic capability permit the United States to take a lead in such operations, often as a member of a multinational coalition.

Since 1989, several multilateral embargoes have been enforced by coalition naval forces. These have been supported by the consensus of the international community, and conducted under international law. Such embargoes are best understood as attempts to maintain world order, peace, and human rights rather than as acts of war. Modern maritime interception operations are typically mandated by resolutions of the United Nations Security Council, and normally allow humanitarian shipments of food and medicine to the civilian population. Naval "visit and search" operations are conducted with respect to international law and custom.

Examples of maritime interception operations include the multinational maritime interdiction operations against Haiti, Serbia/Montenegro, and Iraq. These operations are less than airtight and require time to take effect. However, they are part of the foreign policy process which led to the implementation of democracy in Haiti, motivated Serbia to accept the Dayton Accord, and reduced Iraq's capability for military aggression both before and after the Gulf War. The United States has been at the forefront of this emerging area of modern operational peacemaking.

In the realm of military operations other than war, naval forces also contribute presence and amphibious capability, along with the ability to apply power at varying levels of intensity in "smaller scale contingencies." Such maritime and littoral contingencies include:

- counterpiracy
- interdiction of drugs
- counterproliferation operations against weapons of mass destruction
- migrant control and refugee operations
- interdiction of illegal migrant smuggling
- peacekeeping operations (such as in Bosnia)
- intervention in complex humanitarian emergencies (such as in Somalia)
- disaster relief
- non-combatant evacuation operations
- support of search and rescue missions

### Information Warfare

The ocean environment enhances military command, control, and communications. Ocean-borne platforms can provide military units deployed overseas with constant, secure, real-time communication with tactical and strategic leadership in the United States. Information superiority has several components: gathering, processing, and disseminating information; information operations to defend against attack; and information operations directed against an adversary's information.[5] Information warfare is in its infancy but holds forth the hope of military dominance without the use of physical force or loss of life.

### Intelligence, Surveillance and Reconnaissance (IS&R)

The forward presence of ocean-based military forces enable the United States to gain a better understanding of developing political military situations. Developing better intelligence, surveillance, and reconnaissance are key ways to improve awareness of the battlespace, to track the disposition of enemy forces, to enhance transparency among nations (i.e., reduce the risk of accidental war), and to monitor U.S. allied and neutral warfighting assets. Better IS&R technology permits more precise tracking of enemy assets, allowing for more effective disabling of opponents with less use of firepower, less brute force, and less chance of collateral damage to

[5]Joint Chiefs of Staff, National Military Strategy of the United States of America, p.2 (1995).

noncombatants. It also promises the potential for improved tactical and strategic awareness, enabling forces to "fight smarter." Thus, the use of up-to-date information technology and modern sensors can help reduce battlespace confusion, often referred to as the "fog of war."

### Tactical Environmental Support

A thorough understanding of the dynamics of the ocean environment is necessary for the success of maritime missions. The Navy's operational oceanography community[6] is responsible for understanding the effects of the natural environment on the planning and execution of naval operations, and for interpreting atmospheric and ocean phenomena for forces worldwide. This community must respond to new technological opportunities and to new mission needs.

The ocean and marine environment affect all aspects of naval warfare. Amphibious, mine, and special warfare forces all require rapid, accurate environmental information to support their basic operations. The ocean's structure, which varies due to subtle changes in salinity and temperature, determines how sound propagates through water and thus affects the use of sonars; likewise, the environment can be used to find or hide submarines. Similarly, changes in temperature and moisture through the atmosphere affect radars used to detect incoming aircraft or missiles and can create "ducts" where radars cannot detect incoming threats. Today's high-tech weaponry increasingly requires sophisticated environmental inputs for optimal performance and to support the precision required to engage hostile targets while avoiding collateral damage to civilians persons, property, and other noncombatants.

In coastal regions, the dynamics of marine weather and ocean processes are closely intertwined and change rapidly in both space and time. Accurate short-term and long-term modeling of ocean effects can contribute greatly to the success of naval operations. Continued rapid advancements in the modeling field, and especially in the modeling of coastal areas, will continue to maximize the operational capabilities of naval forces.

New technology is continually being exploited, including the use and development of new satellite sensors to collect data remotely--especially in regions where access is limited. Microsensor technology is being exploited to create small, often expendable sensors such as drifting buoys and miniaturized weather stations to gather information on microscale features. Relatively small portable sensors are being used on-scene to conduct rapid coastal surveys and measure near-shore underwater obstacles.

Despite progress in remote sensing of the environment, vast areas of the world's coastal zones remain devoid of data. Military commanders will continue to require data with ever greater resolution and accuracy to enhance their margin of safety and optimize their decision making. Additionally, advances in computer technologies are needed to analyze such data and improve predictions of the effects of the environment on naval operations.

---

6 Headed by the Oceanographer of the Navy on the Chief of Naval Operations Staff and supported by 3,000 plus civilians and military personnel worldwide.

## COAST GUARD OPERATIONS

Three U.S. uniformed armed services operate on the world's oceans: the Navy, the Marine Corps, and the Coast Guard. Each has a different mission and unique capabilities. The Navy forward deploys heavily armed air, surface, and subsurface platforms forward to carry our nation's battles overseas and check adversaries on "blue water." The Marines respond in times of crisis with ship-borne amphibious expeditionary forces to carry the fight forward and ashore from the sea. The Coast Guard's national security missions include national defense, maritime safety, maritime law enforcement, and marine environmental protection.

### National Defense Operations

Because of the special capabilities of their vessels and the training of their crews, Coast Guard units play a critical support role and sometimes lead in enforcing UN sanctions and international embargoes at sea. Although the Coast Guard recently deployed its own surface assets to enforce the UN sanctions against Iraq in the Northern Arabian Gulf, it is often the case that a Coast Guard boarding team operates from a Navy vessel. The Navy and Coast Guard also provide for harbor defense in the event of a contingency involving maritime transport of military equipment to provide the joint commanders with safe maritime transportation into and out of strategic ports.

### Maritime Safety

The Coast Guard is charged with ensuring the safe operation of commercial and private vessels, safe movement of vessels in and out of ports, and salvage and recovery operations. For example, the Coast Guard has responsibility for maritime search and rescue, but often relies on commercial mariners and airmen, as well as the Navy, to provide vital surface and air assets to assist in such operations, particularly when the operations are long range. The Coast Guard's Aids to Navigation Program and Vessel Traffic Services provide for the safe and efficient movement of vessels into and out of high traffic ports.

### Maritime Law Enforcement

Interagency cooperation has been the key to the United States' increasing effectiveness in the vital area of maritime law enforcement. Such efforts involve the Department of State, the Department of Defense, the Justice Department, the Coast Guard, the Customs Service, the Federal Bureau of Investigation, the Drug Enforcement Agency, the Environmental Protection Agency, the National Marine Fisheries Service, and the Immigration and Naturalization Service, as well as numerous state and local law enforcement agencies. These agencies cooperate to prevent shipments of contraband by sea and preserve the living marine resources of the United States.

In addition to being an armed service, the Coast Guard is also the only federal law enforcement agency with jurisdiction in both U.S. waters and on the high seas. In this arena, the

Coast Guard is the primary enforcer of U.S. laws that include customs and border control statutes, marine resource protection regulations, and the interdiction of contraband. This law enforcement authority distinguishes the Coast Guard from other branches of the armed forces and provides the nation with unique options for responding to national security challenges.[7] The Coast Guard's maritime law enforcement role was rooted in its inception as the Revenue Cutter Service in 1790. The Service's 207 years of experience fighting piracy, combating smuggling and fiscal violations, and enforcing other U.S. laws inside U.S. waters make it the Navy's natural partner for national security in sea denial missions, such as maritime interception operations.

Counterdrug operations have become one of the Coast Guard's most prominent law enforcement missions. The Coast Guard, as the nation's lead agency for maritime interdiction of illegal narcotics and co-lead agency for air interdiction, regularly conducts aggressive counterdrug patrols throughout the Caribbean Sea, eastern Pacific Ocean, and the Gulf of Mexico. Joint operations are frequently undertaken in a unified environment involving several different agencies, including the Department of Defense (the lead agency for detection and monitoring), the Department of Justice (which prosecutes those who violate the law), and other civil law enforcement agencies.

Enforcement of living marine resource regulations is critical to the protection of not only the resources, but also the commercial fishing industry. The National Marine Fisheries Service (NMFS) manages the resources and develops regulations that are enforced at sea by the Coast Guard and NMFS enforcement agents. Most of those matters are handled administratively by NMFS although some actions are brought in court by the Department of Justice. This arrangement has served the North Pacific fisheries well and can hopefully be duplicated to preserve those few remaining stocks off the North Atlantic coast.

The Coast Guard's prevention, enforcement, and response role in marine environmental protection helps to reduce the amount of pollution entering the world's waterways. In response to marine environmental challenges, the Coast Guard has equipped its newest class of ocean-going buoy tenders with a pollution response capability. As a world leader in marine environmental protection, the Coast Guard, in conjunction with other agencies, shapes the safety and pollution control standards for international and domestic maritime transportation through its policy-making activities and enforcement of the Marine Protection Research and Sanctuaries Act[8], the Clean Water Act[9], and the Shore Protection Act.[10] and other laws and regulations.

---

7 U.S. Coast Guard, *National Security and the Coast Guard*, (COMDTPUB CP 16011.1), P. 8 (1995)
8 33 U.S.Code, Section 1401.
9 33 U.S.Code Sections 1215-1387.
10 33 U.S.Code, Chapter 39

## SPECIAL QUALITIES OF NAVY AND COAST GUARD PLATFORMS

Platforms operating at sea bring special capabilities to the table in those situations in which U.S. military forces must be ordered into action to meet one or more components of our national strategy of peacetime engagement, deterrence and conflict prevention, or conflict control. Navy and Coast Guard vessels have unique attributes of carrying capacity, the endurance inherent to the duty cycle, mobility, sovereignty, and other abilities to resist attack:

> *Carrying capacity:* Ships can duplicate land bases because of their ability to carry a variety of essential defense functions. Theater missile defense is one example. Although space systems may contribute to the launch detection of hostile missile(s), large, heavy radars based at sea are needed to either detect, in the case of depressed trajectories, or to manage the interception of hostile missile threats. Ships are the obvious platform for such systems since they can carry the detection systems as well as large quantities of interceptors. Because of their carrying capacity, ships are also ideal platforms for almost all heavy logistics evolutions, command and control duties, space tracking, and intelligence operations.
>
> *Duty cycle and Mobility*: The constant presence of a ship gives U.S. military planners a significant advantage. Space sensors generally observe intermittently, and airborne sensors, unless based aboard ship, require large numbers to maintain a presence far from base. Because ships can often perform their missions far from a potential adversary's coastline, they can continuously gather valuable information without threatening or alerting them.
>
> *Sovereignty:* Warships and public vessels engaged in non-commercial service enjoy sovereign immunity. Therefore, questions of landing or access rights do not arise if U.S. ships are operating on the high seas or transiting through littoral areas and through straits.
>
> *Defense against physical attack* and *jamming:* A ship standing well offshore is much more secure from physical attack than warfare centers ashore, and it has the carrying capacity to serve as the platform of choice for many information collection operations against an actual or potential adversary. Warfare centers ashore may be surrounded by a hostile populace and if attacked from over the horizon, must defend in a more cluttered environment. A moving ship is much harder to target with a missile or truck-bomb than an installation ashore, whose static coordinates can be read from a map or a GPS receiver. The positioning of warfare capabilities offshore provides separation from the land-based jammers, thus limiting their effect.

## OCEAN SCIENCE AND TECHNOLOGY IN SUPPORT OF NATIONAL SECURITY

The ocean has always had a profound influence on human life and activities. It has been an important source of food and means of commerce. In recent decades, the United States has been the world leader both in basic ocean studies and research on the ocean's practical influence on human activities. This pioneering work has been largely the result of remarkably successful partnerships between federal agencies and universities, in which federal agencies support the research of academic scientists who provide internal and external research through a variety of mechanisms.

Oceanographic research, funded in large part by the federal government, is important to many of the nation's social concerns, including national security. World political changes are redefining national defense interests, and altering our research and development priorities for the littoral areas where our national defense operations are most likely to take place. Experience gained in the 1991 Gulf War, highlighted the need for better information related to oceanic and coastal processes.

### U.S. Oceanography since World War II[11]

World War II thrust the United States into global affairs, and its many sea campaigns not only drew public interest to the ocean but highlighted our lack of understanding of it. Most members of the small marine science community turned to military oriented work in uniform, in the civil service, or at universities and related institutions. Academic ships, as well as those of the federal government, were put on Navy research and surveying tasks. The Navy needed oceanographic help in everything from submarine warfare to amphibious landings. This assistance contributed to the war effort and demonstrated to the nation that marine science was more than an abstract endeavor and could contribute to the public good on many levels.

Since World War II, the United States has been a world leader in most areas of oceanography. Vannevar Bush's *Science: The Endless Frontier* is still the classic statement of the essential ingredients of scientific excellence. He noted that "without scientific progress, no amount of achievement in other directions can ensure our health, prosperity, and security as a nation in the modern world. This essential new knowledge can only be obtained through basic scientific research." The plan of Vannevar Bush for government support of university science led to the formation of the Office of Naval Research (ONR), which is charged with ensuring the development of strong academic research programs in scientific fields of interest to the Navy. The Cold War and the threat from both surface vessels and, particularly, submarines led ONR to conclude that expanding and strengthening the basic science of the ocean were in the national interest.

[11] See generally, U.S. Naval Academy Press, *Oceanography into the Next Decade*, (1992)

The postwar and post-Sputnik periods from 1960 to 1980 were marked by growing national awareness of the world and an intense interest in science. In marine science, interest broadened globally , leading to such major ocean-related programs as the International Geophysical Year, the Deep Sea Drilling Project and the International Decade of Ocean Exploration. While originally responsible for the postwar academic expansion of oceanography, the Navy is progressively concentrating its support in a more limited number of Navy-relevant areas, but continues to provide some oceanographic research vessels to U.S. academic institutions and provide research opportunities for use of specialized platforms.[12]

Oceanographic research studies with national security implications include hydrodynamics, marine life, the interaction of seawater with ocean boundaries, ocean acoustics, and geoacoustics. Knowledge of the exchanges of energy, heat, and mass at the ocean-atmosphere interface is important to climate and weather prediction. Oceanographic research has advanced from the past era of exploration to one of increased observation and description of oceans systems and interactions with the atmosphere.

## Beyond Ocean Scientific Research: Civil Applications

Over the years, practical oceanic research has resulted in spin-offs which benefit everyone worldwide. Navigation charts and aids are the prime example of a naval contribution which benefits civilian mariners worldwide. The National Imagery and Mapping Agency (NIMA) is chartered to provide DoD-wide mapping, charting, and geodesy support. Under the Navy's direction, NIMA is producing digital replications of traditional paper nautical charts to support the Navy's transition from paper to digital navigation products. Known as Digital Nautical Charts (DNC),™ these digital charts allow near real-time display of one's own GPS position and significantly enhance the safety of navigation at sea. Through joint efforts between the Navy and NIMA, new survey sounding information will also be seamlessly incorporated into future editions of DNC™. NIMA's world leadership in the production of digital charts holds considerable promise for the civil sector.

The Navy also took the lead in providing LORAN and the two-dimensional TRANSIT satellite navigation system for maritime navigation. These programs led to the development of the current standard, the joint three-dimensional NAVSTAR global positioning system (GPS). GPS relies in part on space-borne clocks developed by the Naval Research Laboratory's Timation program.[13] Mariners worldwide benefit from these navigation aids.

---

12 *Research Facilities*: ONR assists in the management of the federal and academic fleet of oceanographic research ships, remotely operated vehicle (ROV) technologies (manipulative capabilities), and other oceanographic platforms that support the Department of the Navy and national science and technology projects. The Navy is exploring the use of other specialized platforms (e.g., ALVIN, ROVs, AUVs, etc.) to increase science and technology capabilities. The Coast Guard provides support to ocean research by operating and maintaining the U.S.' only polar icebreakers. Currently, there are two of these valuable assets in commission with a third under construction. These platforms are tasked with the re-supply of U.S. research facilities in the Arctic and Antarctic regions as well as providing research facilities onboard for use by embarked scientists.

13 Ibid.

The research into secure and reliable means of maritime communication has extended into the civilian sector. Financial institutions are studying methods engineered for the military for safe, reliable, and rapid means of moving large volumes of data, secure from the danger of disruption or unauthorized monitoring. The Internet, the result of communications programs funded by the Department of Defense, has provided incalculable benefits worldwide. There are countless other examples of the fruits of military research spilling over into the field of marine engineering, marine environmental and pollution control technology, meteorology systems, communications, and biology.

### Ocean Data, the Public, and the Navy

The Navy is a major provider of oceanographic information as well as an end-user and much of this information has been freely distributed as a matter of course. While being careful to ensure that data gathered for military operations is handled in accordance with existing international norms, the end of the Cold War has enabled the Navy to declassify a significant amount of formerly classified data, some of which has been useful to scientific pursuits.

Procedures to allow increased access by civilian scientists to the Navy's underwater surveillance system[14] (SOSUS) data are being implemented. Initial investigations of civil applications, coordinated closely with NOAA, proved remarkably fruitful. For example, a short demonstration project that was conducted provided more information on marine mammal movements than all the data previously collected. SOSUS also proved to be the most effective monitoring system for underwater earthquakes, providing the possibility of better tsunami (tidal wave) predictions. NOAA is investigating whether SOSUS could aid offshore fisheries enforcement in detecting illegal drift-net deployments. Researchers also want to use the system for acoustic monitoring of the ocean water to detect change in global climate, relying on the premise that sound travels at different speeds through water depending on density and temperature.

Greater public access to formerly classified Navy information, and relaxation of foreign disclosure and export controls are the result of changes in the world's political/military situation. In the late 1980s, the Navy declassified selected Arctic under-ice data collected by Navy submarines for use in climate change research. An Environmental Task Force comprised of academics, scientists, and government officials was later established to determine the potential usefulness of classified intelligence and defense databases for addressing serious global environmental problems. The Central Intelligence Agency has agreed to release millions of 1960s era satellite images, and the Navy has declassified all sea level (altimetry) data from GEOSAT satellites, which researchers have used to improve the nation's knowledge of global seafloor features and the earth's gravity field. A Navy working group is completing review of additional data sets for declassification.

---

[14] SOSUS is comprised of a series of acoustic listening arrays on the seafloor which was developed during the Cold War to detect the Soviet submarine fleet.

## LOGISTICS SUPPORT AND INFRASTRUCTURE

### Commercial Transport

International and maritime trade have been growing at twice the rate of the world's economy for some time. Large merchant vessels are the most flexible and cost-effective modes of intercontinental and coastal transport. Increasingly, new markets and new resources are found overseas. As the world evolves from a collection of disconnected national and regional economies to one global inter-linked economy, freedom of commercial transit on the high seas and through straits and other navigational choke points becomes ever more important. At the same time, the ability of military forces to respond abroad in case of crisis requires the sealift and logistic support that can only be provided by the U.S. merchant fleet.

Military and commercial mobility on the high seas are linked. Commercial navigation depends on naval forces to keep open the lines of communication. Naval forces depend on commercial trade for logistics support. Commercial navigation requires security and freedom from both state-sponsored interference and freelance piracy. It requires freedom from illegal regulatory controls by foreign governments, as well as safe and efficient use and access to the nation's ports and waterways.

### Sealift, Shipbuilding and Repair, and Maritime Employment

The United States must assure a viable maritime industrial base to satisfy its commercial and military requirements. Cabotage laws, which govern navigation and trading along the coast and include such statutes as The Passenger Ship Act of 1886[15] and The Merchant Marine Act of 1920 (Jones Act),[16] are common to over 45 countries. By imposing citizenship and construction requirements for vessels to engage in domestic trade, these laws seek an adequate national fleet in peacetime to sustain the nation in war. Opponents, however, argue that such laws restrict free trade and increase costs. Government shipbuilding subsidies or loan guarantees, such as the Maritime Loan Guarantee Program (Title XI), are a common means used by nations to support their industrial base. Some argue that free trade, competition, and elimination of international subsidies could allow the nation to meet its economic requirements. However, the President's 1993 Plan for Competing in the International Market looks carefully at these competing considerations and comes out in favor of a policy of limited government support in meeting the nation's commercial and military sealift requirements. This is set forth in *National Security Directive 28:*

> "The U.S. national sealift objective is to ensure that sufficient military and civil maritime resources will be available to meet defense deployment and essential economic requirements in support of our national security strategy. The Department of Defense will determine the requirements for

[15] 46 U.S. Code Appendix Section 289.
[16] 46 U.S. Code Appendix Section 883.

sealift of deploying forces, follow-on supply and sustainment, shipbuilding and ship repair. In coordination with the Department of Defense, the Department of Transportation will determine the capacity of our merchant marine industries to meet these requirements and to provide the sealift required to support the essential industrial activity during wartime."

*National Security Directive 28* reflects the link between the seagoing armed services, U.S.-flag merchant vessels, the merchant seamen who crew them, and the commercial maritime industrial base of ports, shipyards, and ship repair facilities. Playing a vital national security role since colonial days, the U.S. Merchant Marine is often referred to as another arm of the nation's defense.

The 1992 Mobility Requirements Study, the 1995 Bottom-Up Review, and the 1997 Quadrennial Defense Review reaffirmed the requirements for "defense deployment." To deploy U.S. forces overseas and resupply them, the U.S. Merchant Marine provides U.S.-flag civilian-crewed commercial ships and civilian crews to government-owned support ships. These sealift assets account for about 95 percent of all the tonnage delivered in support of military requirements in peacetime and during times of crisis. Naval shipyards and ship repair facilities build and help maintain Navy and merchant ships, activate inactive ships, and repair battle-damaged vessels.

Over 4,800 civilian mariners crew the 200 commercial vessels with military features which are included in the Afloat Preposition Force, Fast Sealift Ships, Ready Reserve Force ships, Maritime Security Fleet, and Navy Fleet Auxiliary Force. Over half of these sealift ships are actively deployed or are in commercial service around the globe. The Maritime Security Fleet is composed of militarily useful dry cargo commercial vessels which receive operating assistance in return for a commitment that these vessels, and the commercial intermodal systems which support them, will be made available for national security purposes if needed. Inactive strategic sealift ships are positioned throughout the United States and overseas and are capable of being activated within 4 to 20 days. All of the vessels in 4 or 5 day readiness have a cadre crew of civilian mariners. These vessels have already proven their value in supporting defense deployments in Desert Shield and Desert Storm, Somalia, Haiti, and Bosnia.

The Department of Transportation's Maritime Administration is charged with ensuring a viable U.S. Merchant Marine and maritime industry to meet national security needs. The Maritime Administration, in cooperation with the Navy, supports programs directed towards sustaining the maritime infrastructure, including maritime education and training; National Defense Features and Title XI loans; operational differential subsidies and maritime security agreements; and the development of technologies and industrial processes. Since 1980, major shipbuilding in the United States has been maintained predominantly by construction of Naval vessels, but with the end of the Cold War, the Navy's construction program has been significantly reduced. The Navy's proposed Fiscal Year 1997-2003 shipbuilding program will average less than six ships a year compared to 10 ships per year in Fiscal Year 1992-1997 and 19 new ships per year during the 1980s. To maintain the "shipyard mobilization base," necessary to build, repair and activate Navy and merchant ships, more commercial ship construction is needed. In 1996, the United States constructed only 1.8 percent of the world's gross tonnage; Japan and Korea accounted for almost 60 percent.

Present programs recognize that the decline in the number of oceangoing ships operated, repaired, or built in the United States impacts the industrial base of shipyards and their labor force. There are over 280 privately owned firms of varying capabilities, employing over 98,000 workers, involved in shipbuilding and ship repair in the United States. However, only 43 yards are capable of dry-docking vessels of 122 meters in length or over,[17] and only 6 shipyards are building Navy combatant ships. This impacts the Navy with respect to the number of U.S. facilities and qualified shipyard workers available to activate, build, and repair active and naval auxiliary vessels in times of national emergency. The United States has to assure a viable military industrial base to meet it's military sealift needs. While this requirement receives less attention than other military budget items, it is of great importance to National Security and will be subject to continuous review and debate.

## SOUND MANAGEMENT OF THE OCEAN'S ENVIRONMENT AND RESOURCES: ENVIRONMENTAL SECURITY

### Environmental Security Challenges and Response

The Law of the Sea (LOS) Convention is a fundamental framework for the array of international agreements[18] that protect ocean access, maintain the environmental quality of the oceans, and guard against imprudent exploitation of marine resources. In the past, the rigor of the ocean environment alone was sufficient to safeguard ocean resources from over-exploitation. Scientific progress brought technology, which in turn put living oceanic resources within reach for commercial harvest and seabed extraction. Nations began to face overfishing, as whalers and giant drift nets depleted stocks and even threatened species with extinction. There was also uncertainty over ownership and sovereignty of hydrocarbons and minerals and threats posed to the marine environment from oil spills associated with oil exploration and transportation. Because all nations enjoy the benefits of proper management of the world's natural resources, responsible international management of ocean resources is in the interest of all nations.

Recognizing that national and global security are enhanced by protection of ocean resources, the Navy, Coast Guard and National Marine Fisheries Service (NMFS) have mounted

[17] U.S. Department of Transportation, Maritime Administration *Report on Survey of U.S. Shipbuilding and Repair Facilities* pgs. 40, 54 (1996)

[18] Includes the 1989 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal (Basel Convention); The 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972), as recently amended; The Safety of Life at Sea Convention 1974, as amended (SOLAS Convention); The 1973 Convention and 1978 Protocol for the Prevention of Pollution from Ships (MARPOL); and the 1972 Convention on Prevention of Collisions at Sea (COLREGS).

a combined effort to detect, monitor, and suppress illegal large-scale high-seas driftnet activity.[19] The Departments of Justice and State are addressing these illegal activities in legal and diplomatic fora, and in 1991, Navy operational monitoring assets began being used for high-seas driftnet detection. In an effort to assist in the recovery of the endangered Northern Right Whales in the critical habitat located off the coasts of Georgia and Florida, the Navy has undertaken extensive operational measures to preclude whale injury resulting from operations along the Eastern Seaboard. The Coast Guard and the Navy are also providing direct monitoring assistance to the NMFS and conservation organizations to study the migratory and other behavioral patterns of the Northern Right Whales to protect that species.

On the international scale, the serious decline of fisheries in the Grand Bank of Newfoundland,[20] the George's Banks off New England, and other areas have either spawned incidents of violence involving armed forces or created other clear implications for global security. Legal regimes are being negotiated to deal with "ownerless" resources and marine pollution that cannot be specifically linked to particular vessels or nations, especially land-based sources.[21] Practical solutions are needed. The Department of Defense, in cooperation with other agencies, has begun isolating and containing the effects of serious pollution incidents.[22] The Navy is also now a part of a team working to develop a Black Sea Regional Oil Spill Contingency Plan which would be implemented by naval forces based in the Black Sea.[23]

## Environmentally Sound Ships

The Assistant Secretary of the Navy noted the importance of the environment to the Navy mission stating:

> "By maintaining compliance with all environmental standards, we ensure our access to training and operating ranges on land, in the air, and at sea. We recognize that many of our actions, whether it is to train new Sailors or Marines, maintain readiness of combat forces, or test new weapon systems have an impact

---

19 Large scale (greater than 2.5 kms in length) high sea driftnets are banned by a 1991 UN General Assembly Resolutions 44.225, 45.197, and 46.215 because of the devastating impact of large-scale driftnet fishing on both the targeted fish stocks and because of the problem in incidental damage to marine mammals and non-target fish species. Abandoned driftnets are also a serious hazard to navigation.

20 The collapse of the cod stocks are indicative of the collapse of once numerous species including herring, halibut, and blue-fin tuna. Indiscriminate fishing techniques (e.g., use of large nets and trawls which scrape the sea floor, use of drift nets, and precision navigation devices) consume entire populations in single scoops. In 1996, the World Conservation Union's annual Red Data Book of threatened species listed for the first time numerous marine fish—more than 100 kinds worldwide including cod, haddock, blue fin tuna, swordfish, Nassau grouper, and summer flounder.

21 International norms are just evolving to attack the transboundary impacts of pollution from land-based sources. Since over 90 percent of ocean pollution is derived from land-based sources, this problem is especially acute.

22 Literally thousands of mostly small, spills occur every year around the world. Incidents like the 250,000 barrel spill of Exxon Valdez in Prince William Sound in 1989 and the release of 12 million barrels of oil in the Persian Gulf as "ecocide" by Iraq during the Gulf War are two of the most prominent examples. The Navy and the Coast Guard have developed a worldwide oil spill contingency plan and response capability in cooperation with other nations. State-of-the-art oil spill recovery equipment is pre-positioned in strategic locations and maintained in a constant state of readiness. If needed, the recovery equipment can be shipped by military aircraft to remote locations.

23 The plan will be exercised by elements of the U.S. Sixth Fleet during the summer of 1998.

> on the natural environment. We need to understand those impacts, and take appropriate actions to minimize them. Beyond the strict interpretation of the law, we have an ethical responsibility to conserve the natural resources entrusted to us."[24]

This principle has been reinforced by the Chief of Naval Operations who stated that "national defense and environmental protection are and must continue to be compatible goals. Therefore, an important part of the Navy's mission is to prevent pollution, protect the environment, and protect natural, historic, and cultural resources."[25] Consistent with that policy, protection of the marine environment is mission essential. Navy ships conduct operations, in port and at sea, in such a manner as to minimize or eliminate any adverse impact on the marine environment.[26]

The sea services work hard to be good stewards of the oceans. The Navy views protection of the environment as a very practical challenge for operations and logistics. Recognizing the importance of assessing environmental factors and impacts during operations at sea, the Navy, in conjunction with the Joint Staff, is developing a Naval Warfare Publication (NWP 4-11). This document will serve as a ready reference for operational planners, afloat staffs, and vessel commanders seeking to integrate complex environmental requirements into day-to-day operations.

The International Maritime Organization (IMO) is responsible for implementing the International Convention for the Prevention of Pollution from Ships 1973, as modified by the 1978 Protocol (MARPOL 73/78). MARPOL establishes legal principles, applied to owners and operators through the national laws of the flag state, which govern the control of marine pollution as a result of vessel/platform source emissions into the air and water. Because the roles of military vessels are unique, MARPOL 73/78 exempts warships, naval auxiliaries, and other public vessels on noncommercial service from compliance but does require each party to adopt appropriate measures, not impairing the operations or operational capabilities of such ships, to comply with the Convention in so far as reasonable and practicable.[27] This "exemption" is frequently misunderstood by the public to mean that navies are not taking action to prevent pollution. The Navy complies with waste treatment and disposal standards, generally speaking, that are far more rigorous than those mandated by IMO regulations. To this end, "the Navy has established the goal of Environmentally Sound Ships of the 21st century (ESS-21) that will be able to minimize waste generation and treat or destroy unavoidable waste on board."[28]

---

24Pirie, R.B. Jr., Assistant Secretary of the Navy (Installations and Environment). Statement before the Subcommittee on Readiness of the Senate Armed Services Committee on the Fiscal Year 98 Department of the Navy Environmental Budget. 15 April 1997.

25 Dept. of the Navy, *Environmental and Natural Resources Manual* (OPNAVINST 5090.1B) (1994).

26Ibid.

27Article 3, International Convention for the Prevention of Pollution of Ships, 1973.

28Dept. of the Navy, *Report to Congress, U.S. Navy Ship Solid Waste Management Plan for MARPOL Annex V Special Areas*, Nov. 1, 1996. The Navy's 21st Century Surface Combatant (SC-21) will satisfy applicable environmental regulations related to waste management while at the same time functioning as a highly capable warship. A NATO Naval Armaments Group (SWF/12) is examining on a similar concept in a NATO context.

The Navy has also installed install plastic waste processors on most surface vessels in order to avoid plastic disposal at sea. Congress also gave the U.S. Navy until the year 2000 to install pulpers and metal and glass shredders on surface ships. Other developmental successes include oil water separators, sewage vacuum collection systems, and elimination programs for ozone depleting substances, including conversion, replacement, and recycling initiatives. Naval designers have started to consider advanced waste treatment systems for future ship designs, including thermal destruction technologies (such as the plasma arc), to support ESS-21. Research and development is also proceeding on development of oily water membrane effluent minimization systems, and sewage and graywater treatment systems. To prevent the introduction of non-indigenous species, the Navy has implemented a rigorous ballast water exchange procedure for ships so equipped. Obviously, the technological gains which the Navy makes in connection with ESS-21 system development may have civil applications and benefits.

Public and congressional support is key to the ability of naval forces to maintain the required readiness to achieve national security objectives and execute the National Military Strategy. Therefore, the Navy has involved the public, environmental groups, and legislative representatives in Navy marine environmental protection programs. A forward looking environmental policy ensures that the sea services operating overseas can continue to enjoy port access because of their good reputation abroad for pollution control and waste disposal.

## THE LEGAL ENVIRONMENT

Maritime Forces must comply with laws that directly protect ocean resources. The Marine Mammal Protection Act and the Endangered Species Act (ESA) require such forces to avoid the taking of marine mammals and, in the case of the ESA, to consult with appropriate resource agencies regarding operations that may affect the continued existence of endangered species or may modify their critical habitat.

Potential environmental impacts are fully analyzed through a comprehensive environmental planning process, complying with the U.S. National Environmental Policy Act (NEPA) for activities within the United States[29] and Executive Order 12114 for activities outside of the United States. The Navy has found that early consideration of potential environmental impacts can enhance military readiness by assuring access to critical training areas. Operational doctrine is also being written to fuse the analysis which is conducted for environmental compliance purposes with all other military planning conducted in advance of military exercises or operations.

The Departments of Defense (represented by the Navy) and EPA are developing Uniform National Discharge Standards[30] to address the problem of differing State Water Quality standards as they pertained to liquid discharges from warships and other public vessels which could have

29 Including the 3 nautical mile limit of the territorial sea subject to state jurisdiction.
30 This initiative was authorized by Section 525 of the 1996 National Defense Authorization Act.

adverse impacts on the marine environment. The resulting regulation, developed in consultation with other Federal agencies and affected states, will enable DoD to operate under one uniform environmental protection standard throughout the United States.

As stewards of the marine and littoral environments, the Navy has an obligation to care for the natural resources on which the world depends. Protecting the environment is a part of mission accomplishmen--it is good citizenship and protects continued naval access into foreign waters. The Navy is committed to protecting human health and the environment while performing its military mission. These obligations come with an impact upon the Navy's increasingly scarce economic resources. In the coming years, there will be continued discussion over how extensively environmental obligations will shape military activities at sea in view of the military planning, readiness and budgetary constraints. The "openness" of environmental law procedures, such as NEPA, and the military's need to limit dissemination of sensitive national security information must be harmonized. Restrictions on the use of weapons systems and the operations of ships and other military platforms should strike an appropriate balance.

**Freedom of Navigation, Ocean Resources, and the Law of the Sea Convention**

Access to the oceans throughout the world, including the areas off foreign coasts at great distances from the United States, is vital to U.S. security and economic interests in global navigation, overflight, and telecommunications. These interests are best served by a globally accepted public order of the oceans that minimizes the challenges to and costs of securing such access. The LOS Convention restrains the growth of excessive maritime claims and codifies key legal provisions in the areas of environment, fisheries, and public vessel sovereign immunity which balance the vital interests of maritime and coastal states.

Free trade requires freedoms of navigation and overflight. The United States also takes an interest in protecting rights of transit for international commercial shipping[31] and promoting free trade. The LOS Convention codifies traditional freedoms of navigation and overflight. These freedoms include the right of innocent passage through foreign territorial seas, the exercise of high seas freedoms[32] seaward of territorial seas, and rights of transit and archipelagic sea lanes passage through international straits and archipelagic waters. Norms favoring foreign port access, marine scientific research, and specific limits of coastal state authority over the submerged lands and resources adjacent to their shores, are all contained in the LOS Convention.

A few decades ago, there was a explosion of extended sovereignty claims, as some states acted unilaterally to maximize their offshore jurisdiction. A great contribution of the LOS

---

31 During the so-called "War of the Tankers" between Iran and Iraq during 1980 through 1988, neutral merchant shipping sustained tremendous losses. In the 8-year conflict, 543 ships were attacked, most in international waters. Over 200 lives were lost, including 53 Americans. In an effort to contain the effects of that conflict, the United States authorized the reflagging of Kuwaiti tankers and in 1987, commenced with providing those and other vessels military escort as they conducted their transits through the Straits of Hormuz and the Gulf.

32 The high seas freedoms of importance to DoD include the transit of ocean spaces, task force maneuvering, exercises, flight operations, surveillance and intelligence collection, communications, and space activities, cable laying, military surveys, and ordnance testing and firing.

Convention is that the trend in excessive claims has abated with some states having rolled-back their excessive claims. As more states become parties to the LOS Convention, which entered into force in November 1994, there should be a heightened degree of convergence towards the principles it sets forth. As of January 1998, 123 states are parties to the Convention.[33]

The position of the Department of Defense on the LOS Convention is clear:

> "The Department of Defense has long supported the Convention on national security grounds. The Nation's security has depended upon our ability to conduct military operations over, under, and on the oceans. We support the Convention because it confirms traditional high seas freedoms of navigation and overflight; it details passage rights through international straits; and it reduces prospects for disagreements with coastal nations during operations."[34]

### Other International Legal Initiatives

While ratification of the LOS Convention is an urgent short term goal of the Executive Branch of the United States Government in the oceans arena, other international initiatives affecting the use and quality of the oceans will require attention early in the coming decade. The establishment of universally accepted rules for oceans governance will provide DoD and the Coast Guard with clear guideposts for the types of design and operational standards which may have to be met in the future. The rules will also be helpful in addressing global problems of environmental degradation and resource depletion which can lead to conflict. Initiatives which are currently under study include:

(a) Seeking universal accession of states to the recently concluded 1994 Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Species. Universal acceptance of that agreement is important to help protect fish species and because it establishes unique multinational enforcement provisions and is a balanced model for international conservation.

(b) Implementing the Global Action Plan on Marine Pollution from Land-Based Sources. While international efforts to control vessel source pollution have been largely successful, the more pervasive land-based sources have been inadequately addressed.

(c) Obtaining universal accession to the 1996 Protocol to the London "Dumping" Convention. That Convention establishes new safeguards and provides legal clarity

33 The United States is still not a party to the LOS Convention. However, the Convention was forwarded to the Senate for advice and consent in the Fall of 1994 and is currently awaiting action by the Senate Foreign Relations Committee. Furthermore, since 1983, the United States has regarded most of the LOS Convention to represent a codification of customary international law.

34 Department of Defense, *National Security and the Law of the Sea Convention* p.1 (1996)(Quoting from Secretary of Defense William Perry Statement on July 29, 1994).

on the permissible types of dumping at sea, including the dumping of high and low-level radioactive wastes.

(d) Obtaining universal participation among flag states of Annex VI of MARPOL. This Annex sets forth new international standards applicable to air emissions from ships.

(e) Working with the IMO and the International Atomic Energy Agency (IAEA) to find acceptable regimes for the safe and secure methods for transporting nuclear materials at sea. Striking an appropriate balance between the competing international interests in this area is important from a nuclear safety and non-proliferation perspective.

## MANAGEMENT ISSUES

Following a joint hearing in January 1996, Congress established a National Oceanographic Partnership Program (NOPP) to improve knowledge of the oceans through federal, academic, and industrial partnerships in research and education. Federal coordination is achieved through a National Ocean Research Leadership Council, which includes broad representation from federal agencies with oceans interests and is currently chaired by the Secretary of the Navy. In 1997, twelve partnership projects were funded to establish new coastal laboratories, develop plans for a virtual ocean data center, improve ocean data collection and processing, and expand public and education outreach activities. NOPP's challenge, in this time of declining budgets, is to seek out and foster the most beneficial projects and partnerships that meet national oceanographic requirements and program goals. In the coming years, there will be continued study on whether NOPP, and programs like it in other agencies, are meeting their objectives.

From time to time, legislative proposals are made to renew operating or differential subsidies for the U.S. merchant fleet engaged in international trade for the purpose of leveling the economic playing field for labor and operating cost, since only 3 percent of U.S. foreign waterborne trade is carried by the U.S. merchant fleet. In the past legislative session, there were proposals to substantially scale-back the "Jones Act," which establishes a preference for U.S. owned and crewed vessels engaged in the coastwise trade. Proposals have also been made to provide subsidies to U.S. shipyards to equalize the labor cost differentials with shipyards overseas, where direct or indirect construction subsidies are routine. U.S. defense spending in U.S. shipyards and for the charter of U.S. flag vessels is expected to decline, and this decreased spending may increase pressure on the Congress and the Executive Branch to address this problem.

The Federal Environmental Task Force (discussed above), which was formed in the mid-1990s, and successor initiatives, have collectively resulted in the transfer of formerly classified environmental data to scientists and others in the civilian sector to help solve global environmental and resource questions. The Navy has offered some further access to classified data if a source for the cost of "sanitizing" data can be found. In the coming years, stakeholders from the government and private sector will have to determine the appropriate level of investment for making defense information with civil applications available to the public.

There is an increasing awareness that marine pollution and decreases in sustainable yields of marine living resources can be one contributing factor to political instability in coastal regions around the world. In the coming years, the United States must assess what the federal government can or should do to help prevent or mitigate these types of problems. A strategy may be needed to avoid costly impacts on the United States in the form of military humanitarian intervention, responses to mass migration, and unprogrammed foreign aid expenditures. The United States must also consider the appropriate role of private and international aid organizations in this overall process.

Finally, striking the correct balance between federal and state environmental laws designed to protect the marine environment with military readiness and operations is an ongoing process and continues to be a challenge.

## EDUCATION AND EXPLORATION

The nation should continue to fund pure and applied research across the spectrum of ocean sciences to meet future defense needs. An investment in defense science will pay dividends to the civilian sector. A more complete understanding of the ocean environment will enable U.S. military forces in the future to meet their traditional defense missions while at the same time minimizing the impacts of those operations on the marine environment. Science is key to finding ways to sustainably develop and manage ocean resources to meet the needs of an increasing world population. Ocean exploration missions are important to meet defense science needs and advance the nation's overall position in science and technology. The United States must continue to attract the best and the brightest to America's shores to study, conduct research, and advance the technology base.

The nation invests heavily in education and training activities to support national security programs. A full spectrum of training facilities is dedicated to training seagoing professionals. These include the Military Service Academies (Naval and Coast Guard Academies), the Merchant Marine Academy, and the Naval Reserve Officer Training Units located at major universities across the country. The Navy and Coast Guard operate a network of schools to provide apprentice level technical training in all fields relating to the operations of ships at sea including: engineering, ships services, nuclear and conventional propulsion systems, combat systems, navigation and operations. Finally, the Naval Postgraduate School, Naval War College, and Naval Medical Research Institute are among the world-class graduate level teaching and research organizations that are responsible for educating military leaders in the United States and abroad. This investment in training is significant, but the payoff is the world's most highly trained cadre of mariners and marine scientists who serve in both military and civilian positions.

A continuing challenge will be finding ways to reduce the costs of training America's seagoing professionals and give other interested citizens access to some of the training facilities and opportunities that are available to those in the federal government. The Navy has been building partnerships with private industry, other government agencies, and academia to further the public understanding of oceanography. Some clear examples of success are Project JASON, hosted by the Naval Meteorology and Oceanography Command and the University of Southern Mississippi's Gulf Coast Research Laboratory, which brings live interactive broadcasts from JASON expeditions to students and teachers in many states. The challenge will be finding more of these opportunities to connect the marine professionals in government with motivated members of the public.

## CONCLUSION

The United States is a maritime nation which owes much of its security and prosperity to its ability to use the seas successfully to enhance commerce and national security. Key to this success has been the preservation of strong maritime forces and sealift. U.S. maritime forces must be able to fight smarter and win, with smart maneuver, smarter weapons, and a reliable stream of remote sensor and tactical environmental data.

Preservation of the comprehensive legal regime set forth in the Law of the Sea Convention is essential to assure freedom of navigation and overflight on the high seas and through straits and other choke points for military and commercial vessels. For over 200 years, the United States has recognized the importance of keeping open the sea lines of communication at sea for commercial and military purposes. National and global security demand that this task continue as a matter of national priority.

## LIST OF ACRONYMS

| | |
|---|---|
| DNC | Digital Nautical Charts |
| ESA | Endangered Species Act |
| ESS-21 | Environmentally Sound Ships of the 21st century |
| GPS | Global Positioning System |
| IMO | International Maritime Organization |
| IS&R | Intelligence, Surveillance and Reconnaissance |
| LORAN | Long-Range Aid to Navigation |
| LOS | Law of the Sea |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MIO | Maritime Interdiction Operations |
| NEPA | National Environmental Policy Act |
| NIMA | National Imagery and Mapping Agency |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NOPP | National Oceanographic Partnership Program |
| ONR | Office of Naval Research |
| SOSUS | underwater surveillance system |

# 1998 Year of the Ocean

## ENSURING THE SUSTAINABILITY OF OCEAN LIVING RESOURCES

Contents

## EXECUTIVE SUMMARY

The ocean covers nearly three fourths of the planet and embraces most of the earth's biosphere—the region where life occurs. The ocean's living resources are a treasure for current and future generations of humankind. Fisheries provide food for billions of people; through science, new medicines and materials from the amazing diversity of marine life forms are being discovered; and the ecosystem functionings of marine life sustain human life in ways just now beginning to be discovered. Marine aquaculture holds the promise of helping to meet the food demands of a growing world population. As worldwide observance of the Year of the Ocean proceeds, it is worth taking stock of current perceptions about the living ocean, the status of its resources, the threats it faces, and the steps that the United States is taking to secure this treasure for successive generations.

Knowledge about marine species and ecosystems lags far behind the state of information about terrestrial systems. Despite the value that living marine resources represent, relatively little still is known abou. them—indeed, most species are unknown and whole new ecosystems have been discovered in the last two decades. Yet, for those species and ecosystems most studied to date—particularly commercially exploited fish, protected marine mammals and turtles, and certain coastal ecosystems—trend indications have convinced many observers that the productive limits of the ocean are being reached and often exceeded..

Both U.S. and world fisheries, with a few exceptions, exhibit flat or declining trends in harvests and the majority are thought to be fully or overutilized. Recent trends in catches, trade, contribution to food supplies, and overall economic viability are not encouraging. Certain marine mammals and sea turtles in U.S. waters appear to be recovering after years of population declines. Still, habitat destruction and human activities are increasingly placing other species, such as salmon, in jeopardy, while less well studied marine organisms are probably being lost before ever being identified, much less protected. The world's most biologically diverse marine ecosystems, coral reefs, provide home to hundreds of commercially valuable fish species. Despite their importance, the health and cover of shallow water coral have declined worldwide over the last two decades. Without another marine ecosystem, coastal wetlands, many species of fish and shellfish cannot survive. Yet, existing programs to protect wetlands notwithstanding, the habitat, acreage, and function of wetland areas continues to decline.

Research and experience have shown that the bounty of the ocean is not limitless. Increasing population and the accompanying expansion of human activities have the capacity to diminish the ocean's productivity in numerous ways. The ocean's living resources and the benefits derived from them are threatened by fisheries operations, chemical pollution and eutrophication, alteration of physical habitat, and invasions of exotic species. Looming on the horizon are new threats caused by ozone depletion and human-induced climate change, whose potential negative impacts on whole ecosystems add further to the impact of already existing threats caused by other human activities.

The U.S. government, in partnership with public and private stakeholders, has recognized these threats to the marine environment and is taking steps to address these problems. Evidence already shows that U.S. management and conservation practices are paying dividends in healthier resources. For example, the United States has set a policy framework for sustainable utilization of fisheries through the Sustainable Fisheries Act of 1996. Provisions of the Act being implemented include prevention of overfishing, designation and conservation of essential fish habitat, reducing bycatch, and managing harvesting capacity. As fishery harvests are reduced to sustainable levels, marine aquaculture will play an increased role in meeting domestic and world food needs. The United States is developing the technology and policy framework that will allow this expansion in food production in an environmentally sustainable manner.

Regarding other concerns, strong protection under the Endangered Species Act and Marine Mammal Protection Act has enabled the recovery of certain marine mammals and increased populations of at least two sea turtle species in U.S. waters. Integrated coastal area management, meanwhile, is providing new tools to protect the most productive coastal and marine ecosystems. The United States has also been a leader in advancing international initiatives to conserve marine fisheries and biological diversity—a shared resource. In each of these natural resource management areas, the United States is beginning to apply a precautionary approach that acknowledges the limits of scientific knowledge and requires erring on the side of conservation. The key to success will depend on sound science and strengthened partnerships with all stakeholders to conserve and sustainably use the nation's marine living heritage.

The Year of the Ocean is an opportune time to examine the challenges confronting marine living resources in light of new tools: advanced and expanded scientific information, the precautionary approach, increased inclusiveness and partnerships, and the potential of ecosystem-based management. Much has been done in the past 20 years, and 1998 provides an excellent starting point for a new direction for the next 20 years.

## INTRODUCTION

Humans have sailed the seas for centuries, but considered anything beneath the surface or beyond the horizon to be "incognito," and to be labeled as dangerous: *Here be dragons*. While our modern perspective may lead us to scoff at the early map makers, even today many maps treat the ocean as essentially flat, blue, empty space between the continents—featureless and devoid of interest. Despite quantum leaps in scientific knowledge about the ocean, many Americans still view the ocean as limitless, vast, and unknowable. According to recent survey research, however, citizen awareness of the value of ocean resources and the threats they face is growing (The Mellman Group, 1997). As worldwide observance of the Year of the Ocean proceeds, it is worth taking stock of existing knowledge about the ocean—and the health and abundance of its living resources—in order to be better able to chart a course for the future.

Life on earth arose from the ocean, and living marine resources continue to provide essential ecosystem services on which all life depends. Only in recent years has the extent to which the ocean is host to a vast diversity of species and ecosystems been recognized. Even though no "dragons" have been found, exploration of the ocean, which covers nearly three-fourths of the planet, has revealed creatures even more unusual, and living resources even more valuable, than could have been imagined by our ancestors. Only in the last 20 years have the seas begun to yield the secrets of the deep ocean floor. For example, the deep ocean is home to communities of organisms whose productivity is based on chemosynthesis instead of photosynthesis, the latter being the process by which most plant life on the earth and in the sea converts sunlight into useable biological energy. Other whole new ecosystems have been discovered in the ocean in recent years, and the vast majority of species remain to be discovered. Although the ocean may have fewer species overall than terrestrial environments, the array covers a much higher degree of diversity at higher taxonomic levels. All but one of the several dozen known animal phyla are represented in the ocean, while only about one half occur on land.[1]

Providing humanity with food, economic benefits, and recreation, living marine resources represent a treasure for current and future generations. These resources range from the tremendously productive phytoplankton, which help maintain atmospheric gas balances, sequester carbon, and form the base of many marine food chains, to corals, which build reefs that protect coastlines and create the most biologically diverse ecosystems; and from pelagic fishes upon which many of the world's commercial fisheries depend, to deep sea hydrothermal vent communities with unique adaptations that may provide important resources for future biotechnology breakthroughs (see Box 1).

[1]Taxonomy is the system used by biologists to describe and classify organisms. The so-called taxonomic pyramid is divided into kingdom, phylum, class, order, family, genus, species. A whole new Kingdom, the Archaea, was discovered in deep sea hydrothermal vents. The Archaea are as different from bacteria as bacteria are from plants and animals.

**Box 1: The Value of Living Marine Resources**[2]

The diversity of life in the ocean provides a natural "hope chest" for current and future generations. The ocean's biological diversity—the living resources that compose it and the ecological processes that sustain it—form a foundation for the quality of human life as well as the raw materials to enrich it. Biological diversity, or biodiversity, refers to the variety and variability among living organisms, and among the ecological complexes of which they are a part. It encompasses all of the world's living resources. Marine living resources provide essential economic, environmental, aesthetic, and cultural benefits to humanity.

**Direct use values:** The fish humans consume represent the most widely recognized economic value, whether from capture fisheries or marine aquaculture. Sixteen percent of all animal protein consumed worldwide comes from the ocean. In Asia alone, one billion people rely on fish as their main source of protein. The Food and Agriculture Organization of the United Nations estimates the total value to fishers of the world's marine catch at $80 billion per year. The comparable value of fishes landed by U.S. fishers is $3.5 billion. Fishes and seaweeds provide important fertilizers and livestock feed. Besides food, marine living resources provide products including ornamental marine life, raw materials, and medicines. Marine bioprospecting extracted Arabinosides from the sponge, *Tethya crypta,* leading to more than $50 million annual sales in derived antiviral medicines. Just five drugs developed over the past few years in research funded by Sea Grant have a market potential estimated at $2 billion annually.

Direct uses also include non-consumptive uses such as ecotourism, recreation, and research. The economic return from whale watching, SCUBA diving, and visits to aquariums far exceeds that which could be earned from consumptive use of the organisms in question. Millions of tourists spend about $2 billion a year in the Florida Keys, with the National Marine Sanctuary and other marine protected areas providing a major attraction. Without sustainable management of these nature-based tourist attractions, economic potential can diminish or be lost entirely.

**(continued)**

[2] The system for valuations for marine biodiversity (direct, indirect, option, and non-use values), follows: UNEP 1995. Global Biodiversity Assessment. Cambridge University Press, Cambridge, U.K. 1140 pp.

**Box 1 (continued)**

**Indirect use values:** Maintenance of intact, healthy ecosystems provides global and local benefits. Marine ecosystems provide natural goods and services such as carbon storage; atmospheric gas regulation, particularly by the ocean's enormously productive phytoplankton; nutrient cycling; and waste treatment. Coral reefs, mangroves, and kelp forests protect coastal areas from weather and storms. Marine algae contribute nearly 40 percent of global photosynthesis. In many cases, indirect use values greatly exceed direct use values, yet they often are not incorporated into economic calculations. Globally, the indirect use values of marine ecosystems recently have been estimated at $5.2 trillion per annum for open ocean ecosystems and $11.7 trillion for coastal ecosystems (Costanza *et al.* 1997).

**Option values:** Many components of biodiversity not used, or even recognized today, may help meet human needs in the future. Technological advances in food production and pharmaceuticals rely heavily on the natural genetic diversity of plants, animals, and microorganisms. Advances in molecular biology have ensured that the coming century will see an acceleration in the use of genetic materials. Marine organisms have evolved complex chemical compounds and processes for defense and predation, or for survival in extreme environments—such as deep sea hydrothermal vents. These compounds and the underlying genetic diversity have tremendous potential economic importance that would be foreclosed by the loss of marine biodiversity.

**Non-use values:** The sea has been a source of ideas on subjects from past global climates to the ecology of uncommon species, as well as a source of inspiration: "The oceans, with their powerful storms, their shimmering palette of colors, and their varied mysterious sea life, have inspired some of the world's finest painting, poetry, stories, and music." (Norse 1993) The spiritual, cultural, or aesthetic regard in which people hold the natural world and its resources and the values humans place on retaining these systems for future generations are usually not captured by current market or economic models, but are inextricably linked to human appreciation of the sea and its inhabitants. This appreciation stimulates the formation of conservation values and a stewardship ethic.

Yet at the same time that humankind was learning more about the diversity of living marine resources, it was also learning how to better exploit the marine environment in search of minerals, food, waste disposal, and transportation. As population increased, demands accelerated for food, products, and services from the ocean, as did demands for living and recreational space on its shores.

In the past, most human activities were seen as separate from the ocean, or of such insignificance in the face of the sea's vastness that they didn't matter. Pollution was one of the first human actions to be seen as possibly damaging to the ocean. Huge oil spills in the early 1970s coincided with the emergence of the environmental movement and spurred governments and the public to focus on pollution from ships. Blowouts from oil rigs off Santa Barbara, California heightened concern about offshore oil drilling. Also at that time, ships routinely disposed of wastes overboard, and concern was just beginning about land-based sources of pollution or the effects of either of these sources on the marine environment. By the 1980s, ocean dumping was internationally recognized as a problem and agreements were put in place to control disposal of shipboard waste and intentional dumping. By then, Americans had made the connection between clean water and healthy coasts. Control of industrial and municipal waste water discharges into rivers, streams and coastal waters has been regulated in the United States since the passage of the Clean Water Act in the early 1970s. Dumping of industrial wastes and sewage sludge into the ocean off U.S. coasts ended in 1988 and 1992, respectively, as a result of the Ocean Dumping Ban Act of 1988.

As the United Nations and its member nations, including the United States, prepare to observe the Year of the Ocean, there is both increased awareness of human impacts on living marine resources as well as good news about how these impacts are being addressed. The good news is the growing worldwide acceptance of the precautionary approach to marine resource management. A concept unheard of a decade ago, the precautionary approach states that in the face of uncertainty, managers and decision makers must err on the side of conservation of living marine resources and protection of the environment. This is the opposite of earlier resource management approaches, where the proponent of resource use prevailed until something went wrong. Representing a radical shift of the burden of proof from those who would conserve resources to those who would use them, the precautionary approach is now being integrated into U.S. policy and practice, as well as into many international agreements. And this is occurring none too soon, since many ocean resources continue to decline in the face of increasing demands upon them.

The federal government, as steward of U.S. living marine resources in partnership with the American people, has the opportunity to observe the Year of the Ocean in both a reflective and forward-looking manner. The Year of the Ocean provides a vehicle to accomplish several goals including;

- increase public awareness of what is known about the marine environment
- solidify and strengthen federal partnerships and cooperation with stakeholders
- use acquired knowledge to act on behalf of the resources
- use enhanced communication to engage others to act
- expand the knowledge base and the application of the precautionary approach

This paper is intended to provide stakeholders and interested constituents with information on what is known about the state of living marine resources, how human actions affect these resources, and what tools resource managers can use to progress from this year's observance of the Year of the Ocean to a future wherein the ocean's living resources are used sustainably. Not only does the Year of the Ocean observance provide an opportunity for federal managers to communicate to the public and to bridge the gap between perception and today's best available science, it will provide avenues through which the public and user groups can participate in the important decisions regarding marine living resources.

## THE STATUS AND TRENDS OF LIVING MARINE RESOURCES

Knowledge about marine species and ecosystems lags far behind that of terrestrial systems. In the last two decades, discoveries in the ocean have been made that have shaken the foundation of human understanding of what is in the sea. These discoveries have highlighted how little is still known about the oceans, and have led to greatly increased estimates of overall marine biodiversity. Recent discoveries have ranged from a new large cetacean—the pygmy beaked whale (*Mesoplodon peruvianus*)—first recorded in 1991, to the discovery in 1997 of an entire new deep-sea ecosystem of eyeless worms living in symbiosis with bacteria that feed on methane ice in the Gulf of Mexico. Contributing to the improved understanding of the state of marine life that has been acquired in recent decades have been improved information gathering techniques, more stringent reporting requirements, advances in technology, cooperation among states, academia, and other nations, and increased outreach to stakeholders, user groups, and others.

Yet, as the U.S. government and its partners in marine resource management observe the Year of the Ocean, it is important that the limitations regarding human understanding of marine organisms, their habitats, and the factors that affect them be recognized. Notwithstanding the important strides that have been made, what relatively little is known about the state and trends of marine living resources is concentrated in the areas of commercially exploited species, protected marine mammals and turtles, and certain commercially significant and accessible coastal ecosystems such as wetlands and coral reefs.

Until recently, the oceans were thought to be a limitless source of food and natural resources, and a limitless sink for human pollution. Trends for living marine resources during the last few decades, however, have convinced many observers that human activities are reaching and often exceeding the productive limits and recuperative potential of the ocean. Many fishery resources are being overexploited, and the ability of many species and ecosystems to recover from overutilization or excessive pollution is limited. The following section summarizes what is known about the status and trends of fisheries, protected species, coral reefs, and coastal wetlands.

### Fisheries

Among the best known ocean living resources are wild populations of fish and shellfish that are harvested commercially and used directly and indirectly as human food. Worldwide, there are 15 to 20 million fishers, 90 percent of whom are small-scale fishers; moreover, fisheries provide up to 180 million more jobs in associated sectors (FAO 1993). Recent trends indicate that both worldwide and in the United States, about one-third of the resources on which these fishers depend are overfished (Figure 1).

The domestic and global status of many commercial fish stocks reveal a pattern of declining populations and are increasingly a source of serious concern to scientists, managers, and policy makers. On a global basis, fishery resource reports by the UN's Food and Agriculture Organization (FAO) since the early 1990s have highlighted that many of the traditional commercial stocks are overutilized and thus showing declining yields and productivity. Increases in total catch from capture fisheries in the last two years consist of low-value pelagic species taken by a small number of countries, and the harvesting of new deepwater stocks that are unlikely to support current levels of exploitation. In its latest annual report, FAO has concluded that 60 percent of commercial stocks are either overfished or fully harvested (Figure 1; FAO 1996).

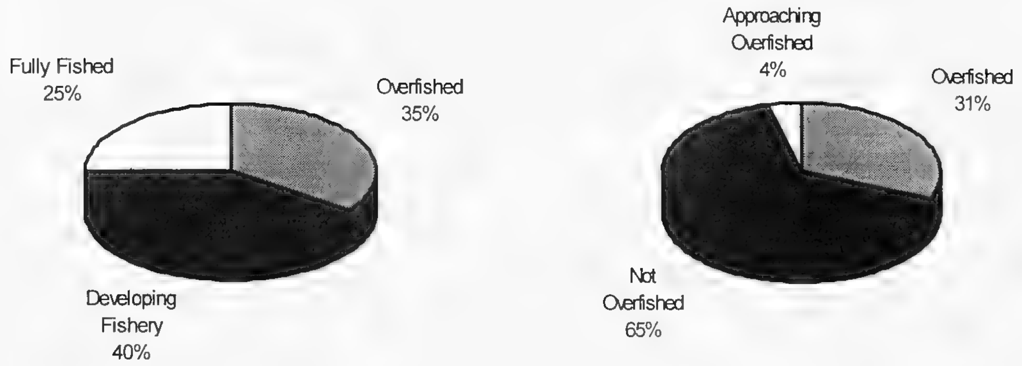
Since the enactment of the Magnuson Fishery Conservation and Management Act in 1976,[3] fisheries in the United States have been managed by a system of eight regional councils, which develop Fishery Management Plans in accordance with national standards. Under this system, limits on catches, seasons, areas, and gear have contributed to the conservation of U.S. fishery resources. Among management successes are Alaska groundfish, where the transition from foreign fleet to U.S. fleet vessels for harvesting (provided for by the 1976 Magnuson Act) was made while maintaining the stock, which is the most abundant in the nation. Other management successes include king and Spanish mackerel, where significant declines in the late 1970s and early 1980s were reversed with a strict rebuilding plan and stocks are no longer considered overfished. Other successes include management actions that led to the recovery of stocks of striped bass , and surf and ocean quahogs on the Atlantic coast (Matlock in press). In all, the Councils have developed 39 management plans covering hundreds of species.

Despite management successes, many fish stocks in the United States are threatened. The National Marine Fisheries Service's (NMFS) 1997 *"Report to Congress on the Status of Fisheries in the United States"* (NMFS 1997) covered 727 marine species under federal management in the nation's 200-mile offshore exclusive economic zone. Of these 727 species, sufficient information to determine their fishery status was available for only 279 species, less than two-fifths of the total. Of these, 86 species (31 percent) were listed as "overfished," 183 species (66 percent) were listed as "not overfished," and 10 species (3 percent) were considered to be approaching an overfished condition (Figure 1). The overfished species included some of the most valuable commercial fish and shellfish. The basis for the identification of overfished stocks in the NMFS report was the overfishing definition used in the Fishery Management Plans, supplemented with information from the 1995 edition of *"Our Living Oceans"* (NMFS 1996). The Sustainable Fisheries Act of 1996 provided a more scientifically rigorous definition

3 The Sustainable Fisheries Act of 1996 reauthorized and amends the Magnuson Fishery Conservation and Management Act (which has been renamed the Magnuson Stevens Fishery Conservation and Management Act.)

of "overfished" and "overfishing." Fishery Management Plans are currently being amended based on this definition and it is likely that additional stocks will be identified as overfished.

**Fig. 1. Status of Fisheries**




Status of World Fisheries
Based on 200 major fish resources.

Source: FAO 1996.

Status of U.S. Fisheries
Based on 279 of 727 federally managed species for which sufficient data are available.
Source: NMFS 1997.

Annual U.S. catches have fluctuated between 4.5 and 5.0 million tons since 1990 and the gross first-sale value has not varied much from an annual average of $3.5 billion. To put these quantities and revenues in perspective, the United States is the fifth largest fishing nation, and its catch represents about 5 percent of world totals.

Internationally, FAO estimates that without major changes in fishery management, landings will not be able to exceed current levels despite increased demand from growing populations, and could in fact be reduced by as much as 25 percent (FAO 1996). In recent years, the fishery sector's contribution to the world's growing food needs has been supported largely by a booming inland and coastal aquaculture sector. The culture of marine species offers important opportunities for enhancing global food production and food security. Indeed, aquaculture is the fastest growing segment of U.S. food production. Without careful planning and oversight, however, aquaculture in marine and coastal environments can have negative impacts on natural biodiversity. These impacts include:

- habitat degradation (e.g., intentional destruction of mangroves in shrimp culture or unintentional negative impacts on benthic communities from the buildup of wastes under culture pens);
- eutrophication;

- genetic effects on or competition with native species by non-indigenous cultured species;
- introduction of disease to natural populations.

Economically important shrimp aquaculture operations in Asia were hit hard by disease in 1996. The international community has acknowledged the need for sound marine aquaculture practices so that it remains a sustainable industry with minimal adverse impacts on the surrounding environment (Allsopp 1997).

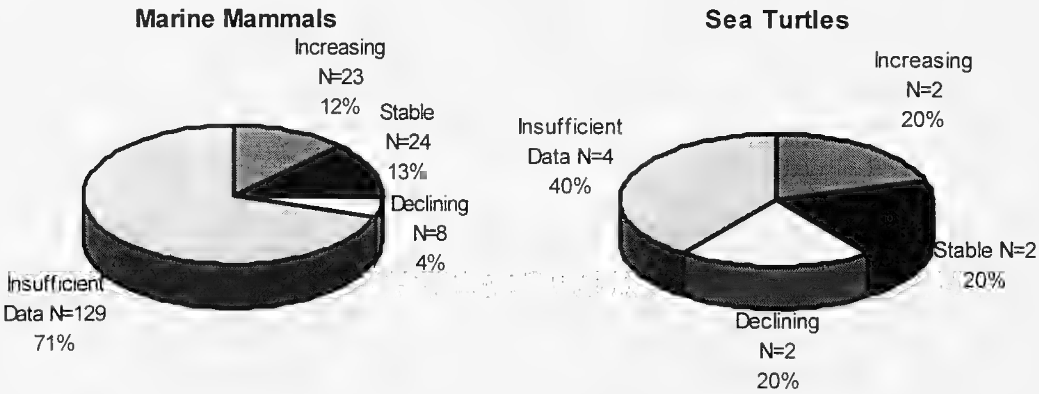
### Protected Marine Species

In the past, the exploitation or incidental capture of many marine species, along with a lack of adequate natural resource management policies, led to the decline and even extinction of many marine species. This process began early—the Steller's sea cow, the largest marine herbivore known to have occupied America's coastal waters, was hunted to extinction in 1768—and has continued into the second half of the 20th century. Current threats to marine species remain significant. For example, many West Coast Pacific salmon populations are at risk; scientists continue to seek answers to declines among some sea turtle, sea lion, seal, and seabird populations; and the northern right whale is critically endangered with fewer than 300 animals remaining in the Atlantic Ocean.

Since the enactment of the Marine Mammal Protection Act (MMPA) in 1972 and the Endangered Species Act (ESA) in 1973, selected marine species, particularly marine mammals, sea turtles, and salmonids have received greatly enhanced levels of protection in the United States. Pacific grey whale populations have largely recovered from overexploitation and have been removed from the endangered species list. However, other species have shown little sign of recovery despite two decades of protection. Of the 163 marine mammal stocks managed under the MMPA, there is sufficient long-term population data to describe trends for only about one third of the stocks. Eight of these are declining, 24 are stable, and 23 are believed to be increasing (Figure 2; NMFS 1996).

There were 38 marine species and seabirds listed under the ESA as of December 1997. Endangered marine species in U.S. waters include the northern right whale, sei whale, sperm whale, finback whale, bowhead whale, blue whale, humpback whale, Hawaiian monk seal, West Indian manatee, California least tern, hawksbill sea turtle, leatherback sea turtle, Kemp's ridley sea turtle, shortnosed sturgeon. Certain populations of Steller sea lions, brown pelicans, roseate tern, green sea turtles, olive ridley's sea turtles, sockeye salmon, chinook salmon, cutthroat trout, and steelhead trout are also endangered. Threatened species in U.S. waters include marbled murrelet, loggerhead sea turtle, Gulf sturgeon. Also threatened are certain populations of coho salmon, chinook salmon, cutthroat trout, steelhead trout, Steller sea lion, southern sea otter, green sea turtle, and olive ridley turtle.

**Fig. 2. Status of Marine Mammals and Sea Turtles in U.S. Waters**




Source: NMFS 1996

Six species of sea turtles regularly occur in U.S. waters (Figure 2). All are listed as endangered or threatened under the ESA. The Kemp's ridley sea turtle (*Lepidochelys kempi*), is the most endangered species of sea turtle in U.S. waters. After precipitous declines in population size, it is now showing signs of recovery. In 1947 an estimated 40,000 females nested in one day. By 1966, only 6,000 nests were documented, and the plummeting population continued to decline to a low of 702 nests documented in 1985. Among the causes for the decline of this species were the incidental capture of the species at sea and taking eggs and nesting females from the primary nesting beach in Mexico. The Mexican government began full protection of the nesting beach in 1966, and in 1978, the U.S. Fish and Wildlife Service and Mexico's Instituto Nacional de la Pesca began a cooperative program to enhance the recovery of the Kemp's ridley sea turtle. The National Marine Fisheries Service has provided funding in recent years to maintain and enhance protection efforts on the nesting beach. In addition, NMFS required that shrimp trawlers install turtle excluder devices in their nets by the early 1990s. As a result of increased hatchling production and protection at sea, the turtle population is showing signs of recovery. More than 2,200 Kemp's ridley nests were documented in 1997. Green sea turtle populations also appear to be increasing in the U.S. Atlantic and in Hawaii, although there is great concern about the increasing frequency of fibropapillioma disease in this species (NMFS 1996).

As a result of human activities such as logging, dam building, overgrazing, mining, urbanization, overfishing, poor hatchery policies, and natural events such as floods, drought and El Niños, Pacific salmonids are rapidly disappearing in California, Oregon and Washington. Since 1990, five stocks have been listed as endangered and seven as threatened under the ESA.[4]

---

[4] Endangered stocks are the Sacramento River winter run chinook (*Oncorhynchus tshawytscha*), Snake River sockeye (*O. nerka*), Umpqua River cutthroat trout (*O. clarki clarki*), southern California steelhead (*O. mykiss*) and the upper Columbia River steelhead (*O. mykiss*). There are two chinook stocks, two coho (*O. kisutch*) stocks and three steelhead stocks listed as threatened.

Coastwide reviews of all chinook, sockeye, cutthroat, chum (*O. keta*) stocks will be completed in 1998. Listing determinations will follow immediately after the status reviews are completed. The ESA provides strict prohibitions on taking endangered salmonids and provides for the responsible federal agency to put rules in place that will reduce, or in some instances prohibit, takes of threatened species as well. The ESA has flexibility that allows both state conservation plans and Habitat Conservation Plans with private parties to aid in conservation and recovery of listed species. The Oregon Coastal Salmon Restoration Plan is a positive model for other states to follow as it provides scientifically based strategies for conservation and couples those strategies with funding to implement them. The Oregon Plan was developed as a grassroots effort with stakeholders. Habitat Conservation Plans with large industrial land owners and state agencies are in place in the west and more are in the development phase.

## Coral Reefs

As the world's most biologically diverse marine ecosystems, coral reefs are home to one-third of all marine fish species and tens of thousands of other species. Recent estimates suggest that while nearly 100,000 species are known to occur on coral reefs, the number may be underestimated by a factor of ten (Reaka-Kudla, 1997) Coral reef areas under U.S. jurisdiction cover approximately 16,879 square kilometers (NOAA 1998). They are home to approximately 550 coral-dependent species of commercially valuable fishes are under federal management, with an annual commercial value of nearly $75 million. The value of recreational fisheries is at least this much (Spurgeon, P.G. 1992, NMFS 1996). Coral reefs provide critical protection to shorelines and attract SCUBA divers and other forms of tourism. Despite their importance, shallow water coral health and cover has declined worldwide over the last two decades. This decline is directly attributable to human influences, including: siltation from onshore deforestation and construction, pollution, physical damage, dredging, overfishing and destructive fishing practices, and other abuses. Although the collection of live corals is largely prohibited in the United States, a growing international trade in corals and coral reef species is contributing to the degradation and destruction of coral reef ecosystems worldwide.

Concomitant with increasing human pressures on coral reefs, the last decade has seen an alarming increase in coral diseases, with growing evidence that susceptibility to disease is in part linked to human-induced stresses. It has been estimated that 10 percent of the earth's coral reefs have been degraded beyond recovery, and another 30 percent are likely to decline significantly within the next 20 years (Jameson *et al.* 1995). It is difficult to generalize about the condition of coral reefs in the United States. There is agreement, however, that coral reefs are threatened wherever they are close to large concentrations of people, and that data are available to evaluate the status and trends of coral reefs in only a few sites (NOAA 1998). The International Year of the Reef, 1997, provided impetus to several international reef monitoring programs, such as the International Coral Reef Initiative's Global Coral Reef Monitoring Network and the all volunteer ReefCheck. These efforts will serve to greatly increase understanding of the status and outlook for coral reefs worldwide.

## Coastal Wetlands

If coral reefs represent the most diverse marine communities, coastal wetlands and estuaries rank among the most productive ecosystems. These ecosystems, including salt marshes, seagrass beds and mangroves, provide habitat for migrating waterfowl and are associated with some of the world's greatest fisheries. They also provide critical ecological functions as the sources of nutrients for nearshore production, as filters for land runoff, and as stabilizers for coastal lands.

The relationships between wetlands and fish production are an essential and important part of the ongoing debate on wetland regulation and policy. Although research continues to increase understanding of wetland ecosystems, the life cycles of most commercial fish and shellfish species are fairly well understood. Biologists have determined that wetlands play an important part in providing food, protection, and spawning areas. For example, wetlands are crucial for shrimp production, and estuarine habitat is critical for salmon. Approximately 75 percent of the nation's commercial fishes and shellfishes depend on estuaries at some stage in their life cycle. Estuaries themselves depend on their wetlands to maintain water quality and provide the basis for food chains that culminate in seafood harvests. Many estuarine-dependent species have even closer ties to wetlands in that they feed, take refuge, or reproduce within them. Without wetlands, these fishes and shellfishes cannot survive.

Until quite recently, the United States was losing wetlands at an alarming rate. The Clean Water Act, and other federal environmental laws have been instrumental in decreasing wetland losses since that time. From 1982-92, the losses totaled 31,000 acres of wetland per year, down from 157,000 acres per year in 1974-83, and down further from the 398,000 acres per year in 1954-74 (USDA/NRCS 1995). However, despite regulatory programs and natural resource management plans, human population growth and development continue to yield a net loss of habitat acreage and function. Coastal population has risen by 40 million people since 1960, and continues to grow at four times the national average. This challenge will become more acute as each year marine, estuarine, and riverine fish habitats are further sacrificed to physical destruction, nonpoint and point discharges, eutrophication, waste dumps, and other human activities. These losses are complicated by natural changes predicated on geology and climate. Globally, coastal wetlands are also among the most threatened habitats—mangroves are being cleared for timber or for shrimp farms, and estuaries are being dredged or polluted.

## Summary

Basic assessment and information on status and trends are the fundamental tools managers of natural resources require. Uncertainty is a reality in marine resource management. The greater the uncertainty, the more conservative the management must be. Managers rely upon scientifically based information to reduce the degree of uncertainty. The need for accurate, timely, and precise scientific information has never been greater. Current knowledge of marine resources—the threats they face and their condition—is tremendously improved from what it was 20 years ago. However, in the ocean realm, many of the fundamentals are still unknown. Yet, what is known indicates that the trend in U.S. waters and worldwide is toward overutilization and increased damage. The following section describes the threats to marine living resources that have resulted from the observed trends.

## THREATS TO THE SUSTAINABILITY OF LIVING MARINE RESOURCES

The international observance of 1998 as the Year of the Ocean comes at a time when the earth's living marine resources face unprecedented stress from human activity. As human population and economic growth increase, particularly in coastal zones, the worldwide trend is for more pressure on coastal areas, the ocean, and the marine wildlife that inhabit those regions. Moreover, because marine species do not occur or function in isolation, it is not sufficient to simply protect marine mammals, manage salmon, etc. Rather, management and conservation regimes that recognize and take into account the interrelationships of all ocean life must be developed . However, public perception continues to operate considerably behind the state of the knowledge of scientists, decision makers, managers, and various other marine-oriented constituencies about the threats facing the marine environment.

In a landmark report, "*Understanding Marine Biodiversity*," (NRC 1995) the National Research Council identified the five most important agents of present and potential threat to marine biodiversity at the genetic, species, and ecosystem levels. These factors also have been identified by the Parties to the Convention on Biological Diversity[5] as key threats (UNEP/CBD 1995). The five categories are:

1. fisheries' operations;
2. chemical pollution and eutrophication;
3. alteration of the physical habitat;
4. invasions of exotic species; and
5. global climate change.

### Fisheries Operations

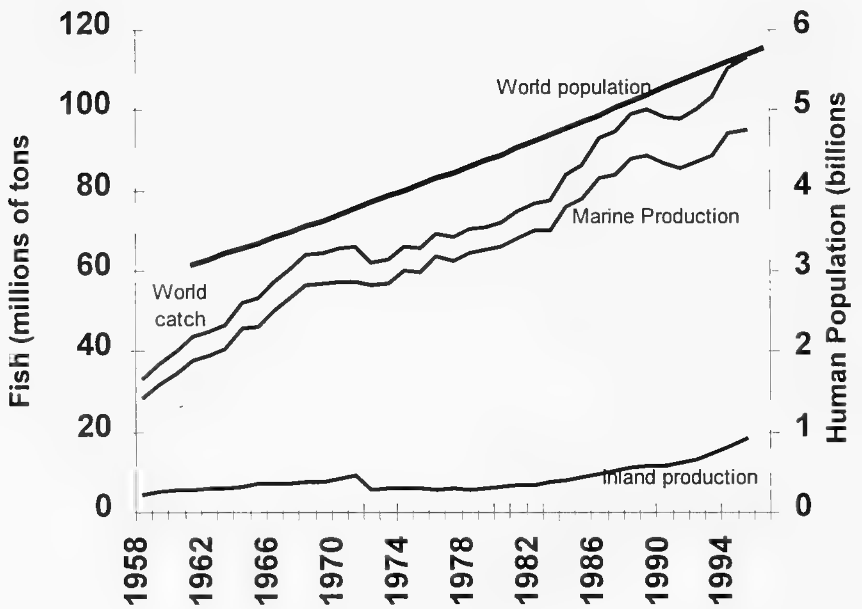
Until very recently, far more effort has been expended on trying to increase catches of fish than on developing conservation and management efforts. This was in keeping with the historic view that the abundance of marine fishes was so vast, and the impacts of fishing so small, that there was no need to regulate it. In fact, serious management of U. S. marine fisheries began only 20 years ago. The passage of the Magnuson Fishery Conservation and Management

[5] Note: The United States has signed but not yet ratified the Convention on Biological Diversity

Act in 1976 was the first comprehensive federal legislation to address this subject. It was as much focused on fishery development as conservation, but at the time, was considered revolutionary in its scope and vision.

The period from 1885 to 1950 was one of developing marine fisheries and slowly increasing research in fisheries both in the United States and abroad. Marine fishing regulations were very few. Catches continued to increase, particularly after World War II, through the application of newer technology and bigger and faster boats. In the 1970s and 1980s, fleets expanded at twice the rate of catches, which peaked in 1989, leveled off for a few years, then climbed again as a result of large catches of low-value pelagic species (FAO 1997; Figure 3).

**Fig. 3. Human Population and Global Fish Production 1958-1995**




Note: Production includes aquaculture and fisheries both for human consumption and for livestock feed. Source: FAO 1996

In the early 1970s, a public constituency developed for the protection of whales, seals, and dolphins. It exerted tremendous influence on the United States and governments around the world to halt commercial exploitation of these marine animals. The U.S. Congress enacted the Endangered Species Act and the Marine Mammal Protection Act in the same era as it addressed issues of clean water and clean air. During this era of environmentalism, Congress also enacted the Magnuson Fishery Conservation and Management Act. By the mid-1980s, laws and regulations governing marine mammals had been revisited and made more stringent, but the emphasis in fisheries was still in the development mode. This included federal financial assistance to encourage and promote new fisheries and greater fishing power.

The constituencies supporting fish conservation have grown tremendously in recent years. Scientists and managers who had predicted and tried to stop calamities such as the New England groundfish collapse were joined by environmentalists, who saw the connections between protecting endangered and threatened marine mammals and fishing operations. The decline of New England's groundfish fishery finally served as the wake up call—to managers and fishermen, as well as conservationists—who all pressed for reform in fishery management.

It is now recognized that fishing can and already has had profound effects on marine fish populations. Underscoring the issue, the National Research Council reported in 1995 that fishing activity has affected "... virtually every habitat except the deepest sea floors. Even with management practices now in place, fisheries have major impacts on ocean environments, ranging from direct harvest to bycatch effects, habitat destruction, genetic changes, and food web changes" (NRC 1995).

Fishing affects marine living resources both directly and indirectly. The principal direct impact is taking out more fish than the populations can replace. Indirect impacts include bycatch, the destruction of habitat, and other ecosystem effects that may accompany fishing activities. The most visible attention to overfishing focused on international commercial fisheries, such as those using large-scale driftnets on the high seas, conservation of highly prized fishes that cross boundaries between or among nations and the high seas (known as straddling and highly migratory stocks), and the problem of reflagging vessels to avoid conservation measures. Several accords reached through the UN have addressed these issues. However, destructive overfishing even occurs in artisanal and small-scale fisheries worldwide, where biomass fishing (using fine-mesh nets to capture all fish species and age classes), blast fishing, poisoning (with cyanide, rotenone, bleach, etc.) deplete stocks and destroy habitats.

*Direct fishing impacts from overfishing*

Although a wide variety of both human-caused and natural factors affect the living resources of the ocean, the most widely studied and probably best understood is resource overuse. Under this broad heading, managers generally agree that the immediate pressure points are overfishing and overcapacity. Overfishing generally refers to harvesting at excessive levels. The term was defined in the latest Sustainable Fisheries Act amendments to the Magnuson-Stevens Act 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." Overcapacity, on the other hand, refers to excessive levels of catching power, usually measured in terms of the number and size of vessels, and the power and technical efficiency of the engines and gear. In other words, overcapacity refers to boats and technology; and overfishing to the impact of the boats and gear on the target fisheries.

Overfishing and overcapacity reflect fundamental global demographic, economic, and technological trends. Specifically, continuing population growth, increased economic activity, the general trend toward more abundant and protein-rich diets, and the evolution of fish finding and capture technology, all tend to promote operations and investments in the global fisheries sector. The resulting overfishing and overcapacity has placed major and difficult responsibilities on governments, especially with respect to management and fisheries enforcement. These trends are exacerbated by the tendency of many governments to continue to promote fishery development in the absence of meaningful access controls.

In the United States, the passage of the 1976 Magnuson Fishery Conservation and Management Act was intended to allow the domestic fishing fleet to replace foreign fishing within the area between the states' outer territorial sea limits (usually three miles) and 200 miles seaward—the Exclusive Economic Zone. However, the fisheries management system at that time was not operating under the premise that these resources were threatened by overexploitation. In the late 1970s to late 1980s, managers did not adequately consider the impact that fishing, albeit by domestic fishermen rather than foreign vessels, would have on fish stocks. As a result, domestic fishing capacity increases were generally unconstrained and even encouraged. By the early 1990s, one objective of the Magnuson Fishery Conservation and Management Act had been accomplished—foreign fishing was gone. However, a second objective—to stop overfishing—was far from being met. By the 1990s, the realization that overfishing could occur on a large scale, and actually had occurred, was reaching an audience beyond the scientific community in the United States and throughout the world.

In the past two decades, the world's fishing nations have so excessively increased their efforts that global fishing capacity in the traditional fisheries is estimated to be 30 percent greater than required to take the world catch (Garcia and Newton 1995). In the United States, it has been estimated that about one- third of all the fisheries for which sufficient data exist are overfished. There is no similar calculation for the level of overcapacity in U.S. fisheries, but it is assumed to be significant. A good example is the halibut fishery in the Gulf of Alaska, which before regulations were instituted that limited access, saw 8,000 boats vying for the catch quota in two 24-hour marathon fishing derbies.

In summary, overfishing has become a global problem. Evidence indicates that overfishing and overcapacity exist worldwide:

- in the countries that are developed, traditional fishing powers;
- in resource-rich coastal countries that have tended to overestimate the potential of these resources and have failed to institute adequate safeguards;
- in countries in transition from centralized to market-based economies where governments are struggling to reorder investment and economic policies in the fisheries sector; and
- in developing countries that have promoted their fishery sectors too aggressively, or where demographic changes have provided incentives for destructive fishing practices.

*Indirect fishing impacts*

The most significant indirect impacts of fishing on marine biodiversity include bycatch, habitat destruction and ancillary impacts on interacting species or ecosystems (NRC 1995). Bycatch is the capture and associated mortality of nontarget species or of the mortality of the target species that are discarded because of size, quality, or other preferences. For example, in the southeast U.S. shrimp fishery, for every pound of landed shrimp, approximately 4-5 pounds of non-target species (mostly juvenile fish) are also captured and mostly discarded. The high level of bycatch in shrimp trawls has contributed to the closure of some commercial fisheries in the Gulf of Mexico. Bycatch is also a major concern for endangered or threatened species—e.g., sea turtle bycatch in shrimp fisheries; marine mammal drowning in gillnets; and shark, seabird, and sea turtle bycatch in longline fisheries. It is estimated that the unregulated longline fisheries for toothfish in the Southern Ocean may have contributed to the incidental mortality of 66,000 to 100,000 seabirds in 1997 alone (CCAMLR 1997).

By its very operation, fishing changes the relationships among species in a marine foodweb. It can change the functioning of a marine system by altering the composition of a particular marine community—either by simply removing large amounts of all types of organisms, as in the shrimp example above, or by taking large numbers of fish of a certain age or size from a system. For example, in the Georges Bank/Gulf of Maine fishery, the "bottom fish" species of cod, hake, flounder, and haddock were severely overfished resulting in their replacement by commercially less valuable fish species (i.e., skates and dogfish). The ensuing ecosystem shift may preclude the recovery of the cod fishery, despite a stable but much reduced biomass for this species.

Marine fisheries may alter or destroy habitats. Fishery practices that can harm habitats include bottom trawling, blast fishing, and the use of fish traps and poisons on coral reefs. Bottom trawls can be particularly destructive, with impacts on benthic habitats and invertebrate communities lasting for many years (Jones 1992). Habitat destruction is extensive and may contribute to the decline of fish and other species; yet because the destruction is hidden below the surface, it is seldom well documented or quantified.

## Chemical Pollution and Eutrophication

Land-based sources are estimated to account for more than 75 percent of the pollutants entering the world's ocean. Human communities daily generate new pollution that further degrades already diminished ecosystems. Some forms of pollution originate hundreds of miles inland and are carried to the sea by rivers or through the air. Point sources originate from a specific place, such as an industrial facility or municipal sewage treatment plant. Non-point sources originate from dispersed areas, such as agricultural lands (silt, pesticides, fertilizers, and animal wastes), roadways and other paved surfaces (hydrocarbons), deforested hillsides (silt), septic tanks, and atmospheric deposition. These sources cause at least as much harm to marine living resources as do point sources, but are generally much more difficult to address.

The various land-based sources of pollution affect marine biodiversity in many ways. Soil erosion and contamination from pesticides and fertilizers all degrade ocean habitats. Chemical pollution also can cause physiological effects such as increased mortality rates, decreased growth, impaired reproduction, genetic mutations, tumors, disease, or endocrine disruption. Pollution can cause physical as well as chemical harm to ocean organisms and their habitats, for instance, by smothering ocean bottom communities, blocking pathways, entangling animals, or by changing the level of light availability for photosynthesis. Eutrophication, the process of organic enrichment, results from excess nutrients from runoff (particularly nitrogen in the coastal zone). Eutrophication can cause harmful or noxious algal growth, shifts in food chains, oxygen depletion (anoxia), and other undesirable effects on marine ecosystems. Finally, pollution is believed to contribute to the observed increase in the occurrence of blooms of unicellular marine algae, which can cause mass mortalities in a variety of marine organisms and cause illness and even death in humans who consume contaminated seafood.[6]

### Alterations of Physical Habitat

The health of living marine resources is dependent upon the integrity of their habitat. No organism can live in isolation; all are dependent upon the health and biodiversity of the surrounding ecosystem, which provides the necessary ingredients of life. However, human activities can change, degrade, or destroy these habitats and the biodiversity associated with them. Habitat degradation is an important factor in the decline of many species, salmon being the prime example. Moreover, as world population increases, so do demands on the coastal environment. According to the United Nations, more than half of the world's population lives within 60 km of the shoreline and this could rise to 75 percent by the year 2020.

Coastal zones contain the planet's most productive marine ecosystems, providing habitats and essential spawning and nursery areas for the major portion of the commercially and recreationally important fisheries. Coastal habitats (mangrove swamps, estuaries, wetlands, seagrass beds, coral reefs, etc.) are fragile, biologically productive, and susceptible to degradation through human activities. In addition, the living marine resources in coastal wetlands often serve as efficient filters for land-based contaminants, and coral reefs and wetlands buffer storm surges and help retard coastal erosion. It is here, where the shore meets the sea, and where people are most inclined to build, manufacture, and recreate, that the most susceptible and diverse aspects of marine life exist.

In the United States and worldwide, coastal salt marshes have been destroyed by dredging and filling, mangroves have been removed for shrimp aquaculture, coastal development has altered natural patterns of erosion and sedimentation, and mining and dredging have directly altered habitats for marine species. The effects of development are not limited to the shoreline. As noted above, trawl-fishing operations are a major cause of underwater habitat destruction. Similarly, activities such as unsustainable forestry, mining, the diversion of water for agriculture,

[6] For a more comprehensive discussion of marine pollution, please see the Year of the Ocean Marine Environmental Quality Discussion Paper.

and dams or other construction far upstream can alter habitats for anadromous species (those that spend part of their life at sea, and part in fresh water) and alter sedimentation and water flow downstream.

### Invasions of Exotic Species

A marine scientist noted several years ago that the bottom of San Francisco Bay looked much like the bottom of Tokyo Harbor. Species that were at home on the opposite side of the Pacific had moved in and taken over, in some cases pushing out the local fauna. Over 234 exotic species have been identified in San Francisco Bay and Delta, and exotic species may account up to 99% of the biomass in some habitats (Cohen and Carlton 1998). The phenomenon, known as invasions of alien or exotic species, is one of the least known threats to marine biodiversity. Non-indigenous species are introduced both inadvertently and intentionally. Not all intentional introductions are harmful. In the marine environment, for example, introductions of oysters and other shellfish have been the basis of a multi-million dollar aquaculture industry. Yet, these same introductions have also unintentionally introduced new disease organisms traveling in shipments of the aquaculture species.

Many introductions of marine organisms occur via the exchange of ballast water in international shipping. The increase in international trade has greatly increased this pathway for non-indigenous species introductions. Inadvertent introductions through ballast water have been implicated in outbreaks of red-tide dinoflagellates in Australia; the invasion of the Black Sea by the American comb jellyfish with disastrous effects on plankton biomass and the anchovy fishery; and the invasion of the Great Lakes by Eurasian zebra and quagga mussels that have caused great economic damage in inland waterways. In most cases, the ecosystem effects of invasions of exotic species are still unknown.

### Global Climate Change

Historically, changes in global climate have significantly altered the ecosystems and processes of the world's ocean. Today, these natural changes are being joined by alterations to the earth's atmosphere as a result of human activities. Chief among these are decreases in stratospheric ozone caused by ozone-depleting substances such as chlorofluorocarbons, and global warming caused by increased atmospheric concentrations of so-called greenhouse gases such as carbon dioxide and methane, which are produced by human activities.

Ozone depletion—particularly in higher latitudes—has resulted in increases of ultraviolet-B (UV-B) radiation reaching the earth. A number of studies have confirmed that increased UV-B can damage phytoplankton and zooplankton, the basis for much of the ocean's enormous productivity. The world community has taken the issue of ozone depletion seriously, and the Montreal Protocol to the Vienna Convention has set countries on a course to the phase-out of most classes of ozone-depleting substances.

The Intergovernmental Panel on Climate Change (IPCC) in its Second Climate Change Assessment concluded that human influences on the earth's climate were already discernible, and that the climate is expected to continue to change in the future in response to human influences (IPCC 1995). IPCC further noted that "Climate change and a rise in sea level or changes in storms or storm patterns could result in the erosion of shores and associated habitat, increased salinity of estuaries and freshwater aquifers, altered tidal ranges in rivers and bays, changes in sediments and nutrient transport, a change in patterns of chemical and microbial contamination in coastal areas, and increased coastal flooding. Some coastal ecosystems are particularly at risk, including saltwater marshes, mangrove ecosystems, coastal wetlands, coral reefs, coral atolls, and river deltas. Changes in these ecosystems would have major negative effects on tourism, freshwater supplies, fisheries and biodiversity. Such impacts would add to the modifications in the functioning of coastal ocean and inland waters that already have resulted from pollution, physical modification and material inputs due to human activities."

### Summary

Through research and from the hard lessons of experience, it is now acknowledged that the ocean is not limitless. It cannot continue to absorb all the garbage, chemical spills, and other wastes from human activities, nor can it maintain its productivity in the face of ever increasing harvests of its marine life. It no longer is acceptable to act from the assumption that all is well until proven otherwise, or until the ocean itself offers proof in declining catches, diminished productivity, or lingering contamination. The primary threats to marine biodiversity are fisheries operations, chemical pollution and eutrophication, physical alteration of marine habitats, and invasions of exotic species. Looming on the horizon is the threat of human-caused climate change and its potential to aggravate existing problems.

## THE U.S. STRATEGY FOR ACHIEVING SUSTAINABLE LIVING MARINE RESOURCES

The past decade has seen two fundamental changes in the processes for making decisions about living marine resources: first, adoption of the precautionary, risk averse approach, and second, the new inclusiveness and openness of resource management decision making. In addition to these underlying process changes, the information base has been increased, new technologies have been applied, and a new way of looking at marine wildlife has been adopted—as ecosystems as opposed to single species.

Using these approaches, the U.S. government, in partnership with public and private stakeholders, is taking action to address the threats to living marine resources and to ensure the productivity and promise of these resources for future generations. In particular, the United States is investing in improved science; taking action to eliminate overfishing; promoting environmentally sustainable approaches to marine aquaculture; ensuring the health of protected marine species; and improving planning and management in coastal and marine environments.

In some cases, living marine resources are well on the way to recovery. In other cases, the policy framework has been set and new policy is just beginning to be implemented. In all cases, the themes of improved science, the precautionary approach, expanded partnerships, and application of ecosystem principles will be applied to better management of the nation's living marine resources.

**Science in the Interest of Stewardship**

Effective stewardship of ocean living resources requires investment in science to better understand the components and processes of marine biodiversity. Only through a much better understanding of marine biodiversity and ecological relationships will it be possible to manage fisheries and marine aquaculture sustainably, reap the biotechnology benefits of marine genetic resources, and conserve these critical resources for future generations.

The United States is committed to improving the knowledge base necessary to conserve and manage the world's marine living resources. In these efforts, the U.S. system of private and public universities, and state and federally funded research institutions and laboratories, play a crucial role through worldwide scientific collaborations. In addition, the National Oceanic and Atmospheric Administration and other federal agencies work in cooperation with state agencies, the environmental community, Native American tribes, Pacific Islanders, international entities, non-governmental organizations, the fishing industry, and others in the private sector, to ensure access to the most recent and comprehensive data available.

Much, however, remains to be done. Most marine biological communities still need to be characterized, and there are still vast numbers of undescribed species of invertebrates and bacteria. This represents more than idle scientific curiosity, since economic opportunities in marine biotechnology will depend on this knowledge. Moreover, as information on multi-species relationships, ecosystem interactions, and environmental influences become more available, management approaches can move toward more explicit considerations of the impact of human activities on all components of the ecosystem. (See Box 2)

In every aspect of the strategic vision of U.S. marine resource management agencies, the acquisition of sound biological, economic, and social information is highlighted as the first step to focused policy decision making. Such information is crucial to pursuit of a precautionary approach to management that focuses decisions rather than allowing scientific uncertainty to fuel controversy and confusion. This information is required not just for current management decisions, but also to conserve resources and anticipate future trends, assure future use opportunities, and assess the success of management efforts.

**Box 2: Research Priorities**

The National Research Council (NRC 1995) has identified five fundamental research objectives to better understand marine living resources. These objectives are:

- to understand the patterns, processes, and consequences of changing marine biodiversity by focusing on critical environmental issues and their threshold effects;
- to improve the linkages between the marine ecological and oceanographic sciences;
- to strengthen and expand the field of marine taxonomy;
- to facilitate and encourage the incorporation of (1) new technological advances in sampling and sensing instrumentation, experimental techniques, and molecular genetic techniques; (2) predictive models for hypothesis development, testing, and extrapolations; and (3) historical perspectives in investigations of the patterns, processes and consequences of marine biodiversity; and
- to use the new understanding of the patterns, processes and consequences of marine biodiversity derived from regional-scale research to improve predictions of the impacts of human activities on the marine environment.

## A Precautionary Approach to Building Sustainable Fisheries

The United States has realigned its core marine fishery programs to address more effectively the domestic and global crisis confronting living ocean resources. To restore sustainability in this sector, the United States is dedicated to a long-term program of recovery for overfished fisheries in its own 200-mile Exclusive Economic Zone. It is also working with foreign governments, international organizations, and regional fishery management bodies to move toward the same goal in all other waters.

The new strategic direction in U.S. fisheries management is based upon the Sustainable Fisheries Act of 1996 (also known as the Magnuson-Stevens Fishery Conservation and Management Act). While not explicitly stated in the Act, the precautionary approach concept shapes the core of mandated actions to reverse the decline of U.S. fisheries and move toward rebuilding them.

Toward these ends, Congress has provided directives and discretionary means to:

1. Establish guidelines to assist in the description and identification of "essential fish habitat" and impacts on that habitat, and to take steps to ensure that programs further the conservation and enhancement of that habitat

2. To the extent practicable, avoid bycatch, and to the extent that such bycatch cannot be avoided, minimize the mortality of such bycatch

3. Place stricter conditions on the use of new fishing gear

4. Apply measures that will eliminate overfishing in domestic waters and identify management actions to rebuild those fisheries within ten years (except in cases where the biology of the fish, other environmental conditions, or specific international agreements dictate otherwise)

5. Study and, if appropriate, implement a fishing capacity reduction program

The Sustainable Fisheries Act includes U.S. commitments to apply domestically many of the same principles that have been negotiated internationally in the U.N. Straddling Stocks Agreement and the Code of Responsible Fishing. The Act now requires the optimum yield for each fishery to be set equal to or less than the maximum sustainable yield. Overfishing is now defined in the law, and managers have explicit time frames and milestones for identifying overfished fisheries and getting them on the road to recovery. The Act also directs that recommendations be developed to expand the application of ecosystem principles in fishery conservation and management activities.

The Sustainable Fisheries Act has set the stage for turning the product of a failed fisheries management system into healthy, productive, and sustainable fisheries in the very near future. The fundamental changes in the approach to management have begun, and some successes have already been witnessed.

**Box 3: International Sustainable Fisheries Initiatives**

For centuries, customary international law and practice have been *mare liberum*, freedom of the sea. It was customary that anyone possessing the wherewithal to ply the seas and cast nets was free to fish. Further, it was assumed that anyone wishing to impose any restrictions on fishing (or other activity) on the seas bore the burden of proof to show that the activity was harmful before any limitations were necessary. Moreover, the only persons permitted access to the arenas where decisions about marine wildlife were made were government officials and user groups. Over time, these two presumptions have shifted, most recently and most thoroughly in an international agreement about ocean fishing.

The United States has been a leader in promoting international agreements and initiatives that shift the focus from increasing catches at all costs to sustainable fishing, ecosystem protection, conservation of biodiversity, and the precautionary approach to fishery management. These agreements include:

- The 1982 U.N. Convention on the Law of the Sea contains a comprehensive menu of dispute settlement procedures. Universal acceptance of the Convention (including accession to the Convention by the United States) would provide additional tools to deal promptly and constructively with disputes involving fisheries management.

- The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks has been heralded as a "sea change" in international fisheries law (Freestone 1997). The UN Agreement on Straddling Stocks has been held up as a measure against which effective fishery management regimes should be measured. In addition to its precautionary provisions, the Agreement calls for collection and use of best available scientific information, and directs signing nations to conduct their fishery business in open, accessible "transparent" forums where interested parties can observe and participate.

**(continued)**

**Box 3 (continued)**

- The 1994 Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas requires flag states to strictly regulate the activities of their high seas fishing vessels.

- The 1995 UN FAO Code of Conduct for Responsible Fisheries, is a nonbinding document that details the full range of principles that undergird sustainable (responsible) fisheries management. Subsequently, NMFS produced a plan in 1997 to implement these principles in domestic fisheries.

- The United Nations adopted a global moratorium on the use of large-scale pelagic driftnets on the high seas which took effect in 1992. The United States has played a lead role in the detection, apprehension, and prosecution of fishing vessels violating the UN moratorium on large-scale pelagic driftnets.

- The United States is participating more actively in various regional management bodies, particularly those dealing with North Atlantic and North Pacific issues, and is a strong supporter of a recently initiated effort to launch a new management organization for the tuna fisheries of the Western Pacific.

- The United States is also promoting international efforts to reduce fishery impacts on dolphins, sea turtles, sharks, and seabirds.

- Finally, the United States is supporting initiatives designed to enhance conservation and improve the sustainability of fisheries through a number of international organizations and agreements, including FAO, the UN Commission for Sustainable Development, the World Trade Organization, the Organization for Economic Cooperation and Development, Asia Pacific Economic Cooperation, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and the Convention on Biological Diversity.[7]

[7]Note: The United States has signed but not yet ratified the Convention on Biological Diversity

The depletion of the world's fish stocks and the impact of fisheries activities on biodiversity and fishery ecosystems are a global problem and have attracted international attention in recent years. In partnership with other nations, the United States has embarked on a series of initiatives designed to improve the management of fisheries that are not restricted to one coastal nation's Exclusive Economic Zone and explore ways of dealing more effectively with the effects of environmentally harmful practices and economic incentives in the fisheries sector. (See Box 3)

**Developing Robust and Environmentally Sound Marine Aquaculture**

World population is expected to increase by one billion people during the next decade. This, coupled with the increasing affluence of the world's people, means that future demand for seafood is projected to continue growing for the foreseeable future. Despite this increase in demand, future seafood harvests from the wild are not expected to increase significantly above the current levels.

A major junction in world history is fast approaching—one where humans for the first time will need to move from increased harvesting of wild fish stocks to aquaculture (the production of farmed crops of fishes, shellfishes and other aquatic plants and animals). This shift will be the next in a series of historical food production revolutions that have allowed humankind to continue feeding itself despite shrinking farmland and growing population worldwide.

Aquaculture already accounts for 25 percent of world food fish supplies, with China, India, Taiwan, and Thailand among the leaders in this field. Given current population projections, aquaculture production would have to double to 52 million metric tons by 2025 in order to maintain the present level of per-capita fish consumption. The potential for growth in this industry is obvious. The United States currently produces only about $800 million of the $33 billion annual value worldwide of aquaculture products, or less than 3 percent of the total. Aquaculture in marine and brackish water holds particular promise for increased growth.

Legitimate concern about the negative environmental effects of some aquaculture operations has hindered industry growth in the United States. Addressing these concerns and developing new environment-friendly technologies will allow the industry to expand. Two examples of new technologies that address water quality issues associated with aquaculture are: (1) the development of ways to move aquaculture to the open ocean where the water has a greater nutrient carrying capacity, and (2) using onshore recirculating systems. These technologies can be a model for other nations to use to reduce the negative environmental impacts of aquaculture. Additionally, uniform observance of an international code of conduct, such as the aquaculture provisions of the FAO Code of Conduct for Responsible Fisheries, will help to minimize future negative impacts on the environment.

Whether aquaculture is done in ponds or tanks on land, or in the ocean, it always depends on the availability of clean water and a source of broodstock (frequently from wild stocks). Many aquaculture operations also depend on wild-caught fish for feed. At the same time, aquaculture can contribute to the restoration of fisheries through stock enhancement and by reducing pressure on wild-stock harvest. This interaction between aquaculture and fisheries suggests that a holistic fisheries management approach to the marine environment should include both components.

The goal of U.S. ocean programs should be to maximize the benefits from the nation's ocean resources that are received by U.S. citizens. This goal includes sustainable fisheries in the context of a healthy coastal and ocean environment. Marine aquaculture can begin to fulfill its potential to help achieve these goals through a dynamic effort by the federal government in cooperation with other state and local governments and the private sector to promote and refine it.

### Enhancing the Protection and Recovery of Marine Species by Working in Partnerships

Protected marine species in the United States include marine mammals and species listed under the Endangered Species Act. Many of the direct threats to protected marine species arise from human activities such as fishing, shipping, coastal and watershed development, water pollution, seismic exploration, and offshore mineral development. Reducing conflicts between these species and human activities in the marine environment is the key to their conservation and recovery. In addition, some marine mammals may cause harm to other protected marine species, such as salmon, or interfere with fishing or aquaculture operations. All these conflicts require more "people management" than "wildlife management." Years of regulatory approaches have not been completely successful in reducing human-caused mortality and injury to protected species. A number of federal programs and policies now recognize the value of involving local stakeholders in decision making and implementation of management actions. Natural resource managers have begun employing new stakeholder models to gather information, assess problems, and find the technology or ingenuity to solve them.

Under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973, the National Marine Fisheries Service has been working with fishermen to identify means to reduce interactions with marine mammals during fishing operations, restore habitats for endangered salmon in the Pacific Northwest and California, develop conservation plans to restore coho salmon, and reduce the entanglement of albatrosses in longline fishing gear in the North Pacific. Similar efforts to engage user groups in helping to solve protected species problems is one strategy for recovering protected species and incorporates the new goal of openness or transparency in marine resource decision making.

In addition, the United States is working to:

- Assess the status of, and impacts to, protected species. Information is needed to identify and focus management actions, limit the scope of restrictions, and promote the recovery of all protected species.

- Develop and implement conservation and recovery plans for depleted marine mammals and endangered and threatened species. This is being done in partnership with states and the private sector.

As knowledge about the interconnectedness of living systems increases, the importance of acting with foresight and preventive measures when conserving protected marine species likewise increases. Waiting for a species to reach the brink of extinction before taking action is counterproductive. By applying ecosystem approaches, conserving remaining critical habitats, and restoring degraded habitats, the opportunity exists to conserve for future generations both individual species and the web of life on which they depend.

The United States is also working internationally to conserve marine species. The International Whaling Commission, through its ban on commercial whaling, has been instrumental in promoting the recovery of many large whale species from the brink of extinction. The Convention on International Trade in Endangered Species of Wild Fauna and Flora actively supports nations' efforts to manage species sustainably and reduce the negative impacts of international trade in species and products of species. Increasingly, the Convention has devoted attention to marine species protection. The United States has also been a leading force in the development of numerous other treaties and agreements. For example, it played a key role in the recently concluded negotiation of the Inter-American Convention for the Protection and Conservation of Sea Turtles,[8] the first international agreement devoted solely to the protection of sea turtles. The Convention establishes national sea turtle conservation programs in the signatory countries. These programs will include prohibiting intentional take (except for subsistence take as allowed under the convention), prohibiting domestic or international sale of turtle parts or products, conserving and restoring marine habitat and nesting beaches, and promoting efforts to enhance sea turtle populations. All Parties will establish a monitoring and observation program to verify that these measures are being applied.

### Sustaining Healthy Coasts by Focusing on Whole Ecosystems

Clearly, efforts to rebuild and sustain fisheries and recover and protect endangered species are important. But they rely to a large degree on traditional wildlife management approaches that concentrate on one species at a time. Single species management is limited in its effectiveness, especially as pressures on the marine environment intensify. Each individual species has a habitat which it needs to live and reproduce, and depends on a community of other species for food and survival. This community of species--their dynamic interactions with each other and the physical environment, and their overlapping mosaic of habitats--together constitute an ecosystem. Increasingly, the United States and the world community are recognizing the critical importance of conserving whole habitats and communities, both for the recovery of individual species, and for the ecosystem functions that they provide. Internationally, the

---

[8] Note: The United States has not yet ratified the newly completed Inter-American Convention for the Protection and Conservation of Sea Turtles.

Convention on Biological Diversity exemplifies this approach, as does the FAO Code of Conduct for Responsible Fisheries.

The importance of habitat conservation has always has been a part of the Marine Mammal Protection Act and the Endangered Species Act, and it has gained increased emphasis in fisheries with passage of the Sustainable Fisheries Act in 1996. The Sustainable Fisheries Act has provided significant new tools to protect and conserve the habitat of marine, estuarine, and anadromous fish and shellfish resources. By October 1998, all Fishery Management Plans must be amended to identify and describe "essential fish habitat"—defined as those waters and substrate necessary to fishes for spawning, breeding, feeding, or growth to maturity—for each federally managed species. The Act also includes new provisions to ensure the conservation and management of essential fish habitats once these areas are designated. Fishery Management Plans must include measures to minimize to the extent practicable adverse fishing and non-fishing related effects on essential fish habitats. In addition, federal agencies that authorize, fund, or undertake actions that may adversely affect these habitats must consult with the National Marine Fisheries Service to evaluate the effects of their actions on the habitat and the associated life stages of the fisheries involved. These new policies represent an important application of the precautionary approach to fisheries and environmental management.

Just as the sources, types, and routes by which land-based pollution affect species and ecosystems are complex, so are the mitigating measures. The human side of the equation is an equally complex, dynamic web of interrelationships among human institutions, societal and economic demands for products and services, and natural resources. Society's demands from a coastal area can exceed the area's capacity to meet the combined demands simultaneously. For that reason it can be difficult to maintain an area's long-term environmental integrity, which is critical to marine biodiversity. The management system that attempts to achieve this balance must be flexible and adaptable, and must be capable of responding to dynamic changes over time.

As a process for decision making, integrated marine and coastal area management aims to prevent, control, or mitigate adverse impacts of human activities on the coastal environment. It involves all stakeholders, including decision makers in public and private sectors, resource managers, non-governmental organizations, land users, and the general public. A central feature is the use of economic incentives. These are often more effective at changing human behavior, and can be more politically feasible. They also can be more effective in terms of results and cheaper to manage and enforce than the use of restrictive regulations.

Marine protected areas, as part of a larger integrated area management scheme, provide one of the most effective mechanisms for conserving marine living resources and the habitats on which they depend. Marine protected areas can:

- be a valuable management tool to protect areas that are repositories for marine biodiversity;

- protect unique and/or ecologically significant resources;
- provide a living "laboratory" against which to test the effectiveness of management measures;
- enrich and form a critical link among nations' food supplies;
- attract revenue-generating tourism activities; and
- provide potential future benefits from marine biotechnology development.

Marine protected areas provide one key tool for the protection, conservation, and restoration of coastal and marine habitats (and their biodiversity) in which multiple uses and demands can be balanced.

The United States has been a leader in establishing areas within its maritime jurisdiction designed to protect and conserve the biological resources of its marine and coastal regions. The National Marine Sanctuary Program was established under legislation because "this Nation historically has recognized the importance of protecting special areas of its public domain" (Marine Protection, Research, and Sanctuaries Act of 1972). Under this legislation, the Sanctuary Program identifies, designates, and manages areas of national significance with respect to conservation, research, recreational, ecological, historical, educational, or aesthetic qualities. The program administers 12 sites nationally, with two more in development. The primary goal of the National Marine Sanctuaries is to protect biodiversity, biological productivity, cultural resources, and areas of pristine condition. In addition, a number of national parks, seashores, and monuments throughout U.S. coastal regions are administered by the National Park Service, and even more areas are managed by the states. In the Caribbean region, the United States has worked toward the adoption of the Specially Protected Areas of Wildlife Protocol,[9] which promotes the concept of protected areas within the region. The concepts applied by the U.S. Man and the Biosphere in the Biosphere Reserve Program offer an ideal setting for coordination, cooperation, and interdisciplinary research in fostering harmonious relationships between humans and the biosphere.

The 1987 amendments to the Clean Water Act have also served to enhance marine species protection efforts through the establishment of the National Estuary Program. Unlike traditional regulatory approaches, the National Estuary Program focuses on protecting not just water quality or individual species, but whole ecosystems. It also engages local communities in protecting estuaries and the species that inhabit them, and requires stakeholders to create a comprehensive conservation and management plan for long-term protection of these resources. Currently, 28 National Estuary Programs are working to safeguard the health of some of the nation's most important coastal waters. A second program, the National Estuarine Research

[9] The United States has not yet ratified the SPAW Protocol.

Reserve System, provides for the cooperative management, with states, of estuarine areas representing various regions and estuarine types in the United States.

The United States has also begun to address the threat of exotic invasive species in the marine environment, through interagency and international initiatives. The Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 established an interagency Aquatic Nuisance Species Task Force. This effort has begun to document the extent of the problem, develop management approaches and provide public outreach. Ballast water discharge from ships appears to be the major vector of aquatic invasions. Internationally, the United States has joined with other nations in promoting measures to control the spread of non-indigenous organisms through the regulation of ships' ballast water through International Maritime Organization (IMO), a specialized agency of the United Nations that addresses issues involving international shipping matters.

Integrated marine and coastal area management will also play a critical role in U.S. adaptation to global climate change. While the essential step to protect marine living resources—and the first responsibility of nations—is to reduce greenhouse gas emissions that are generated by humans and contribute to global warming, some level of adaptation to a changing climate will be necessary. Integrated planning efforts will help to protect the huge economic investments in coastal zones, while beginning to take into account the interactions with critical marine ecosystems.

## CONCLUSIONS AND OPTIONS FOR CONSIDERATION

Ocean living resources, the ecosystems they form, and the ecological processes they mediate, provide immense benefits to the United States and to all of human society. Increasingly, however, these resources and their benefits are threatened by human activities. Fishing, waste disposal and runoff, coastal development, and invasions of exotic species have led to worldwide declines in marine species and the integrity of marine ecosystems, particularly coastal ecosystems. Global climate change caused by human activity has the potential to further exacerbate this situation.

The United States is committed to addressing these threats in order to ensure the long-term sustainability of living marine resources and the benefits they represent. Evidence already shows that U.S. management and conservation practices are paying dividends in healthier resources. Continued improvement will require enhanced domestic action and international cooperation to:

- Expand understanding of marine genetic resources, species, ecosystems, and their functions and processes

- Address the direct and indirect impacts of fishing operations and introduce ecosystem approaches to management to ensure sustainability of the resources

- Develop environmentally sustainable marine aquaculture to meet growing demands for food

- Provide enhanced protection for species and habitats at risk

- Implement integrated marine and coastal area management to protect coastal and nearshore marine living resources

- Address the problems of the introduction and spread of non-indigenous invasive species

Against the backdrop of recent reform of the underlying fishery management law in the United States and increased national and international awareness of the value and threats to ocean resources, managers are charting the future and planning strategies for sustaining marine biodiversity. The critical elements at the heart of this new strategic vision are improvements in science; use of the precautionary approach in fisheries and environmental management; developing cooperative partnerships with users of marine resources and other stakeholders; and exploiting the full potential of ecosystem-based management. Human knowledge and approaches to life beneath the sea have come far in the past 20 years, and international observance of the Year of the Ocean provides an excellent focal point for a renewed commitment to better management in the next 20 years.

## REFERENCES

Allsopp, W., 1997. World Aquaculture Review: Performance and Perspectives. Pages 153-166 *in* E.L. Pikitch, D.D. Huppert, and M.P. Sissenwine, editors. Global trends: fisheries management. American Fisheries Society Symposium 20, Bethesda, Maryland.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Niell, R.V., Paruelo, J., Raskin, R.G., Sutton, P., and van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387: 253-260.

CCAMLR 1997. Report of the 16$^{th}$ Annual Meeting of the Commission and Scientific Committee for the Conservation of Antarctic Marine Living Resources.

Cohen, A. and Carlton, J. 1998. Accelerating invasion rate in a highly invaded estuary. Science 279:555-558.

FAO, 1993. Fisheries Series No.40 Fisheries Statistics Series No. 111. Food and Agriculture Organization (United Nations).

FAO 1996. State of the World Fishery and Aquaculture. FAO Fisheries Circular. Food and Agriculture Organization (United Nations).

FAO 1997. FAO Marine Resources Service, Fishery Resources Division. 1997. Review of the state of world fishery resources: marine fisheries. FAO Fisheries Circular. No. 920. Rome, FAO. 173 pp.

Freestone, D.. 1997. "International Fisheries Law: Who is Leading Whom?" The Magnuson Stevens Act: Sustainable Fisheries for the 21st Century? Tulane Law School Symposium, Sept. 7-9, New Orleans, LA

Garcia, S.M. and Newton, C. 1995. Current Situation, trends and prospects in world capture fisheries. FAO Conference on Fisheries Management and Global Trends. Rome, FAO.

IPCC, 1995. Climate Change 1995: IPCC Second Assessment Report. Intergovernmental Panel on Climate Change.

Jameson, S.C., McManus J.W., and Spaulding, M.D. 1995. State of the Reefs: Regional and Global Perspectives. NOAA Publication.

Jones, J.B. 1992. Environmental impact of trawling on the seabed: a review. *N.Z. J. Mar. Fresh. Res.* 26:59-67.

Matlock, G.C. (in press). Management history - management future. Paper presented at: The Magnuson-Stevens Act: Sustainable Fisheries for the 21st Century. September 1997. Tulane Law School, New Orleans, LA.

The Mellman Group. 1997. U.S. Poll – Majority of Americans Say that Oceans Should be Priority over Space Exploration. Report for SeaWeb Marine Conservation Initiative, a project of the Pew Charitable Trusts, December 1997.

NMFS. 1996. Our Living Oceans: Report on the Status of the U.S. Living Marine Resources, 1995. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-19, 160 pp.

NMFS. 1997. Report to Congress on the Status of Fisheries in the United States, September 1997.

NOAA 1998 (on-line). "The extent and condition of U.S. coral reefs" by S.L. Miller and M.P. Crosby. NOAA's State of the Coast Report. Silver Spring, MD: National Oceanic and Atmospheric Administration. URL: http://state_of_coast.noaa.gov

Norse, E., Ed. 1993. Global Marine Biological Diversity: A Strategy for Building Conservation into Decision Making. Island Press, Washington, D.C., 384 pp.

NRC. 1995. *Understanding Marine Biodiversity: A Research Agenda for the Nation.* National Academy Press; Washington D.C. 114 pp.

Reaka-Kudla, M.L. 1997. The global biodiversity of coral reefs: A comparison with rain forests. In: Reaka-Kudla, M.L, D.E. Wilson, and E.O. Wilson (eds.) Biodiversity II: Understanding and Protecting our Biological Resources. Washington, D.C., John Henry Press. 551 pp.

Spurgeon, P.G. 1992. The economic valuation of coral reefs. Marine Pollution Bulletin, 24:11, pp. 529- 536. Also, Our Living Oceans: The Economic Valuation of U.S. Fisheries. 1996. NOAA Technical Memorandum.

UNEP/CBD. 1995. The Jakarta Mandate on Marine and Coastal Biological Diversity; Decisions of the Second meeting of the Conference of the Parties to the Convention on Biological Diversity. Jakarta, Indonesia, 6-17 November 1995. United Nations Environment Programme.

UNEP. 1995. Global Biodiversity Assessment. United Nations Environment Programme. Cambridge University Press, Cambridge, U.K. 1140 pp.

USDA/NRCS 1995. National Resources Inventory Summary. U.S. Department of Agriculture.

## DOMESTIC LEGAL REGIME

### Contents



The legal regime covering this topic is based on a collection of important federal statutory authorities. The following is a brief description of some of those authorities relating to ocean living resources. The list is selective and is designed to illustrate some major ocean living resources acts. The list is not meant to be comprehensive.

**Anadromous Fish Conservation Act**, 16 U.S.C. §§ 757a-757g

The Anadromous Fish Conservation Act provides authority to enter into cooperative agreements to conserve, develop and enhance anadromous fish resources, including conducting research and investigations, stream clearances, constructing and maintaining devices to assist with feeding, spawning and migration. The Act authorizes the Secretary of the Interior to enter into cooperative agreements with one or more States for the purpose of conserving, developing and enhancing anadromous fish resources and the fish in the Great Lakes and Lake Champlain that ascend streams to spawn.

**Antarctic Conservation Act of 1978**, 16 U.S.C. §§ 2401-2412

The purpose of the Antarctic Conservation Act of 1978 is to provide for the conservation and protection of the fauna and flora of Antarctica, and of the ecosystem upon which such fauna and flora depend, consistent with the Antarctic Treaty, signed in Washington on December 1, 1959, and the Protocol on Environmental Protection to the Antarctic Treaty, signed October 4, 1991, in Madrid.

**Antarctic Marine Living Resources Convention Act of 1984**, 16 U.S.C. §§ 2431-2444

The Act provides the domestic legislative authority necessary to implement the Convention on the Conservation of Antarctic Marine Living Resources. In order to fulfill its purpose, the Act prohibits activities that harass, molest, harm, wound, or kill finfish, mollusks, crustaceans, birds, or any other species of living organism found south of the Antarctic Convergence. The transportation, sale, importation, exportation, custody, or possession of any of these species by a person who knew or reasonably should have known that the species were taken in violation of the Convention is also illegal. The Secretary of Commerce is responsible for promulgating regulations to implement this Act and for enforcing its statutory prohibitions. Both civil and criminal penalties, as well as seizure and forfeiture remedies, are available under this statute.

**Atlantic Coastal Fisheries Cooperative Management Act**, 16 U.S.C. § 5101

The purpose of the Atlantic Coastal Fisheries Cooperative Management Act is to support and encourage the development, implementation, and enforcement of effective interstate conservation and management of Atlantic coastal fishery resources. The Secretary of Commerce, in cooperation with the Secretary of the Interior, is responsible for developing and implementing a program to support the interstate fishery management efforts of the Atlantic States Marine Fisheries Commission. The Atlantic States Marine Fisheries Commission is responsible for preparing and adopting a coastal fishery management plan to provide for the conservation of coastal fishery resources. States are required to implement and enforce the plan. If the Secretary of Commerce finds that a state has failed to carry out its responsibilities, the Secretary must declare a moratorium on fishing in the fishery in question within the waters of the noncomplying state.

**Atlantic Tunas Convention Act of 1975**, 16 U.S.C. §§ 971-971i

The Atlantic Tunas Convention Act of 1975 implements the International Convention for the Conservation of Atlantic Tunas, signed at Rio de Janeiro May 14, 1966. The Act authorizes not more than three Commissioners to serve as U.S. delegates to the International Commission for the Conservation of Atlantic Tunas. The Secretary of State is authorized to act on behalf of the United States with respect to Commission activities, with the concurrence of the Secretary of Commerce and the Secretary of the department in which the Coast Guard is operating, when appropriate. The Secretary of Commerce is authorized to administer and enforce the Convention, and to promulgate necessary and appropriate regulations. The Secretary of the department in which the Coast Guard is operating is primarily responsible for enforcement activities at sea. The Act also provides for enforcement of the Act and its implementing regulations.

**Atlantic Salmon Convention Act of 1982**, 16 U.S.C. §§ 3601-3608

The Atlantic Salmon Convention Act of 1982 implements the Convention for the Conservation of Salmon in the North Atlantic Ocean, signed at Reykjavik, Iceland, on March 2, 1982. The United States is represented on the Council established by the Convention by three United States Commissioners. The Secretary of State may receive and act upon communications of the North Atlantic Salmon Conservation Organization. The Secretary of Commerce, in cooperation with the Secretary of the Interior and the Secretary of the department in which the Coast Guard is operating, promulgates regulations necessary to carry out the purposes and objectives of the Convention and the Act and prepares statements, reports and notifications required by the Convention. The Act provides for enforcement of the Act and its implementing regulations.

**Atlantic Striped Bass Conservation Act**, 16 U.S.C. § 1851 note

The Atlantic Striped Bass Conservation Act is intended "to support and encourage the development, implementation, and enforcement of effective interstate action regarding the conservation and management of the Atlantic striped bass." Each year, the Atlantic States Marine Fisheries Commission determines whether coastal states are in compliance with the Interstate Fisheries Management Plan for Striped Bass. If a coastal state is not in compliance with the Plan, the Secretary of Commerce and the Secretary of the Interior must declare a moratorium on fishing for Atlantic striped bass within the coastal waters of that coastal state.

**Central, Western, and South Pacific Fisheries Development Act,** 16 U.S.C. §§ 758e-758e-5

The Central, Western, and South Pacific Fisheries Development Act authorizes the Secretary of Commerce to carry out a program for the development of the tuna and other latent fisheries resources of the Central, Western, and South Pacific Ocean.

**Control of "Crown of Thorns" Seastar**, 16 U.S.C. §§ 1211-1213

The Secretary of Commerce and the Secretary of the Smithsonian Institution are authorized to cooperate with and provide assistance to the governments of the State of Hawaii, the territories and possessions of the United States, the Trust Territory of the Pacific Island, and the other island possessions of the United States, in the study and control of the seastar "Crown of Thorns" (*Acanthaster planci*).

**Control or Elimination of Jellyfish or Sea Nettles**, 16 U.S.C. §§ 1201-1205

The Secretary of Commerce is authorized to cooperate with, and provide assistance to, the states in controlling and eliminating jellyfish and other pests and in conducting research for the purposes of controlling floating seaweed. The Congress also consents to any compact or agreement between any two or more states for the purpose of carrying out a program of research, study, investigation and control of jellyfish and other such pests in the coastal waters of the United States.

**Driftnet Impact Monitoring, Assessment and Control Act**, 16 U.S.C. § 1826

The Secretary of Commerce, through the Secretary of State and the Secretary of the department in which the Coast Guard is operating, is required to seek to secure international agreements to implement an international ban on large scale driftnet fishing. The Secretary of Commerce, after consultation with the Secretary of State and the Secretary of the department in which the Coast Guard is operating, must submit to the Congress an annual report describing the steps taken to carry out the Act. If the Secretary identifies any nations that conduct, or authorize their nationals to conduct, large-scale driftnet fishing beyond the exclusive economic zone, the Secretary must certify that fact to the President. Such certification is deemed to be a certification for the purposes of section 8(a) of the Fishermen's Protective Act of 1967.

**Eastern Pacific Tuna Licensing Act of 1984**, 16 U.S.C. §§ 972-972h

The Eastern Pacific Tuna Licensing Act of 1984 implements the Eastern Pacific Ocean Tuna Fishing Agreement, signed in San Jose, Costa Rica, on March 15, 1983. The Secretary of State is authorized to act on behalf of the United States and appoint a United States representative to the representative body. The Secretary of Commerce, in cooperation with the Secretary of State and the

Secretary of the department in which the Coast Guard is operating, promulgates necessary regulations. The Act provides for enforcement of the Act and its implementing regulations.

**Endangered Species Act of 1973 (ESA)**, 16 U.S.C. §§ 1531-1543

The ESA protects species of plants and animals listed as threatened or endangered. The Secretary of the Interior and the Secretary of Commerce determine, through regulations, whether any species are endangered or threatened. The Secretaries also are required to designate critical habitat and develop and implement recovery plans for threatened and endangered species. Federal agencies must insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of critical habitat.

The ESA prohibits the taking of any member of an endangered species. “Take” is defined broadly and includes harassment, harm, pursuit, hunting, shooting, wounding, killing, trapping, capturing, or collecting, or attempting to engage in any of this type of conduct. The requirements of the ESA are enforceable.

**Fur Seal Act Amendments of 1983**, 16 U.S.C. §§ 1151-1175

The Fur Seal Act Amendments prohibit the taking of fur seals in the North Pacific Ocean, except as provided by the Act. Indians, Aleuts and Eskimos who dwell on the North Pacific Ocean may take fur seals for subsistence purposes. The Secretary of Commerce is responsible for regulating the taking of fur seals. The Amendments authorize a North Pacific Fur Seal Commission.

The Fur Seal Act Amendments also authorize the Secretary to administer the fur seal rookeries and other federal real and personal property on the Pribilof Islands.

**Fish and Wildlife Act** of 1956 and associated provisions, 16 U.S.C. §§ 742a-742d, 742e-742j, 742k, 744-748, 750-753, 753a-753b, 754, 758-758d, 760a-760g.

The Fish and Wildlife Act of 1956 authorizes the National Marine Fisheries Service to conduct investigations and prepare and disseminate information and reports regarding fish and their habitats in order to provide for the proposed development of fish resources.

**Fish and Wildlife Coordination Act**, 16 U.S.C. §§ 661-666c

The Fish and Wildlife Coordination Act requires that wildlife conservation receive equal consideration with other features of water-resource development. The Act requires that Federal permitting and licensing agencies consult with the National Marine Fisheries Service, Fish and

Wildlife Service before issuing a permit for activities that modify any body of water. The National Marine Fisheries Service provides comments and recommendations to prevent loss of, and damage to, fish populations and their habitats.

**<u>Indian Treaty Rights to Hunt and Fish</u>**

Certain Indian tribes in the Puget Sound and Columbia River basins of the Pacific Northwest and on the Great Lakes have federally recognized and protected treaty guaranteed rights to take fish including shellfish and, in the case of the Treaty with the Makah, 12 Stat. 939 (Jan 31, 1855) also to take whales and seals. These rights are protected and enforced under the Supremacy Clause of the United States Constitution. The federal government also protects these rights pursuant to its trust responsibility towards the affected tribes. These rights, which were reserved in treaties entered into by the United States with various Indian tribes in the mid-1800's have been the subject of numerous court decisions, including seven decisions by the United States Supreme Court.

The treaties in the Pacific Northwest, commonly known as the Steven Treaties after the principal federal negotiator at the time, Territorial Governor Isaac Stevens, generally contain a provision similar to the following Article 3 of the Medicine Creek Treaty, 10 Stat. 1132 (December 26, 1854):

> The right of taking fish, at all usual and accustomed grounds and stations, is further secured to said Indians in common with all citizens of the Territory, ***: *Provided however,* that they shall not take shellfish from any bed staked or cultivated by citizens,***.

The courts have interpreted these treaties rather broadly, recognizing that they reserved unto the tribes several important legal rights, including: (1) a right of access to all usual and accustomed fishing places; (2) a right to a fair share of the fishery, which has been interpreted to mean 50 percent of the harvestable resource within each tribe's usual and accustomed area; and (3) a right to harvest each tribe's fair share free from state and federal regulations except those non-discriminatory laws necessary for conservation. Moreover, although the focal point of litigation to date has been on anadromous fish such as salmon, the courts and federal regulatory agencies have recently applied these principles to shellfish and other fish species. The interrelationship of these treaty rights with international treaties and other domestic federal laws concerning ocean living resources often raises complex legal issues.

**<u>Lacey Act Amendments of 1981</u>**, 16 U.S.C. §§ 3371-3378

The Lacey Act prohibits domestic and international trafficking in protected fish, wildlife, and plants. It does so in two ways. First, it requires that most shipments of fish and wildlife moving in interstate or foreign commerce be accurately marked and labeled as to their contents. Second, the Lacey Act makes it unlawful to import, export, transport, sell, receive, acquire, or purchase fish, wildlife, and certain indigenous plants taken, possessed, transported, or sold in violation of state, federal, Indian tribal, or foreign laws or regulations that relate or refer to fish or wildlife or plants. Violators are subject to both criminal and civil sanctions. The prohibitions apply broadly to all wild animals, whether dead or alive, and to any part, product, egg, or offspring, including captive-bred animals, and more narrowly to certain wild plants indigenous to the U.S.

**Magnuson-Stevens Fishery Conservation and Management Act**, 16 U.S.C. §§ 1801-1883

Under the Fishery Conservation and Management Act (FCMA), the United States claimed sovereign rights and exclusive fishery management authority over all fish, and all Continental Shelf fishery resources, within the exclusive economic zone. The FCMA established a procedure for authorizing foreign fishing, and prohibited unauthorized foreign fishing within the exclusive economic zone.

The FCMA established national standards for fishery conservation and management within the exclusive economic zone. The FCMA established eight Regional Fishery Management Councils composed of state officials with fishery management responsibility, the regional administrators of the National Marine Fisheries Service, and individuals appointed by the Secretary of Commerce who are knowledgeable regarding the conservation and management, or the commercial or recreational harvest, of the fishery resources of the geographical area concerned. The Councils are responsible for preparing and amending fishery management plans for each fishery under their authority that requires conservation and management.

Fishery management plans describe the fisheries and contain necessary and appropriate conservation and management measures, applicable to foreign fishing and fishing by vessels of the United States. The plans are submitted to the Secretary of Commerce for approval. If approved, the Secretary of Commerce promulgates implementing regulations. The Secretary of Commerce may prepare Secretarial fishery management plans if the appropriate Council fails to develop such a plan. The FCMA also provides for enforcement of the Act.

In 1996, the Sustainable Fisheries Act amended the FCMA and renamed it the Magnuson-Stevens Fishery Conservation and Management Act.

**Marine Mammal Protection Act of 1972 (MMPA)**, 16 U.S.C. §§ 1361-1407

Under the MMPA, the Secretary of Commerce is responsible for ensuring the protection of cetaceans and pinnipeds (except walruses). The Secretary of the Interior is responsible for ensuring the protection of sea otters, polar bears, walruses and manatees. The MMPA established a moratorium on the taking and importation of marine mammals and marine mammal products, except: 1) for purposes of scientific research, public display, photography for educational or commercial purposes, or enhancing the survival or recovery of a species or stock, or for importation of polar bear taken in sports hunts in Canada; 2) when taken incidentally in the course of commercial fishing operations; 3) to deter a marine mammal from damaging fishing gear or catch, damaging private property, endangering personal safety, or damaging pubic property; 4) when taken incidentally by citizens engaged in a specified activity (other than commercial fishing) within a specified geographical region; 5) when the Secretary has waived the moratorium; or 6) if the marine mammal was taken by an Indian, Aleut, or Eskimo for subsistence purposes or for purposes of creating and selling authentic native articles of handicrafts and clothing. The MMPA provides for enforcement of the Act and its implementing regulations.

The Secretaries are directed to initiate negotiations with foreign governments to protect and conserve marine mammals. The Secretaries may transfer management authority for a species of marine mammal to a state. The MMPA also established the Marine Mammal Commission composed of three members appointed by the President.

**Migratory Bird Treaty Act**, 16 U.S.C. §§ 703-715s

It is unlawful "to pursue, hunt, take, capture, kill . . . any migratory bird, any part, nest or egg" or any product of any such bird protected by the Migratory Bird Convention, except as permitted by regulations. The Secretary of the Interior is charged with determining when, to what extent, and how to permit these activities.

**The National Aquaculture Act of 1980,** 16 U.S.C. §§ 2801-2810

The purpose of the National Aquaculture Act of 1980 is to promote aquaculture in the United States. The Secretaries of Agriculture, Commerce, and the Interior are required to establish and periodically amend a National Aquaculture Development Plan. The Secretaries are required to submit a biennial report to Congress that contains a description and evaluation of the actions undertaken with respect to the Plan. The Secretaries are to provide information and assistance on aquaculture activities.

**The National Fishing Enhancement Act of 1984** (Artificial Reefs), 16 U.S.C. § 1220, 33 U.S.C. §§ 2101 et seq.

States may apply to the Secretary of Transportation for obsolete ships which would be designated for scrapping if the state intends to sink such ships for use as an offshore artificial reef for the conservation of marine life.

**National Marine Sanctuaries Act (NMSA)**, 16 U.S.C. §§1431 et seq.

The NMSA provides the Secretary of Commerce with the authority to designate and manage nationally significant marine areas as national marine sanctuaries. The NMSA lists recreational and esthetic qualities as among the things that might give an area special national significance.

The NMSA's stated purposes and policies include comprehensive and coordinated conservation and management; enhancing public awareness, understanding, appreciation and wise use of the marine environment; and facilitating, to the extent compatible with the primary objective of resource protection, all public and private uses of resources not prohibited pursuant to other authorities.

Among the factors the Secretary must consider in determining whether an area merits designation as a national marine sanctuary are present and potential uses of the area that depend on maintenance of the area's resources, including commercial and recreational fishing, other commercial and recreational activities, and research and education; the public benefits to be derived from sanctuary status, with emphasis on the benefits of long-term protection of nationally significant resources, vital habitats, and resources which generate tourism.

**Northern Pacific Halibut Act of 1982**, 16 U.S.C. §§ 773-773k

The Northern Pacific Halibut Act of 1982 implements the Convention between the United States of America and Canada for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea. The Act authorizes the appointment of Commissioners to the International Pacific Halibut Commission, outlines the responsibilities of the Secretary of Commerce and North Pacific Fishery Management Council in regulating the Pacific halibut fishery, and provides for enforcement of the Act.

**Pacific Salmon Treaty Act of 1985**, 16 U.S.C. §§ 3631-3644

The Pacific Salmon Treaty Act of 1985 implements the Treaty between the Government of the United States of America and the Government of Canada Concerning Pacific Salmon, signed at Ottawa, January 28, 1985. It authorizes the appointment of four United States Commissioners to the Pacific Salmon Commission, members of the Northern Panel, Southern Panel and Fraser River Panel, and members of an advisory committee. The Secretary of Commerce promulgates regulations necessary to carry out the United States' international obligations under the Treaty. The Secretary of Commerce may preempt state or tribal law if necessary to fulfill the United States' obligations under the Treaty.

**South Pacific Tuna Act of 1988**, 16 U.S.C. §§ 973-973r

The South Pacific Tuna Act of 1988 implements the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America, signed in Port Moresby, Papua New Guinea, April 2, 1987. The Secretary of State is authorized to act on behalf of the United States in Treaty matters. The Secretary of Commerce, with the concurrence of the Secretary of the department in which the Coast Guard is operating, issues regulations necessary to carry out the objectives of the Treaty and the Act. Operators of vessels may request licenses to fish in the Licensing Area. The Secretary may order fishing vessels to leave the Licensing Area upon making certain findings. Vessels must stow gear while in closed areas and must allow and assist observers. The Act provides for enforcement of the Act and its implementing regulations.

**Sponge Act**, 16 U.S.C. §§ 781-785

The Sponge Act regulates the landing, curing and sale of sponges taken from the Gulf of Mexico and Straits of Florida.

**Tuna Conventions Act of 1950**, 16 U.S.C. §§ 951-991

The Tuna Conventions Act of 1950 authorizes the appointment of not more than four Commissioners to the International Commission for the Scientific Investigation of Tuna and the Inter-American Tropical Tuna Commission. The Secretary of State is authorized to act on behalf of the United States with respect to Commission activities, and the Secretary of Commerce is authorized to promulgate necessary regulations. The Act also provides for enforcement of the Act and its implementing regulations.

**Whaling Convention Act of 1949**, 16 U.S.C. §§ 916 - 916l

The Whaling Convention Act of 1949 implements the International Convention for the Regulation of Whaling, signed at Washington on December 2, 1946. The President appoints the United States Commissioner to the International Whaling Commission. The Secretary of Commerce is authorized to administer and enforce the Act. The Act prohibits persons subject to the jurisdiction of the United States to engage in whaling, or shipping, transporting, purchasing, selling, offering for sale, importing, exporting, or possessing whales in violation of the Convention or implementing regulations. The Act provides for enforcement of the Act.

## LIST OF ACRONYMS

| | |
|---|---|
| FAO | Food and Agriculture Organization (United Nations) |
| ESA | Endangered Species Act |
| IPCC | Intergovernmental Panel on Climate Change |
| MMPA | Marine Mammal Protection Act |
| NMFS | National Marine Fisheries Service |
| NMSP | National Marine Sanctuary Program |
| UN | United Nations |
| UNEP | United Nations Environment Programme |

# 1998 Year of the Ocean

## OCEAN ENERGY AND MINERALS: RESOURCES FOR THE FUTURE

Contents

## EXECUTIVE SUMMARY

A resolution adopted by the members of the United Nations proclaims 1998 as the International Year of the Ocean. The objective of this resolution is to focus the attention of the general public, governments, and decision makers on the importance of the ocean and marine environments as resources for sustainable development. In keeping with this focus, the Ocean Principals Group, an *ad hoc* group of federal government agencies with ocean research and management responsibilities, established three primary goals:

1. Promote public awareness and understanding of the value of the ocean, its resources, and marine activities to the national welfare;

2. Ensure that government does all it can and should to promote the exploration, sustainable use, and conservation of the ocean; and

3. Cherish the national heritage associated with the ocean.

The purpose of this paper is to highlight the importance of domestic ocean energy and mineral[1] resources to the national economy and welfare. For example, although technological advances continue to enhance cost-effective recovery of ocean oil and gas resources, long-term development should be considered within a national energy policy that balances concern for the environment with energy security for present and future generations. Many resource development issues remain to be discussed among all stakeholders—federal, state, and local governments, industry, and the general public. Among these issues are Outer Continental Shelf leasing moratoria, royalty relief, revenue sharing with and impact assistance to coastal states, marine mineral mining, and environmental protection. It is important that stakeholders be actively involved in the process so that these important ocean resources are developed in a reliable, safe, and environmentally sound manner.

During this Year of the Ocean, it is important to evaluate the role of ocean energy and mineral resources to the United States and its citizens. To maintain a reliable and cost-effective supply of oil, natural gas, and other minerals from the ocean, the United States must move from conflict to consensus among all stakeholders. This paper presents issues and ideas for discussion at Year of the Ocean symposia and is intended to serve as a catalyst for important policy decisions that need to be made to ensure a sound energy future and economical and environmentally safe recovery of energy and non-energy mineral resources from the seafloor.

[1]The term "mineral" as used in this paper refers to hard minerals found on and in the seabed; examples are sand, gravel, and shell resources; metals such as manganese, gold, titanium, and polymetallic deposits; sulfide deposits; and phosphates.

## INTRODUCTION

The United States has sovereign rights over the exploration and development of non-living resources, including oil and gas, found in the seabed and subsoil of the continental shelf, which is defined to extend to 200 nautical miles from its coast or, where the continental margin extends beyond that limit, to the outer edge of the geological continental margin. This claim, made under the Truman Declaration of 1945, is confirmed in the 1982 Convention on the Law of the Sea. Currently, about 27 percent of the natural gas and 18 percent of the oil produced in the United States is from the federally managed Outer Continental Shelf (OCS).

The development of the OCS is projected to increase substantially over the next few years. Oil production in the Gulf of Mexico is expected to reach a level of 1.9 million barrels per day by the year 2000, with natural gas production at between 12 and 17.2 billion cubic feet of gas per day. Meanwhile, the federal government collects an average of $3 to 4 billion annually in bonuses, rents, and royalties from oil and gas-producing companies for OCS oil and gas leases. These funds are distributed to the general treasury, the Land and Water Conservation Fund and the National Heritage Fund. These conventional hydrocarbon resources will continue to be an important source of energy, revenue, and employment for the United States well into the next century.

The offshore oil and gas industry, in operation since 1947, has made significant progress in establishing a strong human and environmental safety record. Approximately 85,000 Americans are employed directly in the offshore oil and gas industry, with an equal number employed in supporting jobs. Technological advancements have substantially reduced hazardous working conditions and environmental impacts over what they were a few decades ago. Additionally, new technologies have enabled industry to identify and develop new reserves, both in shallow and deep water. In 1995, Congress passed the Deepwater Royalty Relief Act, which provided new economic incentives to industry to develop deep water areas in the Gulf of Mexico. The Act has contributed to a significant increase in the number of tracts leased and aggregate bonuses received, and it has spurred a surge in employment in the OCS oil and gas industry and supporting services.

The U.S. offshore energy resources are now being produced in water as deep as 5,376 feet using subsea systems. By the turn of the century, this production capability will extend to even greater water depths. However, development of these deep water resources presents new challenges, both technologically and environmentally. These include working under harsh conditions, geohazards, and dealing with irregular ocean bottom relief features. Moreover, deep water resource development places increased demands on coastal ports and communities for facilities and services.

In terms of potential alternative energy resources from the ocean, the vast deposits of methane hydrates found in deeper oceanic areas offer the greatest hope for future economical recovery and production. While technology exists for harnessing renewable and non-hydrocarbon energy sources such as tidal and wave power or thermal stratification, these energy sources are not now economically viable. However, they may become sources of energy in the future as technology advances, conventional hydrocarbons become depleted, and concerns for global climate change continue.

The ocean seafloor contains vast deposits of sand and gravel, phosphorites, and other minerals that are useful—both for public works and commercially. In recent years, severe coastal storms have caused rapid erosion of beaches and barrier islands. Maintaining beaches for tourism is an economic necessity for many coastal communities. Nearshore and offshore sand deposits are becoming important sources for beach renourishment by eastern seaboard coastal communities, and such resources are also being considered for barrier island restoration. Around the world, sand and gravel (marine aggregate) find extensive use in construction and account for the largest tonnage of minerals produced from the ocean. Industry is looking more and more to the ocean for these critical building materials as land supplies of sand and gravel are depleted. Marine aggregate is also used for capping contaminated sediments in estuaries, harbors, and waste dumps. As demand for these resources increases, policies and procedures must be developed to ensure their timely availability in a manner consistent with sound environmental practices.

Marine mining of strategic minerals such as manganese, gold, titanium, and other metals has not been economically viable in the United States. However, mineral extraction in marine areas is expected to begin long before land deposits become exhausted because of issues surrounding land-use priorities, clean-water requirements, and environmental considerations. Technology to extract these minerals economically is being developed, and policies for ocean mining will need to be considered.

## Federal Authorities

The appendix to this paper provides an extensive overview of the federal laws and authorities for ocean energy and mineral resources. A more cursory presentation will be provided here. “”It should be noted at the outset that the term “Outer Continental Shelf” (OCS) is a legal delineation created by federal statute and is not the same as the continental shelf that is defined in the 1958 Geneva Convention on the Continental Shelf. Legally, the OCS comprises that part of the continental margin adjacent to the United States that remained subject to federal jurisdiction and control after enactment of the Submerged Lands Act of 1953.

## Submerged Lands Act, 1953

The Submerged Lands Act established state jurisdiction over offshore lands within 3 miles of shore (or 3 marine leagues for Texas and the Gulf coast of Florida). The Act also reaffirmed the federal claim to the OCS, which consists of those submerged lands seaward of state jurisdiction, and limited states’ claims to inside the landward boundary of the OCS.

### Outer Continental Shelf Lands Act, 1953

The Outer Continental Shelf Lands Act established federal jurisdiction over submerged lands on the OCS and gave the Secretary of the Interior responsibility for administering energy and non-energy mineral exploration and development on the OCS. Additionally, it gave the federal government a mandate to develop OCS resources, explicitly stating that there was "an urgent need for further exploration and development of the oil and gas deposits of the submerged lands of the Outer Continental Shelf." It authorized the Secretary to lease the federal OCS for mineral exploration, development, and production and provided for limited state involvement.

### Outer Continental Shelf Lands Act Amendments of 1978

The Outer Continental Shelf Lands Act amendments of 1978 included many new provisions such as consultation with coastal states and other interested parties, environmental assessment, studies programs, planning, remedies and penalties, and a process for developing leasing schedules in 5-year increments. While they include requirements for coordination and consultation with state and local governments concerning OCS activities, the amendments retained the Secretary of the Interior's broad discretion in managing OCS resources. The national purposes and policies set forth in the 1978 amendments recognize the dual goals of environmental protection and expedited exploration and development.

### Presidential Proclamation Creating the Exclusive Economic Zone

On March 10, 1983, U.S. President Ronald Reagan signed Proclamation 5030, which established the U.S. Exclusive Economic Zone. This consists of those areas adjoining the territorial sea of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and U.S. overseas territories and possessions. The U.S. Exclusive Economic Zone extends up to 370 km from the U.S. coastline. About 15 percent of this area lies on the geologic continental shelf and is shallower than 200 meters.

### Outer Continental Shelf Lands Act Amendments of 1985

The 1985 OCS Lands Act amendments resolved a dispute over how the federal government shares nearshore revenues with affected states, as required in section 8(g) of the OCS Lands Act. The amendments mandated that 27 percent of all revenues from production within 3 miles seaward of the federal-state boundary be given to the states. They also set a schedule for distribution on revenues placed in escrow pending settlement of any jurisdictional disputes between the federal and state governments.

### Outer Continental Shelf Lands Act Amendments of 1994

The 1994 OCS Lands Act amendments authorized the Secretary of the Interior to negotiate agreements (rather than conduct a competitive lease sale) for sand, gravel, and shell resources for use in projects undertaken by federal, state, or local governments for shore protection and beach or coastal wetlands restoration, or for use in other types of construction projects that are wholly or partly funded, or authorized, by the federal government.

Access to OCS hard minerals for purposes other than those specified in the amendments continues to be addressed through the competitive bidding process by granting a lease to the highest bidder for the extraction and use of any mineral.

### Federal Agency Responsibilities

The Secretary of the Interior designated the Minerals Management Service (MMS) as the regulatory agency for managing mineral resources on the OCS. One of MMS's goals is to ensure safe, environmentally sound operations during the production of oil, gas, and minerals from the OCS. This agency accomplishes that goal through a strong regulatory program while supporting research in offshore safety, oil-spill containment and cleanup, structural integrity, and blowout prevention. The continuation of these responsibilities plays a key role in protecting the ocean and ensuring safe, environmentally sound oil and gas development from the OCS.

## ENERGY RESOURCES

### History of Ocean Oil and Gas Development

This year marks the 51st anniversary of offshore oil and gas production. In November 1947, a discovery was made off the Louisiana coast, 12 miles from shore in water 16 feet deep. This represented the first successful commercial development to be made out of sight of land. It was also the first offshore well drilled from a mobile platform, thus initiating the technology that has subsequently been used to drill more than 20,000 offshore oil and gas wells in the submerged lands off the coasts of the United States. Previously, nearshore development was an extension of onshore fields and technology. The earliest nearshore production in the United States was off Summerland, California, in 1896, and was part of an onshore field. These early nearshore wells were drilled from wooden piers extending out from the shoreline. The next milestone occurred in the Gulf of Mexico in 1938 when a discovery in the Creole field, 1.5 miles from shore in 26 feet of water, marked the petroleum industry's first successful venture into open, unprotected waters.

The need for production capability in deeper water depths further offshore has pushed the industry to develop new and better equipment and techniques. Conventional steel-jacketed production platforms stand in as much as 1,198 feet of water off the coast of southern California and in 1,350 feet off the Louisiana coast. In 1984, the drillship Discover Seven Seas drilled an exploratory well in 6,952 feet of water off the coast of New Jersey. In the often ice-bound waters of the Arctic, drilling units have evolved from single use artificial gravel islands to specially designed multi-use caisson-retained islands and ice-resistant mobile units of more conventional design. Historically, the 1,000 feet water depth barrier for installation of production platforms was broken in the Gulf of Mexico in 1976; recently, an exploration well in the Gulf has been drilled in 7,600 feet of water.

Since the enactment of the OCS Lands Act in 1953, outer continental shelf oil and gas production has increased greatly and contributes significantly to the total U.S. domestic production. In 1996, this production reached 18 percent of total domestic oil production and 27 percent of gas production. Between 1953 and 1995, the outer continental shelf has generated more than $110 billion in federal revenues. These contributions may be expected to continue to increase since the OCS is estimated to contain about 19 percent of the nation's proven gas reserves, 15 percent of the proven oil reserves, and more than 50 percent of the nation's remaining undiscovered oil and gas resources.

### Value to the Nation

The federal OCS oil and gas program has provided significant benefits to the United States by helping to address its energy needs, contributing to its economic well-being, and by providing an important source of revenues for the U.S. Treasury. It is estimated that more than half of the nation's undiscovered oil and gas lies on the outer continental shelf; thus, offshore energy resources may play an even more important role in meeting U.S. energy needs in the future. Currently, the United States imports about one-half of the petroleum necessary to meet its energy needs, and the Department of Energy projects this level will reach 61 percent by 2015.

The success of deep water exploration and development in the Gulf of Mexico, largely due to advances in 3-dimensional seismic and production technology, is reversing the long-term decline in domestic oil production. By the end of 1996, there were 26 rigs drilling in water depths greater than 1,000 feet, which compares with 9 such rigs in 1990. Oil production from the Gulf of Mexico increased by 10 percent in 1995, and most of the U.S. oil and gas reserve additions from new field discoveries (79 percent and 70 percent, respectively), and from new reservoir discoveries in old fields (91 percent and 68 percent), were in the Gulf.

The oil and gas industry employs tens of thousands of American workers. The average salary and benefits for workers of producing companies employed as a direct result of activity in the Gulf of Mexico was estimated to be $52,580 in 1992. Since then, a shortage of skilled labor due to the recent boom in industry activity has pushed earnings even higher. In addition to payroll expenditures, producers pay several billion dollars each year to vendors and contractors who support OCS activities. Expenditures by producing companies on employees, equipment, and support services in turn result in additional spending in communities near outer continental activities and throughout the nation. To cite some specific examples, Shell's Auger project involved contractors in 30 states, and work on the Rowan No. 4 jack-up drilling rig involved contractors in 43 states.

Bonus bids, rents, royalties, and other revenues paid to the federal government for the rights to explore for and produce OCS energy resources average between $3-4 billion annually. Total revenues (unadjusted for inflation) are well above $110 billion since passage of the OCS

Lands Act in 1953. Of the OCS revenues collected each year, up to $900 million is deposited in the Land and Water Conservation Fund (for state and federal projects); $150 million goes to the national Historic Preservation Fund; roughly $500-600 million is distributed to coastal states (in accordance with section 8(g) of the OCS Lands Act; and the remainder goes to the U.S. Treasury. Additional revenue is generated from taxes on industry profits and wages.

## The Human and Environmental Safety Record

There are significant risks associated with oil and gas development. With respect to possible risks to humans, some major safety concerns are blowouts, explosions, fires, and vessel and helicopter accidents. Exploration, development, and production of oil and gas also may impact the marine, coastal, and human environments in several ways:

- physical disruption of the seafloor habitat and benthic communities;
- discharge of chemicals, drilling muds and cuttings, and produced waters;
- hydrocarbon air 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;
- socioeconomic impacts on coastal communities and ports—of special concern in Alaska are potential impacts on native Alaskan subsistence culture; and
- accidental oil spills.

Routine permitted activities are carefully monitored to minimize the risk of significant effects on the environment. Spills generally are viewed as much more threatening to the environment due to the immediate damage and disruption a large release can cause to ecological resources and to coastal livelihoods and activities that depend on those resources. The number of significant spills from oil production in state and federal waters has been low and the volume of oil spilled has, in general, continuously decreased over the years. There has not been a spill larger than 1,000 barrels from an OCS platform or rig since 1980. In fact, since 1980, OCS operators have produced some 5.5 billion barrels of oil of which only 61,500 barrels (or 0.001 percent) has been spilled. Natural seeps introduce about 100 times more oil into U.S. marine waters than have spills from OCS oil and gas activities. Increased precautions by industry, enhanced safety technology (e.g., blowout preventors and shut-in valves), and adherence to strict governmental regulations have all contributed to minimizing the risk of oil spills from offshore activities.

The MMS diligently strives to diminish environmental and human risks through its regulatory program, which places stringent environmental and human protection requirements on all OCS operators.

## Environmental Safeguards

Through a broad range of environmental laws, the federal government has the responsibility—either on its own or in cooperation with states—to prevent or eliminate damage to the environment; to regulate pollution to restore and maintain the chemical, physical, and biological integrity of waterways; to protect and enhance air quality; and to protect and promote conservation of plants and animals listed as endangered or threatened.

With respect to development on the OCS, environmental impacts may vary in intensity due to such factors as different methods of transportation (pipeline or tanker) and distances from the shoreline. To address this and protect workers and the environment, the MMS tailors special stipulations as required into leases sold to companies developing the resources. Concerns raised by coastal states and communities, fishing groups, and other federal agencies are likewise addressed. Some concerns may require a study of the impact on local marine life. Studies may lead to requirements for special operating procedures covering such areas as training of personnel and the handling of waste discharges of mud and cuttings. Making existing regulations clearer is yet another approach used to safeguard the environment.

## Technological Improvements

Over the last half century, significant technological improvements in operational safety on the OCS have occurred. Today, for example, computer systems monitor platform operations. Advances in blowout preventors and increased safety inspections have allowed the search for oil and gas to continue into deeper water without compromising safety.

Nevertheless, major concerns about operational maintenance and oil-spill prevention and clean-up remain. Continuous inspections and replacement of platform components and safety equipment are helping to relieve these concerns and ensure efficient and safe operation. Updated training and oil-spill contingency plans now allow for quick response and effective cleanup of a spill if it occurs. Remote sensing technology is being used to monitor oil slick movements more accurately.

Another way human and environmental safety has improved for OCS operations is through the implementation of the MMS's Safety and Environmental Management Program (SEMP) and the U.S. Coast Guard's Prevention Through People program. The SEMP advocates a voluntary, but systematic approach, to safety management by every company operating on the OCS and uses the American Petroleum Institute's Recommended Practice 75 as the operating standard. This program supplements the traditional, compliance-based regulations of the MMS and further enhances its ability to prevent accidents that cause human injury and illness or environmental damage. Through SEMP, the MMS is working collaboratively with the offshore industry to refocus efforts on company safety and environment performance in addition to regulatory compliance. The Prevention Through People program initiated by the U.S. Coast Guard is intended to help elevate worker awareness of human involvement in accidents and to reduce the human error factor. This program differs from SEMP because it deals with vessels that are not stationary or fixed. Through these two programs, the federal government can better identify problem areas and heighten safety for both workers and the environment.

## New Frontiers for Conventional Hydrocarbons

Exploration and development have been moving to remote areas such as deep water provinces, Arctic areas, and isolated natural gas fields, where there has been limited drilling. Interest in OCS deep water areas has increased in recent years, especially in water depths greater than 800 meters, because of better technology, new discoveries in deep water, and the passage of the Deep Water Royalty Relief Act.

While the Arctic presents unique engineering and environmental challenges, there is potential for significant new discoveries on the North Slope of Alaska and in the Beaufort Sea. Proposed development of past discoveries has created an optimistic outlook for the future. Meanwhile, it must not be forgotten that oil and gas are being produced from the OCS offshore southern California. And although there is a current halt on leasing off the Pacific coast, the area holds vast reserves of oil and gas that may prove important to the nation in the future.

## New Technologies for Finding and Recovering Oil and Gas

Three-dimensional seismic acquisition, modeling, and interpretation have greatly increased the efficiency of oil and gas exploration. As a result, fewer wildcat wells are being drilled, and more of them are discoveries. The renewed interest in deep water areas is being credited to better technology including three-dimensional seismic and horizontal drilling. For example, computers are now used to process geological and geophysical data and to create three-dimensional subsurface interpretations. This allows companies to identify reservoirs in progressively deeper water. Extended-reach or horizontal drilling has increased in the last 5 years due to higher production rates and greater recoveries from both new and existing wells. Horizontal drilling brings a larger portion of the reservoirs into contact with the wellbore, thereby increasing the flow rates. Besides the ability to increase recovery in borderline fields and protect environmentally sensitive areas, horizontal wells can provide geological information for sidelong distances up to 5,000 feet in a single formation. It is estimated that over the next 5 years, from one-third to two-thirds of all new wells will be horizontally drilled.

## Methane Hydrates: Unconventional Hydrocarbons

Within the last decade, research has shown that most continental margins are reservoirs for an unconventional energy deposit. Immense amounts of gas are concentrated in frozen, ice-like gas hydrates within the top several hundred meters of sediment in deep water on the continental margins of the United States, from the Gulf of Mexico to the Alaska arctic. The worldwide amount of methane in gas hydrate deposits is conservatively estimated to be the equivalent of at least $1 \times 10^4$ gigatons of carbon. This is about twice the amount of carbon held in all conventional fossil fuels on earth. Gas hydrates may prove to be the only hydrocarbon resource that could significantly affect the future world energy mix. The production history of the Russian Messoyakha gas hydrate field demonstrates that gas hydrates can be produced by conventional methods. Gas from hydrate deposits may become a major energy resource if economically profitable techniques are devised to extract the methane.

## Outlook for Development of Renewable Ocean Energy Resources

The time scale to renew fossil fuels by geochemical processes is long compared to the time in which the modern world can consume known fossil fuel reserves. Consequently, the world's supply of fossil fuels is non-renewable for all practical purposes, and many nations are looking seriously at other alternative energy sources to provide part of their expanding energy needs. Many of the alternative energy sources are derived directly or indirectly from the radiant energy of the sun. The heat content of the world's ocean and the mechanical energy manifested by the various ocean water motions (e.g., surface waves, tides, and mean currents) are among the renewable energy sources available to many countries. This section examines some of these oceanic alternative energy resources.

One way of using the abundant heat content of the surface ocean is to exploit the temperature difference between the warm surface layer of the ocean and the colder, deeper ocean lying below the penetration depth of sunlight. Engines operate between temperature differences by extracting heat from a higher temperature "reservoir" and ejecting "waste" heat into a lower temperature reservoir. The upper and lower layers of the ocean could function as the reservoirs for an engine that could, for example, power an electric generator. In this fashion, the heat of the surface ocean could be converted into a more usable form of energy (e.g., electricity).

The mechanical motions of the ocean such as surface waves and mean currents are indirect manifestations of solar energy and, like the heat content of the ocean, constitute a large source of energy potentially available for human use. This likewise applies to the gravitationally driven tidal motion of the sea. Engineers in many countries have developed various devices for generating electricity from these forms of mechanical energy. Specially designed turbines mounted in dams or on moorings can capture some of the energy manifested in elevated sea level or strong currents. Other mechanical devices move under the influence of surface waves and capture some of their energy. All of these modern devices are coupled with electric generators.

Coastal areas having large amplitude tides and narrow channels or embayments that can be dammed or support moorings with turbines are candidates for practical ocean energy conversion. Devices moored in persistent and strong ocean currents like the Gulf Stream could, in principle, also extract useful energy. Other coastal areas where the tidal energy may be small, but where high wave action is common, are candidates for wave energy conversion.

There are practical problems with mechanical energy converters. Not all coastal areas have the high tidal amplitudes or the frequency of high waves necessary to provide the needed amount of energy for conversion. Tides are periodic with quiescent periods one or two times per day, and high wave activity is not always present even in frequently windy areas. Energy storage thus becomes an important consideration for using some of these devices but also increases operating costs.

In addition, damming bays and straits significantly alters the circulation of water with possible adverse environmental consequences, and rapidly rotating turbines can kill fish, mammals, and freely floating marine invertebrates. Mooring turbines in open water rather than attaching them to dams, and placing streamlined protective housings around the turbine blades, greatly reduces these adverse environmental impacts. The consequent reduction in energy efficiency adds to their cost; nonetheless, many engineers still believe that these systems are commercially viable.

## MINERAL RESOURCES

A wide variety of mineral resources are found on the seafloor. These resources fall into four general categories:

- granular sediments
- placer minerals
- hydrothermal deposits
- hydrogenetic minerals

Granular sediments are transported to the sea by rivers and glaciers and are sorted according to size by wave action on the coastline. They include quartz-rich sand and gravel, carbonate-rich sand, shell, silt, and clay. Gold, diamonds, platinum, tin, and titanium are among the most common placer minerals, as well as concentrations of heavy minerals and ores such as titanium oxide. Hydrothermal minerals are associated with volcanic activity and include sulfide deposits rich in copper, zinc, lead, gold, and silver. Hydrogenetic deposits form by precipitation from seawater under various conditions and host minerals such as phosphorite, salt, barite, and iron-manganese nodules, and crusts rich in cobalt, platinum, nickel, copper, and rare earth elements.

Both coarse sand and gravel and finer sand are extremely abundant on most continental shelves, with the coarsest materials (gravels) occurring closest to the coast and finer grained materials dominating the outer shelves and slopes. The thickest sand and gravel deposits are those formed as a result of glacial action in the northern and southern thirds of the globe. Placer minerals are also found nearest to the coast, usually in association with present or former river systems. Marine hydrothermal minerals are found in the deep ocean volcanos on oceanic ridges and island arc systems. Hydrothermal deposits form in association with underwater vents of mineral-rich hot water called “smokers.”. Hydrothermal deposits also include phosphorite and barite accumulations on the continental shelves. The cobalt-rich manganese crusts found on the flanks of most of the 50,000-plus extinct volcanic seamounts in the Pacific Ocean are hydrogenetic deposits.

### Sand and Gravel

Sand and gravel, used primarily for construction aggregates, constitute the largest tonnage of any ocean mineral produced. These materials are essential resources for the expanding populations of coastal areas. Aggregates are used in nearly all residential and commercial construction and in most public works projects such as roads and streets, dams, airports, bridges, and tunnels. The exhaustion of existing reserves, zoning, government regulations, and competing land uses are increasingly restricting the production of construction aggregate from the land, and thus encouraging the use of offshore aggregate sources close to coastal population centers.

The greatest use in the United States of offshore sand and gravel is for beach renourishment and coastal restoration and protection. With increased development adjacent to or near the coastline, and the natural processes of landward migration over time, there has been a steady increase in the number and size of beach renourishment projects. Traditional approaches to prevent coastal erosion (e.g., jetties and groins) are no longer acceptable in many areas, having become too expensive, ineffective, or damaging to the environment. Beach renourishment, although expensive and short-lived in some cases, is now a widely accepted method of restoring an eroded coastline.

Recent changes in wetland regulation sometimes mandate the building of new wetlands to offset those that have been destroyed and much of the material to construct coastal wetlands will be supplied by offshore dredging. Marine sand may also be used for capping both recent and former offshore dump sites.

Portions of the OCS areas surrounding the United States, especially in the northeast, contain an abundant supply of sand and gravel, much of it near growing metropolitan areas where demand is greatest. The detailed distribution and characteristics of these resources is known in only a few areas. Resource characterization studies are needed to better understand the potential development of resources in specific localities.

Environmental and physical oceanographic studies are needed to better understand the possible impacts of dredging to ocean and seafloor life and the coast. Costs are generally greater for mining offshore sand and gravel than for onshore deposits, but these costs may be offset by lower transportation costs for the delivered product and by a possible reduction in environmental impacts onshore. These advantages have prompted commercial interests to examine further the feasibility of developing marine sand and gravel resources.

### Current Uses of Offshore Sand and Gravel

Offshore sand and gravel use is an established industry in several countries, most notably Japan, the United Kingdom, Denmark, and the Netherlands. Japan obtains most of its construction aggregates from offshore deposits, and the offshore dredging industry in the United Kingdom is growing steadily. The technology developed and the experience gained by these countries in dealing with economic and environmental issues should prove useful for future development of U.S. offshore sand and gravel resources. Major technological developments in dredging, coming largely from the Netherlands and Japan, have occurred over the past 10 years. Innovations include high-capacity underwater pumps and multiple-booster pumps, which enable operation in deeper water and the pumping of sand as far as 7 miles from the dredge to the shoreline.

Although there are no commercial sand and gravel mining operations seaward of the 3-mile federal-state line, on the U.S. outer continental shelf, there have been a number of such operations in rivers, bays, and harbors over the years. One company currently produces construction aggregate from deepening and maintaining the Ambrose Channel across New York Bay, and the State of New York has prepared an Environmental Impact Statement addressing sand mining in other parts of the bay. The same company is seeking leases to dredge sand and gravel in federal waters off the northern New Jersey coast, an indication that economic conditions are favorable for a commercial operation in the New York-New Jersey area.

Sand from offshore deposits has been used for beach renourishment since 1922, when Coney Island Beach in New York City was rebuilt. Since then, hundreds of millions of cubic yards of marine sand have been placed on U.S. beaches. The offshore sand used for beach renourishment projects is generally from deposits within state waters but occasionally it comes from the federal OCS as far as 8 miles from the coast. Project sizes range from hundreds of thousands of cubic yards to 15-20 million cubic yards. To support publicly beneficial projects, a 1994 amendment to the OCS Lands Act (P.L. 103-426) authorized a negotiated agreement process in lieu of competitive bidding for governmental use of OCS sand, gravel, or shell. The amendment authorized fees to be assessed for use of these resources based on their value and the public interest served from their development. Each request to use OCS resources under a negotiated agreement is handled individually. To assist government agencies needing OCS resources, MMS developed procedures and guidelines to explain the National Environmental Policy Act and OCS Lands Act requirements, and the development of terms and conditions for removal of the resource. The MMS guidelines on assessing fees outlines the approach that will be used to determine appropriate fees that balance resource value with other public benefits for governmental shore protection and restoration projects.

To date, two coastal communities have obtained federal OCS sand through this new process, and several more negotiated agreements are in progress. Completed projects using federal sand include Duval County, Florida, where 1.2 million cubic yards of sand were placed on a 10-mile stretch of shoreline, and the U.S. Navy's Fleet Combat Training Center at Dam Neck, Virginia, where 900,000 cubic yards were placed on the beach to protect the facility. New projects are being planned with the City of Myrtle Beach, South Carolina, for Surfside Beach; the State of Louisiana for restoration of the Isles Dernieres and Timbalier Island (two of the most rapidly eroding sections of the nation's coast); the National Park Service for the northern end of the Assateague Island National Seashore in Maryland; and the City of Virginia Beach, Virginia, for Sandbridge Beach.

## Development of Other Minerals

While offshore development of other hard minerals currently is not a significant activity in U.S. waters, active offshore mining of minerals other than sand and gravel worldwide include diamond recovery off the southwestern coast of Africa, tin offshore of Indonesia, and titanium offshore of western Australia. Diamond mining offshore Africa began in 1961 and has become a major contributor to the diamond market. Several companies, including the diamond giant De

Beers, are operating offshore both Namibia and South Africa with very large dredges and at-sea processing plants. Diamonds are now dredged in water as deep as 180 meters and remotely operated bulldozers with large suction hoses connected to a processing ship have been tested for mining in even deeper water. A fleet of over 30 bucket-line dredges are currently working off Indonesia, processing over 40 million cubic meters a year of sediments to recover tin ore. Although no development of the metals-rich manganese nodule deposits has occurred to date, mining exploration licenses have been held since 1984 by several multinational companies in an area of the Pacific Ocean between Hawaii and Central America. There has also been recent interest by Japanese and Chinese firms in manganese nodules off the Cook Islands and other areas in the Pacific.

Mineral deposits in U.S. waters (other than sand and gravel) include massive phosphate beds beneath the continental shelf from North Carolina to northern Florida, titanium-rich heavy mineral sands off the East Coast from New Jersey to Florida, gold-bearing sand and gravel deposits offshore Alaska, barite deposits offshore southern California, manganese nodules on the Blake Plateau offshore South Carolina and Georgia, and the cobalt and platinum-rich crusts in the Hawaiian Exclusive Economic Zone area. Gold was recovered in state waters off Nome, Alaska, from 1986 to 1990 by the WestGold Corporation using the Bima, a converted Indonesian tin mining dredge. Despite the relatively rich deposits, the operation was closed mainly due to steadily declining gold prices.

## ISSUES ASSOCIATED WITH OCEAN ENERGY AND MINERAL RESOURCES DEVELOPMENT

### Energy Issues

*Public Perception*

From its beginning, the OCS program of the United States has faced controversy over the ownership and management of offshore oil and gas resources. Some of the controversy predates the inception of the federal program in 1954, as both the federal government and individual coastal states vied for jurisdiction over the nation's offshore area, with the former eventually gaining title to the great majority of the continental shelf. Additional controversy has arisen over the years as concerns about the program's environmental and socioeconomic impacts have increased. Some of this concern is attributable to a perceived imbalance in governmental and community benefits and costs occasioned by OCS development. In addition, the full range of benefits and costs—and those of alternatives, such as importing oil by supertanker—are not easily or readily identifiable.

The 1989 Exxon Valdez tanker oil spill that occurred in Prince William Sound, Alaska, profoundly affected the public's perception of the OCS program even though the spill was not caused by OCS oil and gas drilling. That event, which rekindled concerns first raised after the Santa Barbara OCS oil spill in 1969, received intense and lengthy media coverage. This heightened concern about the possibility of similar accidents and strengthened negative perceptions about offshore oil development. Despite arguments that development of domestic resources is necessary and beneficial, as well as reassurances about the environmental soundness of the OCS program, a large segment of the population remains unconvinced.

While there is some OCS production activity offshore California, the OCS program at this time is mainly concentrated in the Central and Western Gulf of Mexico, with limited leasing and exploration activity offshore Alaska. Although Louisiana has expressed some concern and reservation about shouldering the bulk of the nation's energy needs, offshore oil and gas are still viewed as important and integral parts of that region's economy, relatively few residents are opposed to it, and extensive infrastructure and technological progress has led to a recent boom in activity in the Gulf.

*Multiple Use Conflicts*

Oil and gas activities on the OCS occur along with many other activities in the ocean, including commercial and sports fishing, tourism and recreation, vessel traffic, military and NASA operations, and non-energy marine mineral extraction. There also are areas of special concern, such as parks and sanctuaries and, in Alaskan areas, subsistence hunting and fishing activities. In addition to the "competition" for space, there is concern from many ocean and coastal user groups that routine oil and gas activities such as seismic surveys, drilling, and discharge of effluent waters and cuttings, may have adverse effects on the coastal and marine habitats and biota.

*Moratoria*

In the 1980s, state and local governments, dissatisfied with OCS policies that gave primary authority to the federal Executive branch, turned to the U.S. Congress to check this authority. Congress responded by adding "moratoria" riders to annual appropriations legislation prohibiting the use of funds for OCS leasing and related activities in much of the outer continental shelf .

In 1990, following analysis and recommendations by an interdepartmental OCS Oil and Gas Leasing Task Force, President Bush announced a series of decisions intended to balance energy production and environmental protection and to allow the OCS program to continue in the less controversial areas. Areas offshore California, southern Florida, the North Atlantic states. Washington, and Oregon were withdrawn from leasing consideration until after 2000. However, Congress continued to enact moratoria for the areas withdrawn by Presidential Order and even expanded prohibitions to some areas and activities that had not previously been restricted. The Clinton Administration has supported a continuation of most moratoria while underlying conflicts are resolved through consultation and negotiation among affected parties.

*Coastal Impact Assistance*

In 1990, President Bush also directed the Secretary of the Interior to prepare a legislative initiative that would provide coastal communities directly affected by OCS development with a greater share of the financial benefits of new development and with a larger voice in decision making. In 1992, the Department of the Interior developed and submitted to the 102nd Congress a proposal for providing impact assistance to coastal states and communities located near OCS oil and gas activities. That proposal was adopted in a modified form by the Senate, but the energy legislation enacted by Congress in October 1992 excluded this and all other provisions relating to the OCS program.

Louisiana, along with some other coastal states and localities, continues to support legislation to provide federal revenues to mitigate onshore effects of OCS activities. The OCS Policy Committee, an advisory committee formed to advise the Secretary of the Interior on policy issues related to the OCS program, proposed an impact assistance plan in 1993. It renewed its support in 1997 and directed a working group to develop an implementation plan for such a proposal. In October 1997, the working group submitted to the full committee its report proposing a detailed program for providing a portion of OCS revenues to affected states and localities. The report was approved by the full OCS Policy Committee and forwarded to the Secretary of the Interior.

*National Energy Policy*

The National Energy Policy Plan, issued in 1995 and entitled *Sustainable Energy Strategy*, presents the Clinton Administration's energy policy. The concept of sustainable development guides the energy policy process and motivates three strategic goals:

1. maximize energy productivity to strengthen the economy and improve living standards;

2. prevent pollution to reduce the adverse environmental impacts associated with energy production, delivery, and use; and

3. keep America secure by reducing vulnerability to global energy market shocks.

The environmentally sound development of the nation's OCS resources will help further the achievement of each goal. As noted above, investments in and production of OCS oil and gas generate billions of dollars annually in bonuses, royalties, and taxes, and create thousands of well paying jobs throughout the U.S. economy. Offshore development under proper environmental safeguards poses less risk of large oil spills than does importing foreign oil in tankers. Expanded use of natural gas, including that produced on the OCS, has substantial environmental benefits over other fossil fuels. Production of oil and gas from the OCS directly reduces the amount of oil that must be imported from abroad, much of it from politically unstable regions, thereby lessening the threat to the U.S. economy posed by supply disruptions.

The development of OCS oil and gas resources is a part of the Administration's commitment to encourage the economically beneficial and environmentally sound expansion of diverse domestic energy resources. The National Energy Policy Plan promotes the production of oil and natural gas resources in deep water in the Gulf of Mexico as one of the nation's best opportunities for adding large new oil reserves, providing new energy supplies for the future, spurring the development of new technologies, and supporting thousands of jobs in the oil and gas and affiliated industries.

### Minerals Issues

Sand and gravel will continue to be the most sought after mineral commodities from the OCS. As previously mentioned, sand has been obtained from well beyond the 3-mile limit of state jurisdiction for beach renourishment, and demands for offshore sand and gravel will likely increase. Sand and gravel reserves on the OCS are immense, with estimates of over 2 trillion cubic meters on the Atlantic shelf alone. In spite of this large resource base, the higher costs and risks of marine dredges are impediments to offshore mining, and conflicts over access still occur. Because transportation cost is the largest factor in sand and gravel extraction and distribution, there could be competition for high quality deposits closest to the coast. Conflicts are also likely to arise with other ocean users, such as fishermen and clammers. However, the use of digital maps in geographic information systems promises to aid in managing both seafloor and water column utilization and minimize multiple-use conflicts.

## THE NEW PARADIGM: MOVING BEYOND CONFLICT TO CONSENSUS

OCS oil and gas development has been a contentious issue since its inception. Prior to the Submerged Lands Act of 1953, states and the federal government argued over who had authority over the seabed and its resources. After passage of the Act, states and other stakeholders believed that the federal government functioned too independently and was insensitive to state concerns when it came to holding offshore lease sales and approving oil and gas development and production activities off their coasts. Passage of the National Environmental Policy Act, the Coastal Zone Management Act, and the Outer Continental Shelf Lands Act Amendments gave states and other constituents a greater voice in offshore oil and gas development. However, the level of discord escalated in the mid-1970s, when concern over foreign oil embargoes and rapid rises in the price of gasoline and heating oil led the federal government to accelerate efforts to develop and produce offshore oil and gas.

Areawide leasing, leasing in frontier areas, as well as several large and highly publicized oil spills gave rise to the idea that human safety, environmental protection, and the socioeconomic well-being of coastal communities were being seriously jeopardized in favor of maximizing oil and gas production. States and others therefore turned to the political arena for relief in the form of Congressionally and Presidentially mandated moratoria. This situation continues today. In order to address public concerns, beginning in the late 1980s and expanding in the early 1990s, the federal government implemented a policy of involving the various stakeholders early in the planning stages, maintaining a meaningful dialogue, and assuring that non-federal concerns play an important and crucial role in the decision process. This new way of doing business and interacting with constituents has been characterized as "moving beyond conflict to consensus."

While disagreement and contention still exist today, involved parties are talking and interacting in a positive manner, and a general atmosphere of trust and respect is replacing the mistrust of only a few years ago. There is a need to build upon this new paradigm so that as the United States enters the 21st century, all parties will continue to work toward a national consensus on development of offshore oil and gas resources while being sensitive to regional and local issues and concerns. This also applies to the relatively new arena of using offshore sand and gravel resources for beach renourishment. As more and more coastal communities look to OCS sand for replenishing beaches and protecting property, and as the commercial sector becomes increasingly interested in OCS aggregate for building materials, it is likely that the issue will become highly contentious if the various stakeholders are not involved early in the decision process.

In October 1993, the OCS Policy Committee's Subcommittee on OCS Legislation offered the following specific recommendations for forwarding the new paradigm of moving beyond conflict to consensus:

1. Regional task forces representing all OCS program stakeholders should be established to focus more on reaching consensus on OCS leasing decisions in an effort to obviate the need for moratoria.

2. A prompt and suitable resolution should be attained for the leases that have been targeted for buyback and are subject to litigation. Generally, section 5 of the OCS Lands Act, as amended, should be the means for considering leases for cancellation and compensation, and section 5 is not in need of amendment at this time.

3. A portion of the revenues derived from OCS program activities should be shared with coastal states, Great Lakes states, and U.S. territories.

4. Economic and technical incentives should be thoroughly analyzed and considered for implementation by the Department of the Interior to encourage the U.S. oil and gas industry's continued participation in the OCS program.

Implementation of these recommendations may go a long way toward ensuring that the OCS program continues to be a reliable and significant contributor to the energy supply and economic well-being of the United States. Involvement of all stakeholders in the planning and decision processes are important to ensure that development and production activities are carried out in a manner consistent with the highest standards of human safety and environmental protection. This approach can also serve as a blueprint for establishing successful OCS mineral programs.

## REFERENCES


Minerals Management Service. *An Assessment of the Undiscovered Hydrocarbon Potential of the Nation's Outer Continental Shelf.* A Resource Evaluation Program Report; 1996. MMS 96-0034; 40 pp.

"Coastal Impact Assistance. A Report from the Coastal Impact Assistance Working Group to the Outer Continental Shelf Policy Committee." October, 1997; 23 pp.

"Environmental Studies in OCS Areas Under Moratoria: Findings & Recommendations. Report of the Subcommittee on Environmental Information for Select OCS Areas Under Moratoria." May, 1997; 82 pp.

"Moving Beyond Conflict to Consensus. Report of the OCS Policy Committee's Subcommittee on OCS Legislation." October, 1993; 71 pp.

*Sustainable Energy Strategy: Clean and Secure Energy for a Competitive Economy.* July, 1995; National Energy Policy Plan, Department of Energy,; ISBN 0-16-048183-X; 22 pp.

"U.S. Outer Continental Shelf Sand and Gravel Resources: Programs, Issues and Recommendations. Final Report of the OCS Policy Committee's Subcommittee on OCS Sand and Gravel Resources." April, 1993; 42 pp.

## DOMESTIC LEGAL REGIME

### Contents



The legal regime covering this topic is based on a collection of important federal statutory authorities. The following is a brief description of some of those authorities relating to ocean energy and mineral resources. The list is selective and is designed to illustrate some major ocean energy and mineral resources acts. The list is not meant to be comprehensive.

## I. OCEAN ENERGY AND MINERAL RESOURCES

The oceans contain significant energy and mineral resources that will become increasingly important as the availability of land-based sources diminishes. There are a number of domestic legal authorities governing ocean energy and mineral resources that involve responsibilities of different federal and state agencies. These domestic legal authorities often provide for a balancing of competing policy objectives. In particular, offshore development that addresses domestic energy and mineral needs must be balanced against the need to protect and conserve ocean and coastal resources and ecosystems. Domestic legal authorities also provide for consultation and coordination among stakeholders. However, the development of ocean energy resources has been controversial. Successful, sustainable development of ocean and mineral resources requires that we move from conflict to consensus among all stakeholders within the framework of a comprehensive management strategy.

## II. FEDERAL AUTHORITIES RELATING TO ENERGY RESOURCES

The United States claims one of the world's largest and richest continental shelves. The outer continental shelf (OCS) accounts for 15 percent of U.S. crude oil production and 25 percent of U.S. natural gas output. The United States collected \$3.0 billion in royalties and other revenues in 1994 (\$2.8 billion in 1995; \$4.3 billion in 1996 (preliminary)). Since 1954, the federal government has received more than \$110 billion from the leasing and production of OCS oil and gas. The OCS has served as a source of about 12 percent of domestic oil production and more than 20 percent of domestic gas production. The Secretary of the Interior has designated the Minerals Management Service (MMS) as the agency responsible for the mineral leasing of submerged OCS lands and for the supervision of offshore operations after lease issuance. The principal federal legal authorities for the development of ocean energy resources are the Outer Continental Shelf Lands Act and the Deep Water Royalty Relief Act.[2]

### **Outer Continental Shelf Lands Act (OCSLA)**, 43 U.S.C. § 1331 et seq

The Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. § 1331 et seq., established federal jurisdiction over submerged lands on the OCS seaward of state boundaries. Under the OCSLA, the Secretary is responsible for the administration of mineral exploration and development of the OCS. The OCSLA empowers the Secretary to grant leases to the highest qualified responsible bidder(s) on the basis of sealed competitive bids and to formulate such regulations as necessary to carry out the provisions of the OCSLA. The OCSLA provides guidelines for implementing an OCS oil and gas exploration and development program, and authorities for ensuring that such activities are safe and environmentally sound. The basic goals of the OCSLA include the following:

- to establish policies and procedures for managing the oil and natural gas resources of the OCS that are intended to result in expedited exploration and development of the OCS in order to achieve national economic and energy policy goals, assure national security, reduce dependence on foreign sources, and maintain a favorable balance of payments in world trade;

- to preserve, protect, and develop oil and natural gas resources of the OCS in a manner that is consistent with the need (a) to make such resources available to meet the nation's energy needs as rapidly as possible; (b) to balance orderly resource development with protection of the human, marine, and coastal environments; (c) to ensure the public a fair and equitable return on the resources of the OCS; and (d) to preserve and maintain free enterprise competition;

---

[2]The development of ocean energy and mineral resources is subject to a number of environmental laws in addition to the environmental protection requirements contained in the OCSLA. Other sections of the legal issue paper will address the legal regime to protect the environmental quality of the oceans. For example, see the Marine Environmental Quality section for a description of the Federal Water Pollution Control Act (also called the Clean Water Act)..

- to encourage development of new and improved technology for energy resource production, which will eliminate or minimize risk of damage to the human, marine, and coastal environments; and

- to provide opportunities for state and local government participation in policy and planning decisions made by the federal government relating to exploration for, and development and production of, minerals on the OCS.

**OCS Deep Water Royalty Relief Act** (Pub. L. 104-58)

The OCS Deep Water Royalty Relief Act (DWRRA), contained in Pub. L. 104-58, provides new incentives to lease and develop in certain Gulf of Mexico deep water areas. Specifically, the DWRRA amends the Secretary of the Interior's discretionary authority to grant royalty relief to include producing and non-producing leases in order to promote development, increase production, or encourage marginal production of certain deepwater leases in the Gulf of Mexico. The DWRRA also contains three other major provisions related to leases issued as a result of sales held before and after the date of the DWRRA's enactment. The following is a summary of these three other major provisions:

- Section 303 establishes a new bidding system that allows the Secretary to offer tracts with royalty suspensions for a period, volume, or value of production.

- Section 304 mandates that all tracts offered by November 22, 2000 in deep water in certain areas of the Gulf of Mexico must be offered under the new bidding system permitted by the DWRRA. The Secretary must offer such tracts with a specific minimum royalty suspension volume based on water depth.

- Existing (pre-Act) leases may apply for royalty suspensions for new production in deep water in certain areas of the Gulf of Mexico. This production does not qualify for royalty suspensions if the Secretary determines that the new production would be economic in the absence of royalty relief. Otherwise, the Secretary must determine the volume of production on which no royalty should be due in order to make the new production economically viable.

There has been a revitalization of oil and gas exploration and development in the Gulf of Mexico and, with the advent of new deep water drilling technologies, a dramatic intensification of interest in developing the frontier deep water areas. Oil production should increase as much as 70-100 percent by the year 2000, with exploration pushing beyond the exclusive economic zone and product pipeline networks extending well off the continental shelf and down the continental slope.

**Ocean Thermal Energy Conversion Act**,(42 U.S.C. § 9101 et seq.)

With regard to alternative energy sources from the ocean, the Ocean Thermal Energy Conversion Act (OTEC Act), 42 U.S.C. § 9101 et seq., established a licensing program for facilities and plantships that would convert thermal gradients in the ocean into electricity. The OTEC Act directed the Administrator of the National Oceanic and Atmospheric Administration (NOAA) to establish a stable legal regime to foster commercial development of OTEC. In addition, the OTEC Act directed the Secretary of the department in which the U.S. Coast Guard is operating to promote safety of life and property at sea for OTEC operations, prevent pollution of the marine environment, clean up any discharged pollutants, prevent or minimize any adverse impacts from construction and operation of OTEC plants, and ensure that the thermal plume of an OTEC plantship does no unreasonably impinge on and thus degrade the thermal gradient used by any other OTEC plantship or facility, or the territorial sea or area of national resource jurisdiction of any other nation unless the Secretary of State has approved such impingement after consultation with such nation. The OTEC Act also assigned responsibilities to the Secretary of State and the Secretary of Energy regarding OTEC plants.

There has been a low level of activity under the OTEC Act since its passage in 1980. Following NOAA's initial environmental studies and implementation of a licensing program, NOAA has not received any license applications for OTEC facilities or plantships. The availability and relatively low prices of fossil fuels, coupled with the risks to potential investors, has limited the interest in commercial development of OTEC projects. The need to protect the environmental quality of ocean resources and ecosystems may outweigh the benefits of constructing OTEC facilities in certain areas. Moreover, OTEC projects have offered an unclear return on a significant investment.

## III. FEDERAL AUTHORITIES RELATING TO MINERAL RESOURCES

The oceans contain valuable deposits of sand, gravel, and other minerals. Among other things, OCS sand deposits are important sources for beach renourishment for many coastal communities. As land supplies of sand and gravel become less available, industry is turning to the OCS as an alternate source of these important building materials. The OCS also contains deposits of strategic minerals such as gold, titanium and other metals which will become more important as an alternate source to land deposits.

The MMS' marine minerals program manages exploration and development activities for federal offshore sand, gravel, and shell, and other mineral resources found on the OCS. The program has focused on six areas: (1) manganese crusts offshore Hawaii and Johnston Island (2) phosphorites offshore North Carolina, (3) heavy mineral placers and phosphorites offshore Georgia, (4) sand resources offshore the gulf coast states and the Atlantic, (5) heavy mineral placers offshore Alaska, and (6) black sand deposits offshore Oregon. The principal legal authority for the development of these resources falls under the OCSLA.

Section 8(k) of the OCSLA Amendments authorizes the Secretary of the Interior to lease minerals, other than oil, gas, and sulfur, on the OCS on the basis of competitive bidding and under such terms and conditions as may be prescribed at the time of the lease offering. Included within this authority is the Secretary's responsibility to design, implement, and manage the OCS minerals policy and development. The basic goals of the MMS marine minerals program are to:

- evaluate and achieve the potential of the OCS as a domestic supply source for strategic and other non-energy mineral resources;

- safeguard the ocean and coastal environments by ensuring that all OCS mineral activity is environmentally sound and acceptable;

- ensure that OCS mineral activities are fully coordinated and compatible with other uses of the ocean; and

- provide an effective consultation process for coastal states and the federal government regarding offshore minerals.

The MMS established a three-tiered regulatory regime for offshore minerals. These regulations govern prospecting activities, leasing activities, and operations on offshore mineral leases. Together, these rules outline the requirements for data and information gathering ventures associated with prospecting and scientific research. These regulations also establish leasing procedures, basic mineral lease conditions, and general procedures to govern discovery, development, and production activities on a lease.

With the cooperation of adjacent coastal states, joint federal-state task forces assess leasing potential of an offshore area. If leasing is determined to be economically feasible, resource and environmental studies follow. The task forces recommend appropriate action to the Secretary and the State Governor(s). Federal decisions to proceed to lease sales are made by the Secretary of the Interior, with review and comment from the Governor(s).

In addition, in 1994, Pub. L. 103-426 (Negotiated Agreements for OCS Sand, Gravel, and Shell Resources), which amends OCSLA sections 8(k) and 20(a), was signed into law. 43 U.S.C. § 1337 (2)(A). This law authorizes the Secretary of the Interior, through the MMS, to negotiate agreements for use of OCS sand, gravel and shell resources in projects undertaken by federal, state, or local governments for shore protection, beach or coastal wetlands restoration, or certain other construction projects. Once the MMS receives a request for OCS sand, gravel, or shell resources and the necessary supporting information, it determines the project's eligibility under Pub. L. 103-426. Once eligibility is established, the conditions of the negotiated agreement are developed.

Coastal states and local communities have been generally supportive of the MMS sand and gravel program and, in light of diminishing coastal and nearshore resources, recognize the need for access to OCS sand for beach nourishment and coastal restoration. The MMS sand and gravel program is active in a number of coastal areas:

- A negotiated agreement was completed with the City of Jacksonville/Duval County, Florida, to use sand from a borrow site 7 miles offshore to renourish several local beaches. A stipulation was attached to that agreement requiring that a benthic repopulation study be conducted for the actual borrow area.

- The Governor of Louisiana has requested initiation of the negotiated agreement process for use of OCS sand from the Ship Shoal area for barrier island restoration.

- The Navy and the MMS entered into a memoranda of agreement to use OCS sand from Sandbridge Shoal, offshore Virginia, to renourish a portion of the federal beach at the Fleet Combat Training Center at Dam Neck near Virginia Beach.

- Plans were being made for a negotiated agreement to use OCS sand to renourish Surfside and Garden City beaches in South Carolina.

- The National Park Service initiated the planning process to renourish a portion of Assateague Island in Maryland using sand from an OCS borrow site.

With the passage of Pub. L. 103-426, the MMS anticipates an increase in requests for negotiated agreements. A wide range of qualified projects could emerge, including those congressionally authorized, federally sponsored, or state/locally sponsored. In addition, requests for OCS sand, gravel, and shell resources via competitive bidding could emerge as OCS mining activities become more commonplace.

**<u>Deep Seabed Hard Mineral Resources Act (DSHMRA)</u>**, 30 U.S.C. § 1441 <u>et seq</u>

With regard to minerals on the deep seabed, seabed nodules contain nickel, copper, cobalt and manganese - minerals important to many industrial uses. No commercial deep seabed mining is currently conducted, nor is such activity anticipated in the near future. However, four licenses have been issued under the Deep Seabed Hard Mineral Resources Act (DSHMRA), 30 U.S.C. § 1441 <u>et seq</u>., for exploration of seabed areas in the Clarion-Clipperton zone of the south Pacific ocean.

The DSHMRA establishes an interim domestic legal regime for deep seabed mining pending adoption of an acceptable international regime. The Administration submitted the Convention and Agreement to the Senate for consent to accession and ratification in October, 1994 and it is pending in the Senate Committee on Foreign Relations. Since that time, the Convention has come into effect and over 123 nations are Parties. The Agreement addresses previously expressed concerns regarding the seabed mining portions of the Convention. The DSHMRA establishes a licensing regime that ensures protection of the marine environment, safety of life and property at sea, prevention of unreasonable interference with other uses of the high seas, and conservation of mineral resources. The DSHMRA encourages other nations that embark on ocean mining ventures to manage the activities of their nationals in a similar fashion and to respect licenses and permits issued under the DSHMRA. The DSHMRA also facilitates the transition from a domestic regime to an acceptable international regime.

The DSHMRA sets forth criteria that would need to be met for an international regime to be acceptable to the United States, namely: assured and non-discriminatory access for U.S. citizens, under reasonable terms and conditions, to deep seabed resources; and assured continuity in mining activities undertaken by United States citizens prior to entry into force of an international regime under terms, conditions, and restrictions which do not impose significant new economic burdens. The DSHMRA also recognizes that a treaty must be judged by the totality of its provisions. The Agreement to implement Part XI of the United Nations Convention on the Law of the Sea revises Part XI in a manner that satisfies these criteria.[3] During the period of provisional application of the Agreement, the DSHMRA remains in effect and provides authority to implement likely United States obligations under the Agreement.

## IV. STATE AUTHORITIES RELATING TO ENERGY AND MINERAL RESOURCES

**Under the Submerged Lands Act**, (43 U.S.C. § 1301 et seq.)

There are a number of state authorities, implemented by different state agencies, relating to energy and mineral resources. Under the Submerged Lands Act (SLA), 43 U.S.C. § 1301 et seq., the location of the energy and mineral resources determines whether or not they fall under state control. Specifically, the SLA granted states title to the natural resources located within three miles of their coastline (three marine leagues for Texas and the Gulf coast of Florida). For purposes of the SLA, the term "natural resources" includes oil, gas and all other minerals.

State authorities range in the nature and extent of their control over ocean energy and mineral resources on state submerged lands. The range depends on each state's evaluation of different policy interests, such that activities may be restricted in certain areas and allowed in others. State management authority for oil and gas exploration and production on state submerged lands may be implemented by more than one state entity. Also, state management of energy and mineral resources is often addressed within the context of a broader state coastal management plan.

State policies also affect energy and mineral resource development on the OCS. As indicated above, federal authorities such as the OCSLA provide for consultation and coordination with

---

International legal authorities relating to ocean energy and mineral resources will be fully addressed elsewhere in the legal authorities issue paper.

affected coastal states. However, consultation and coordination can be difficult when there are a large number of stakeholders representing strong policy interests.

## V. IMPROVING STAKEHOLDER INVOLVEMENT

Successful, sustainable development of ocean energy and mineral resources requires that we move from conflict to consensus among all stakeholders within the framework of a comprehensive management strategy. Stakeholders have blocked development of oil and gas resources in many areas of the OCS. Management of ocean energy and mineral resources can be difficult due to the number of stakeholders and the nature of their interests or responsibilities. Federal and state laws relating to energy and mineral resources often contain differing policy objectives that must be balanced. However, the Department of the Interior (DOI) has taken steps to solve conflicts in the application of its OCS program by working with stakeholders.

The history of the OCS program relating to energy resources shows that its expansion has been controversial. When federal management of the OCS began under the OCSLA, oil and gas activity was concentrated in the Gulf of Mexico off Louisiana and Texas, where the program was supported as a part of that region's economy. Following commercial discoveries offshore southern California, the 1969 Santa Barbara Channel blowout and oil spill started opposition to offshore oil and gas development.

In response to the oil embargo of late 1973 and early 1974, the federal government expanded the OCS program to include areas where activities had not occurred before. The increased scope and pace of activity heightened concerns about the environmental and socioeconomic effects of offshore development. Citizens and governments in coastal areas demanded that they be consulted. As a result, the OCSLA was amended in 1978 to provide for environmental consideration and more substantive involvement of state and local governments and others in OCS decision making.

In 1979, oil supply disruptions and price increases renewed pressure for developing offshore energy resources. The federal government announced an area wide OCS leasing plan for frontier areas. The announcement of this plan sparked opposition. Even though the new provisions of the OCSLA called for increased consultation and coordination, many affected parties felt that their concerns and recommendations were not being adequately considered in OCS leasing and development decisions. As a result, the OCS program became the subject of congressional moratoria and administrative deferrals. In May 1992, certain congressional moratoria became the subject of litigation by oil companies under breach of contract and takings claims.

DOI has decided to resolve conflicts related to the OCS program relating to energy resources by working with stakeholders. As part of this approach, DOI endorsed existing congressional moratoria on lease sales in order to maintain the status quo while discussions on various OCS issues ensured. DOI began resolving disputes on existing leases through the settlement of litigation and is taking steps to establish working relationships among stakeholders in a move toward consensus decision making. The MMS has also increased stakeholders' role in developing consensus on 5-Year program and lease sale decisions. DOI's actions will help coordinate decision making, and facilitate comprehensive management of ocean resources.

## LIST OF ACRONYMS

| | |
|---|---|
| MMS | Minerals Management Service |
| OCS | outer continental shelf (particularly as defined jurisdictionally by the Submerged Lands Act of 1953 and subsequent amendments, etc.) |
| SEMP | Safety and Environmental Management Program |

# 1998 Year of the Ocean

## PERSPECTIVES ON MARINE ENVIRONMENTAL QUALITY TODAY

### Contents

"... [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 still 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."

*The State of the Marine Environment, 1989;*
Group of Experts on the Scientific Aspects of Marine Pollution

## INTRODUCTION

Covering nearly three-quarters of the earth's surface, marine and coastal waters are the earth's largest and most vital resources, influencing global energy cycles and biological processes upon which all life depends. The ocean provides food, medicine, natural resources, habitat, and essential ecological services, contributing to many valuable commercial, recreational, and cultural opportunities. Each resource and service provided by the ocean relies upon high marine environmental quality. The complexity and interdependence of these resources, cycles, and biological processes are just being realized as answers are sought to questions such as:

- What are the existing conditions of marine environmental quality?
- Are marine environmental conditions getting better or worse?
- Are coastal and ocean ecosystems healthy?
- Can the fish and shellfish be eaten?
- Can swimming be permitted?
- Is enough being done to manage environmental quality in marine and coastal waters?
- Are there alternatives to traditional regulatory approaches that should be considered in managing pressures (e.g., land-based sources of pollution and coastal development) on the marine environment?
- How will increases in human population, increases in consumption, and improvements in technology affect the way people use the ocean, and what will be the resulting impacts on marine environmental quality?
- Can/should the assimilative capacities of the ocean be seen as the "ultimate sink" for high-risk wastes from human activities?

This paper will address marine environmental quality using a "pressure–state–response" approach. "Pressure" is the demand placed upon the marine environment and its resources by users, pollution, and land-based activities. "State" describes the current conditions resulting from these pressures. "Response" is what is being done to address the pressures. For the purposes of this paper, "ocean" will be broadly defined to include estuarine, marine and other coastal waters (e.g., the Great Lakes).[1]

## THE VALUE OF MARINE ENVIRONMENTAL QUALITY

The ocean plays a critical role in energy and nutrient cycling; it supplies minerals and other natural resources, energy, and habitat for sustaining living resources, and provides a medium for recreation, learning and enlightenment. Nearshore ecosystems are supported by the ocean and the interrelationship between oceanic and land systems. This interrelationship can affect the profit and growth potential of many economic sectors, including natural resource harvesting (e.g., minerals and oil), commercial and recreational fishing, real estate, manufacturing, tourism, and waste assimilation. For communities and businesses around the country, clean water can mean the difference between economic decline and a bright, prosperous future. For marine organisms and ecosystems, marine environmental quality can mean the difference between life and death.

Value can be quantified for some oceanic resources (e.g., oil energy) and services (e.g., transportation), while for other resources, values can only be approximated. Each year, 64,000 million tons of sand is mined from the ocean for construction purposes and for beach renourishment. In the United States, offshore crude oil sites generate between $1 and $9 billion annually and directly employ 85,000 Americans. These sites account for 15 percent of U.S. oil production and 26 percent of natural gas production. While offshore petroleum drilling sites are still a viable source of energy, "alternative" non-hydrocarbon renewable energy sources such as temperature gradients and tidal energy are being explored. These alternative energy sources may depend upon marine environmental quality. Approximately 95 percent of all U.S. foreign trade is carried by vessels and passes through U.S. ports (MARAD, 1994). In 1992, 897 million tons of goods equaling $488 billion passed through U.S. ports (DOT, 1994).[2]

Food harvested from the ocean generates approximately $38 billion in economic activity for the nation annually. The bulk of this revenue is generated by the commercial fishing industry which employs nearly 250,000 people and 70,000 vessels. Recreational fisheries contribute an additional $18 billion annually to the U.S. gross national product. The impacts of poor water quality include fish kills and shellfish bed closures, contributing to millions of dollars in lost fishing revenues. Wetland losses, water diversions, and other construction activities have resulted in the loss of spawning and nursery habitat, further reducing commercial and recreational fisheries' profits. (U.S. EPA, 1996).

1 This broad definition is required because of the extensive use of estuaries, wetlands, and other coastal areas by humans, marine organisms, and wildlife dependent upon coastal ecosystems. In addition, evaluation of the interconnections between the land, particularly coastal watersheds, and the sea is critical to understanding the value of the resources and services provided by the ocean, and the potential impacts of land-based activities, often far from the ocean, upon ocean waters.

2 For more information, see the Ocean Energy and Minerals Resources and the Marine Transportation Year of the Ocean Discussion Papers.

From coral reefs to kelp forests, marine and coastal areas are as different as the life they support is diverse. As a result, these areas attract a multitude of tourists and provide a large variety of recreational activities. In 1993, the recreation and tourism industry was the second largest employer in the nation, with annual sales exceeding $380 billion. Healthy coastal ecosystems are critical to places like Martha's Vineyard, Massachusetts, Santa Cruz, California, the Florida Keys, and similar coastal communities which enjoy revenue from tourists seeking places to swim, fish, boat, hunt, dive, hike, and observe wildlife. The importance of good marine environmental quality was evident in a recent survey conducted for Conde Nast Traveler magazine, wherein 25 percent of respondents revealed that they had changed travel plans because of environmental problems at their intended vacation destinations.

Along with direct monetary contributions, healthy marine ecosystems provide indirect contributions to local economies through their aesthetic, artistic, cultural, and spiritual value. For example, a 1991 American Housing Survey found that "when all else is equal, the price of a home located within 300 feet of a body of water increases by up to 28 percent." (Smith, 1995). Community and business leaders understand the potential value of waterfront locations, and often use them as a focal point for urban renewal.

Coastal wetlands, mangroves, and tidal flats play essential roles in nutrient cycling and providing habitat for wildlife, as well as protecting coastal developments from storm surges and filtering sediments and toxins from waters. Where development has been permitted in low lying areas close to the waters edge or in converted wetlands, infrequent yet intense storms cause billions of dollars in damages (e.g., damage costs from Hurricane Andrew in 1993 were $25 billion). Wetlands, barrier islands, and tidal flats provide a buffer from storms and assist in reducing shore erosion. Many municipalities and some industries are incorporating wetlands into their wastewater treatment systems to remove nutrients, process some chemical and organic wastes, and reduce sediment loads prior to discharge into riverine and marine waters. This form of pretreatment reduces industry and municipality costs, protects shellfish and swimming areas from closures, and reduces the number of fish consumption advisories issued. While wetlands help to improve and maintain water quality, they also play an important role in sustaining the health and abundance of marine species. It is estimated that 77 percent of shellfish and marine commercial species (Chambers, 1991) and 75 percent of all U.S. migrating waterfowl depend upon these areas during some stage of their life cycle.

Although it is difficult to quantify, an article in *Science* by Costanza et al. (1997), estimates the global value of the ocean and the services it provides to be $33 trillion per year. Most of this value lies outside the traditional market system (e.g., commercial fisheries), and comes instead from services such as waste treatment, nutrient cycling, and regulation of disturbances such as floods or storms. Thus, it is important not only aesthetically, but economically to take care of the health of the ocean and its resources.

# PRESSURES ON MARINE ENVIRONMENTAL QUALITY

Population growth, coastal development, resource demand, climate, relative sea-level rise, and natural coastal processes all affect marine environmental quality. Yet, nearly all of the threats to habitat and marine environmental quality are human induced pressures—from physical alteration of the environment to pollution impacts from human activities conducted either directly in/on marine waters or within the watershed.[3] Land based activities impact marine environmental quality, which in turn influences other land and water activities. Increasing rates of economic growth and urbanization, pollution, and changes to ecosystems, can result in user conflicts in the marine environment.

## Economic Growth

Coastal areas are becoming increasingly crowded, with approximately 130 million people—more than half of the total U.S. population—currently residing within 80 miles of the coast. Growing at a faster rate than the nation as a whole, U.S. coastal populations are expected to reach 165 million people by the year 2015 (NOAA, 1997). Population growth translates into employment opportunities, economic prosperity, new industry, improved regional infrastructure, enhanced educational opportunities, and increased tax revenues. However, as coastal populations grow, so does the stress placed on the environment. The features that first attracted people to the coast can be lost or diminished if growth is not planned for or addressed during development. Of course, one outcome of economic growth is that an economic base is developed from which funds can be provided to ameliorate the impacts of growth.

Increasing population generally results in the conversion of open land and forest for activities such as commercial development, agriculture, forestry, and other activities that provide economic growth. In addition to physically altering the habitat, coastal development can reduce permeable surface area, thereby increasing the rate of runoff and impacting water quality by transporting sediments, toxic chemicals, pesticides, herbicides, pathogens, nutrients, and other pollutants to local waterways. Water recharge capacities can be reduced as habitat is changed to accommodate urban development. This "hardening of the coast" places stress upon the water table and can lead to saltwater intrusion and other marine environmental quality issues.

As urbanization and inland activities increase, so do the volumes of municipal and industrial waste discharged into local waterways. This can potentially impair water quality at the same time that demands for potable water, natural resources, energy supplies, wastewater treatment, and transportation of goods increase. Whether from runoff or discharges, excess nutrients, sediments, pathogens, and toxic chemicals can impair water quality. This in turn can result in a degradation or loss of fishing opportunities, changes in wildlife populations, a reduction in the value of wetlands and estuaries, decreases in wetlands available for water

[3] Examples of activities that can impact marine environmental quality include conversion of open land and forests for commercial or residential development, agriculture, forestry, construction, marinas, commercial fishing, shell-fishing, hydro-modification activities (e.g., dams, dredging), and offshore drilling.

treatment, and decreased protection from storms. When habitat is lost, wildlife suffers from a lack of area to maintain life cycle processes.

The ongoing increase in global economic interdependency is expected to raise the value of U.S. imports and exports from $488 billion in 1992 to $1.6 trillion in 2010, while the volume increases from 897 million metric tons to 1.5 billion metric tons (U.S. DOT, 1994). Associated with this economic growth is an increase in potential impacts on marine environmental quality from the additional vessels, port activities, personnel, and other associated industries required to accommodate the production and transport of these additional goods and services. For example, with greater numbers of ships accessing U.S. ports, the potential for the introduction of non-indigenous species through ballast water exchange has increased proportionally.

Increasing demands for shellfish and commercial fish have spurred competition and technology improvements to increase fishing capabilities. According to the National Marine Fisheries Service, commercial landings by U.S. fishermen reached 10.5 billion pounds in 1993. Increased catches in the 1990s, however, reflected the increasing harvest of lower-valued species, as traditional commercial stocks became overfished in the late 1980s and 1990s (NMFS, 1996). Over-exploitation, in concert with impacts from pollution, habitat degradation, habitat modifications such as dams, and by-catch waste[4], has resulted in a depletion of some edible fish stocks, placing some ecosystems on a path toward unsustainability, and leaving some fishing industries on the brink of collapse.

The travel and tourism industry is the largest and fastest growing segment of the expanding service industry in the United States. About 85 percent of all tourism revenues are received in coastal states, but with these revenues come increased demands for drinking water, housing, wastewater treatment, and recreational activities. As leisure pursuits change, so do the demands on waterway uses and water quality. According to the Sports Fishing Institute, Americans participated in 166 million days of fishing in 1990, and approximately 4 million people over the age of 16 participated in shell fishing. The recreational boating industry is growing rapidly with 73.4 million boaters having spent $10.5 billion on related products and services in 1991. Already stressed from pollution, reefs are at risk as increasing numbers of recreational divers concentrate at the ever fewer number of reefs still harboring great biological diversity.

Demands for energy and natural resources promote offshore exploration drilling and mining. These activities can impact marine habitats and water quality through physical disturbances, introduction of pollutants, and suspension of sediments into the water column.[5]

Eventually, the benefits derived from unregulated and uncontrolled economic growth and urbanization in an area can come full circle and be outweighed by losses of economic growth as residents, tourists, businesses, and industry choose to move to other areas where an infrastructure

---

4 By-catch waste is defined here as marine life caught during commercial operations which are not the targeted species. Often these organisms are discarded.

5 For more information see the Ocean Energy and Mineral Resources Year of the Ocean Discussion Paper.

exists that can support the demands of multiple uses and still provide an aesthetically pleasing environment.

## Pollution Pressures

*Direct Discharges*

Direct discharges are defined here to include releases from vessels, discharges of municipal and industrial wastewater via pipelines, and dumping of waste materials, such as dredged material, into ocean waters. In the United States, there are more than 2,000 sewage treatment plants, municipalities, and industrial facilities discharging effluents into estuarine and coastal waters. Approximately 2.3 trillion gallons of effluent are discharged into marine waters from sewage treatment facilities annually. While most of this sewage meets secondary treatment standards prior to disposal, nutrients and pathogens from such discharges can contribute to the degradation of local marine ecosystems—creating "dead zones"[6] and forcing the closure of shellfish beds and swimming areas. Nutrient loading can be significant causes of degradation to coral reefs and other coastal ecosystems.

More than 2.8 billion gallons of industrial waste water per day[7] are discharged directly into U.S. ocean waters (U.S. EPA, 1994). Many of the chemicals discharged into marine waters can be toxic even in minute concentrations, and can compromise the water column, contaminate sediments, and concentrate in marine organisms. Leaching from hazardous waste sites has been the source of many toxins in marine waters (e.g., In New York, PCBs are leaching into the Hudson River in from an abandoned industrial plant). Exposure to these chemicals and metals can pose risks of acute or chronic[8] toxicity to marine organisms. In addition, the risks to predators and humans can be increased if toxins become concentrated through the food chain. In some locations, thermal pollution from electric generating plants has been shown to stress marine organisms by raising the ambient temperature of the water.

During operations, vessels may be responsible for directly discharging oil, sewage, garbage, and non-indigenous species into marine waters. Some pollutants are from direct discharges (e.g., the emptying of sewage from vessel toilets, or ballast water exchange), while others may be a result of leaching (e.g., anti-fouling agents or paints).[9] Once discharged, pathogens in sewage can impact drinking water intakes (e.g., in the Great Lakes), and necessitate the closing of shell fishing and swimming areas; discharged nutrients, meanwhile, can increase eutrophication.[10,11] Oil and other chemical contaminants washed or discharged into the ocean may

6 Dead zones are areas within a water body where the oxygen level in the water is so low that plants, fish, and other marine organisms are unable to survive.
7 This estimate excludes electric utilities and offshore oil and gas effluents.
8 Acute levels of toxins are defined as lethal, while chronic levels are sublethal and result in disease or disruptions to physiological or reproductive processes.
9 According to 1991 customs data, ballast water exchanges from foreign vessels exceeds 58 million gallons per day (Shipping Study, 1995).
10 Eutrophication is the increase in biological productivity of an aquatic system as a result of natural or artificial inputs of nutrients.

be suspended in the water column, ultimately settling in sediments and concentrating in marine organisms. Discharged garbage[12] adversely affects marine life (due to entanglement or ingestion), and can also cause vessel damage through propeller entanglement and by disabling engines when sucked into intake valves. The potential negative consequences of invasions of non-indigenous species are becoming an increasing concern at ports and coastal areas.

In U.S. coastal and ocean waters, dredged material is the primary waste transported and directly disposed.[13] The U.S. disposes of approximately 300 million cubic yards of dredged material each year from inland and coastal waters, only 60 million cubic yards (20 percent)[14] of which are disposed of in open ocean waters. Unregulated and uncontrolled disposal of dredged material can increase suspended solids in the water column and smother benthic organisms. If the sediments are contaminated, there is a potential for acute or chronic toxicity in marine organisms and a risk to human health (U.S. EPA, 1991).

*Indirect Discharges*

One to two-thirds of pollutants contributing to the degradation of coastal and marine waters are from indirect sources, and include sediments, nutrients, pathogens, and toxic compounds. The difficulty in controlling these pollutants is the diverse array of sources (which include runoff and seepage from agricultural and urban areas, and air deposition onto land and into water) and the multiple methods of transport. Nationwide, it has been estimated that indirect loadings account for more than half of the suspended solids, nutrients, fecal coliform, and metals entering coastal waters annually. Runoff from non-urban areas, sewage spills and overflows, urban storm water runoff, and combined sewer overflows are often responsible for seafood advisories and shellfish bed and beach closings.

Pollutants from agricultural and pasture lands include sediments, fertilizers, pesticides, herbicides, and animal wastes which contain bacteria and nutrients. Eighty-eight percent of the total suspended solids entering marine waters are from agricultural runoff, contributing to water quality problems such as light attenuation and the smothering of sensitive ecosystems (U.S. EPA, 1995). Excessive nutrients can stimulate the growth of algae and other plants and organisms, which in turn deplete the levels of dissolved oxygen and harm aquatic life; too many nutrients can also trigger toxic algal blooms. Bacteria and pesticides from agricultural and pasture lands can kill aquatic life, contaminate seafood, and necessitate the closing of shellfish beds. Cleared land has a reduced capacity to absorb water, resulting in increased sediment transport, increased flooding, reduced recharging capabilities of local aquifers, and increased quantities of toxic chemicals and nutrients transported to local waterways.

---

11 The Centers for Disease Control have linked an outbreak of illnesses during the summer of 1997 to waterborne pathogens originating from vessel discharges of sewage in shell fishing areas in the Gulf of Mexico (CDC, 1997).

12 Garbage includes but is not limited to: glass, metal, paper, plastics, and food wastes.

13 While several other nations dump industrial wastes and sewage sludge into ocean waters, the U.S. stopped industrial waste dumping in 1988 and ended such sewage sludge disposal practices in 1992.

14 It should be noted that an estimated 5-10 percent of all sediments dredged in the United States are not suitable for open water ocean disposal (NRC, 1997). Alternative disposal is sought for these sediments.

Many of the pollutants from urban areas are washed to sea through storm sewers. The volume and flow rate of runoff from yards and streets into sewers increases as more land is developed, thus the volume of pollutants such as oil, fertilizers, and litter that is transported to waterways also increases. Fourteen percent of estuarine miles in the United States are impacted from oil and grease (U.S. EPA, 1994c). Oil and grease together are major contributors to estuarine degradation, with 363 million gallons of oil originating from land and municipal and industrial wastes. Annually, oily road runoff from a city of 5 million could contain as much oil as one large tanker spill (Ocean Planet, 1995). Over two million pounds of cadmium, copper, and zinc are carried to U.S. waters from urban areas annually (U.S. EPA, 1984). Nearly 80 percent of marine debris comes from land-based sources, either washed directly into waterways or arriving through storm sewer and combined sewer overflows (Coe, 1996).

Another source of indirect discharges is atmospheric deposition. The scientific community and coastal managers now recognize the importance of atmospheric deposition in causing surface water contamination, and have developed and refined models describing the processes of atmospheric deposition of nitrogen, phosphates, mercury, and other toxic chemicals. As much as 67 percent[15] of the total nitrogen load delivered to the Tampa Bay, Florida, watershed (TBNEP, 1996), and 80 percent of PCBs in Lake Superior (NOAA, 1997), are believed to originate from atmospheric deposition.

*Accidental Releases*

Because industrialized society depends on petroleum products to maintain its accustomed standard of living, large volumes of petroleum are transported each day in the coastal and marine environment. These large volumes are moved by vessels as cargo and fuel, and through pipelines. Fixed facilities, offshore exploration and production platforms, tanker spills, and natural oil seeps contribute millions of gallons of oil to the world's marine waters annually. Spills and leaks cause the formation of tar balls, oil slicks, and tar mats, and can impact the micro-layer, the benthos, the coast, and marine life.

## Ecosystem Alteration

While often necessary to ensure vessel accessibility to ports or to control flooding, hydro-modification projects, such as dams, flood control channels, dredging, water diversions, and the development of wetlands, have profound impacts on coastal and marine habitats—changing the natural flow, timing, and volume of freshwater inflow and sediment depositional patterns in bays and estuaries. This is of particular concern in estuarine areas where changes in water flow can alter the salinity of the ecosystem, increase stress on marine organisms, decrease or eliminate protection from storms[16], and reduce recharge areas. Alteration of flow can also impact marine systems by transporting pollutants and resuspending sediments and toxic chemicals, thereby increasing the potential for concentration of toxins in marine organisms and humans. Activities

---

15 This includes dryfall and wetfall to both the bay and the Tampa Bay Watershed.

16 The Charles River Basin in Massachusetts determined that the loss of 8,442 acres of wetlands would increase flood damage costs by approximately $17 million (Thibodeau, 1981).

such as sandmining, drilling, and shell fishing can physically disrupt benthic habitats and resuspend toxic chemicals and sediments in the water column.

The introduction of non-indigenous species often results in unexpected ecological, economic, and social impacts to the coastal and marine environment. Predation and competition by non-indigenous species has resulted in the eradication of some native populations and the drastic reduction of others, thereby altering local food webs. This process is often compounded by the exploitation of commercial fish. Overpopulation of some non-indigenous species has resulted in the degradation and loss of wetland vegetation and other submerged aquatic vegetation as a result of overgrazing (e.g., nutria). Additional impacts of non-indigenous species can include (U.S. EPA, 1997):

- the introduction of pathogens to coastal waters
- alteration of water tables
- modification of nutrient cycles or soil fertility
- increased erosion
- interference with navigation
- a reduction in sport and commercial fishing yields
- negative impacts on recreational boating and beach use

Overfishing can portend the beginning of an ecologically unsustainable trend. Practices such as "Growth overfishing"[17], cyanide, or dynamite fishing[18] involve the taking of all marine species without concern for size or species. The result is that noncommercial species are killed during the harvesting process of desirable species, or that species are harvested before they reach maturity and can reproduce. This removal of multiple species can alter the ecosystem.

## Climate Change[19]

Throughout time, climate change has affected coastal and marine environments and will continue to do so in the future. However, human activities and alterations to the environment have rendered coastal resources more vulnerable to the effects of climate change. Such effects include accelerated sea-level rise, increased siltation, altered rainfall patterns, and changes in storm frequency and intensity. Over the past 100 years, the relative sea level has risen by 1 to 2.5 mm/yr. Climate change and a rise in sea level or changes in storms patterns could result in increased erosion of shores, changes in coastal and marine habitats, increased coastal flooding, changes in salinity of estuaries and freshwater aquifers, altered tidal ranges in rivers and bays, changes in sediment and nutrient transport, and changes in the pattern of chemical and microbiological contamination of coastal areas. Projections based on long-range climate models

---

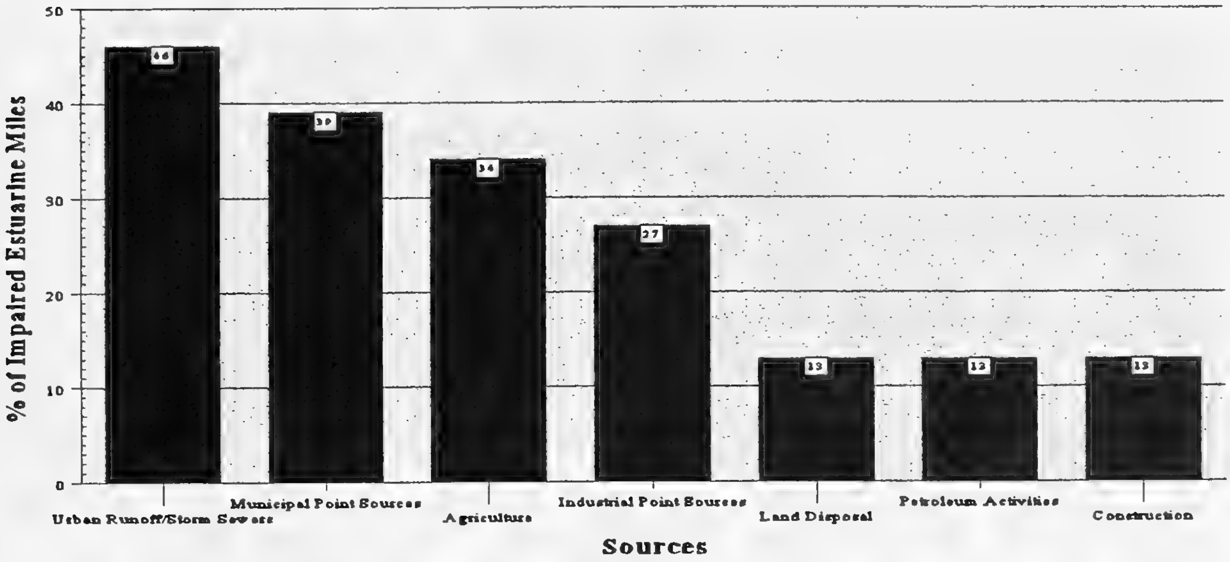
17 Growth overfishing refers to harvesting that results in a reduction in the average size of fish or shellfish landed, and often involves taking fish prior to their reaching sufficient size for reproduction.

18 In some regions of the world, cyanide and dynamite are used in the harvesting of fish. This method kills not only the target species but all marine life in the area.

19 For more information on oceans and climate change issues such as relative sea-level change, tectonic subsidence, sediment budgets and longshore currents, see the Climate and Weather Year of the Ocean Discussion Paper.

*Figure 1: Leading Sources of Water Quality Impairment*

(Source: EPA, 1995)




suggest that freshwater discharges from the Mississippi River to the coastal ocean will increase 20 percent if atmospheric carbon dioxide concentrations double. This is likely to affect water column stability, surface productivity, and global oxygen cycling in the northern Gulf of Mexico. Increased temperatures in the open ocean could result in a shifting of the geographical distribution of certain species.

## THE STATE OF MARINE ENVIRONMENTAL QUALITY

Good environmental quality is essential for sustaining coastal and marine ecosystems,[20] commercial and recreational fisheries, and economic growth in coastal communities. It is also an important means of providing natural protection against rising sea levels and storm damage. The health of coastal and marine ecosystems is affected by water quality, and in turn, water quality is dependent upon ecosystem health. If one is impaired, the other is threatened. Despite their value and the programs designed to protect them, many coastal waters are being degraded at an alarming rate. According to the 1994 National Water Quality Inventory, 44 percent of U.S. estuarine waters are not supporting their designated uses (e.g., fishable or swimmable). Figure 1 shows the major sources of pollution impairing monitored estuarine waters in the United States.

---

20 Marine and coastal areas include a wide variety of systems, such as: wetlands, tidal marshes, sea grass beds, kelp forests, mangrove swamps, coral reefs and deep-sea vents. They provide refuge, food, and nursery areas for shellfish, fish, birds, worms, other wildlife, and a diversity of plant and bacterial life.

## Water Quality in Marine Ecosystems

To understand the current status of water quality in marine environments, it is necessary to consider nutrients levels, along with the extent of contamination by pathogens, chemicals, oil, and debris/litter.

### *Nutrients*

Nutrients have an ambiguous position in the assessment of water quality—they are necessary to support healthy marine ecosystems, but in excess, they can lead to severe oxygen depletion. Excess nutrients also stimulate the growth of dinoflagellates and nuisance algae, such as blue-greens which are often toxic to estuarine and marine animals. This stimulation in growth know as blooms, can have such effects as causing fish kills or manatee deaths, and in some instances may threaten human health. Since the end of World War II, increases in human population density, fertilizer use, animal husbandry, and changes in land use, have contributed to increased nutrient inputs from runoff that range in magnitude from two- to ten-fold. It has been estimated that 40 percent of estuarine and coastal waters are not "fishable or swimmable," primarily because of nutrients and bacteria from urban and agricultural runoff and municipal wastewater discharges (U.S. EPA, 1995a). Recent studies have shown air deposition of nitrogen is also a significant contributor to nutrient over-enrichment of marine waters. For example, 21 percent of nitrogen loadings to the Chesapeake Bay are from air deposition (Valigura, 1996).

### *Pathogen Contamination*

Viruses, bacteria, and protozoa can cause diseases in plants, humans, and other animals. In excess, they contribute to closures of shellfish beds and swimming areas, fish kills, and seafood consumption warnings. The good news is that "approved" shellfish harvest waters are at an all time high. Of the 25 million shellfishing acres classified in 1995, about 59 percent are "approved" for shellfishing, and restrictions on shellfishing waters are at their lowest levels since 1980. There has been a significant decrease in shellfishing acreage that has harvest limitations due to pollution from industry, wastewater treatment plants, and direct discharges; however, there has been an increase in the acreage that is "harvest limited" as a result of boating, marinas, urban runoff, and agricultural runoff (NOAA, 1997). Overall, the condition of shellfish harvest waters in the United States is improving.

During 1996, there were at least 2,596 individual closings and advisories for ocean, bay, and Great Lakes swimming beaches due to bacterial contamination. Over 80 percent of the beach closings and advisories in 1996 were based on monitoring that detected bacteria levels exceeding beach water quality standards.[21] Decreases in hurricane activity in Florida and decreases in the number of heavy storms in California (NRDC, 1997) resulted in fewer combined sewer overflow events and reduced the number of beach closings in 1996. The number of beach closings due to

21 For, example, beaches can be closed to swimming when there is a risk of catching waterborne diseases from raw sewage contamination.

pathogen contamination continues to decrease as a number of metropolitan areas upgrade their sewer systems and separate their storm drains and sewer systems.

*Chemical Contamination*

Since 1940, more than 70,000 synthetic chemicals have been introduced into the marine environment, impacting areas such as the Mobile Delta, where excessive levels of mercury in finfish resulted in the closing of some fishing areas from 1970-72 and again in the early 1990s (U.S. EPA, 1997). Efforts to reduce chemical loadings to marine waters have had some success. Away from the influence of urban sources, offshore monitoring of toxic chemicals has shown a decline in the concentrations of chemicals which have been banned from use in the United States (NOAA, 1997). Meanwhile, reported releases of toxic chemicals to surface waters of the United States decreased by 4.1 million pounds (a decrease of more than 10 percent) from 1994 to 1995 (U.S. EPA, 1997b).[22] The decrease in toxic chemicals released to surface waters is a reflection of real changes in industry practices such as source reduction,[23] installation of pollution control equipment, increased recycling and reuse of waste as raw materials, production changes, and a reduction in the number of one-time events (e.g., spills).

Over the last decade, chemical contamination of aquatic sediments has been recognized as a serious problem in some U.S. coastal waters. In Puget Sound, hot spots of toxic chemicals have been shown to alter and reduce the bottom-dwelling community, to interfere with cellular and physiological processes, and to cause disease in fish. Most hot spots are in areas of high vessel traffic, industrial activities, or poor flushing and are often located near urban centers (NOAA, 1994). Other adverse economic impacts of contaminated sediments include delaying or raising the cost of maintenance dredging of navigational waterways due to the potential dangers of resuspending toxic chemicals into the water column or the need to find disposal sites for the sediments.

*Oil Contamination*

In 1996, approximately 4,200 oil spills occurred in coastal areas and in the open ocean. Spill sources range from minor marina activities to one-time releases from tankers (U.S. DOT), with major tanker spills accounting for only 5 percent of the volume of oil spills. Fixed facilities and offshore exploration and production platforms contribute 15 million gallons of oil pollution to the world's ocean bodies annually. By contrast, 363 million gallons of oil per year reaches the ocean in runoff from land and municipal and industrial wastes. In fact, the yearly road runoff from a city of 5 million could contain as much oil as one large tanker spill (Ocean Planet, 1995). Natural oil seeps discharge 62 million gallons of oil into marine waters annually. Effects on organisms from oil spills can be acute, such as fish kills from initial contact with the toxic

22 This information is from Table 5-1 in the 1997 Toxic Release Inventory. It has been corrected for additions and subtractions of chemicals to the list and for changes in the number of industries monitored, but does not include ammonia, hydrochloric acid, or sulfuric acid.

23 This includes such actions as elimination of spills and leaks during normal operations, process changes, and chemical substitutions.

fractions of petroleum, or subtle, such as chronic effects on reproduction which become evident as toxic chemicals concentrate through the food web of an ecosystem. Effects on human populations are realized through economic losses, such as those associated with the loss of a fishery or tourism. Particularly susceptible to injury from releases of oil are exposed shorelines, shallow reef environments, estuaries, mangrove forests, and wetlands (U.S. EPA, 1993).

*Marine Debris/Litter*

Two hundred and sixty-seven species of marine organisms are known to ingest or become entangled in marine debris that causes injury and sometimes death (MMC, 1995). Coastal communities can lose millions of annual tourism dollars, experience declines in commercial and recreational fish stocks, incur damages to vessels, and see declines in property values as a result of marine debris. Annually, $1.5 million is spent by coastal communities in New Jersey to remove debris from beaches and coastal waters in order to prevent a repetition of the 1987 and 1988 beach seasons when $2 billion in tourist revenue was lost as a result of debris washing ashore. Lost or neglected fishing gear contributes to the depletion of commercial fisheries.[24] And while numbers for the United States are unavailable, Japan estimates that in 1992, the Japanese fishing industry spent $4.1 billion dollars in boat repairs resulting from damage caused by marine debris. Sources of marine debris include vessels and beachgoers, but recent studies show that 80 percent is likely to be from indirect sources such as street litter, improperly sealed waste receptacles, landfills, and from combined sewer overflow events. Annex V of MARPOL, an international treaty banning the dumping of plastics from ships and regulating other garbage discharges, has been in place since 1988 and improvements are being made to reduce marine debris from ships.

## Ecosystem Change

U.S. coastal areas, land and water, support an extensive and unique set of ecological, commercial, and recreational functions, and provide food, shelter, and nursery areas for birds, marine invertebrates, fish, and other wildlife. Across the nation, estuaries contain 32,300 square miles of wetlands, 21,900 square miles of shellfish waters, and 27,000 public recreation sites (Baily, 1993). Despite their ecological importance, many of these productive areas have been modified or lost to support residential, agricultural, industrial, and commercial growth. As habitat is lost, wildlife systems are strained for sufficient area to maintain life-cycle processes.

*Habitat Alteration*

Since the 1700s, the 48 contiguous states have lost nearly half of their original wetlands (Watzin and Gosselink, 1992). Twenty-five years ago, wetland losses were estimated at 460,000 acres each year. Today, wetland losses are estimated to be one-fourth of that rate or less (U.S. EPA, 1997). Nonetheless, physical alteration or degradation of habitat continues to occur, with a

24 For example, approximately 31,600 crab pots were lost in Bristol Bay, Alaska, between 1990 and 1991; if each trap caught and killed one legal-sized crab per year, the annual catch would be 205,400 pounds.

concomitant loss of diversity, as a result of human activities such as channelization, drainage for agricultural purposes, development, and dredging.

Such a drastic decrease in habitat acreage has had a great impact on marine and terrestrial species dependent upon these ecosystems for spawning, nurseries, and habitat. During some stage in life, 77 percent of all commercial species and 80-90 percent of recreational fish and shellfish catches rely upon wetland areas (NOAA, 1997). Eighty percent of endangered species depend on habitat within 10 vertical feet of sea level (NOAA, 1995). Between 80 and 90 percent of U.S. shorelines are undergoing net long-term erosion; while some of this erosion is due to natural processes, erosion resulting from anthropogenic factors has increased over the past century. The development of tidal flats and barrier islands has eliminated unique and essential habitats for many plants and animal species.

In addition to physical alterations, water quality impairment and habitat loss can be caused by excess nutrient loading, sedimentation, and increasing levels of pathogens and toxic chemicals. Sediment and nutrient loadings have increased turbidity and light attenuation, thereby killing submerged aquatic vegetation. Only 10 percent of the seagrass beds that existed several decades ago still exist today. In Florida, siltation and nutrient loads have reduced mangrove forests by approximately 24 percent and caused severe damage to coral reef systems (U.S. EPA, 1997). Alteration of the natural flow can have significant effects on water quality, health, and distribution of living resources. In the upper Laguna Madre River of the Corpus Christi Bay, changes in freshwater flow in 1996 have increased salinities from 10-20 ppt[25] to 55 ppt (U.S. EPA, 1997). The change in salinity has decreased the total productivity of the oyster population and reduced the economic value of the estuary.

While the dredging of harbors and shipping channels can cause temporary increases in turbidity, dredging is necessary for port accessibility and navigational safety. Recent years have seen a change in emphasis on dredged material management. Ports lose revenue when vessels change their destination to ports with shipping channels deep enough to accommodate them. It is now recognized that dredged material can also be a resource for enhancing or building wetland habitats, or for other uses such as beach renourishment. Beneficial use of dredged material usually costs more than traditional open water disposal methods. However, with the passage of more consistent cost-sharing formulas between federal and local project sponsors (e.g., the Water Resources Development Act of 1996), it is expected that the amounts of dredged material used to build habitats will continue to increase.

On a more global scale, climate change as manifested by rises in sea level and changes in storm patterns and storm surges has led to environmental impacts that include:

- increased erosion
- increased salinity of estuaries and freshwater aquifers
- altered tidal ranges in rivers and bays

25 ppt equals parts per thousand

- increased coastal flooding
- changed sediment and nutrient transport patterns
- changed patterns of chemical and microbiological contamination in coastal areas

Secondary impacts from climate change that may occur include inundation of waste disposal sites and landfills from storm surges which result in the reintroduction of toxic materials and increased siltation into the marine environment. Areas in the U.S. Gulf Coast are experiencing a relative sea level rise of 10 mm/year. In Oahu, Hawaii, one quarter of the beaches have been lost or significantly degraded over the past 50 years due a multiple of marine environmental pressures, but heightened storm surges could greatly increase this rate.

*Adverse Biological Effects*[26]

The over-exploitation of living resources, the physical destruction of habitats, pollution, changes in climate, and the introduction of non-indigenous species, all combine to threaten the biodiversity, integrity, and productivity of marine and coastal ecosystems. Over-exploitation of species reduces their ability to maintain population levels.[27] Overfishing can create an imbalance in ecosystems by depleting food resources for predators while allowing populations on which depleted species would have otherwise fed to grow. This can be the beginning of an ecologically unsustainable trend.

The introduction of exotic or non-indigenous species into an area, whether intentionally or accidentally, often results in unexpected ecological, economic, and social impacts to the marine and estuarine environment. These occurrences often pose threats to local species that are relied upon for food, medicine, recreation, and raw materials (Norse, 1993). Through predation and competition, introduced species have contributed to the eradication of some native populations and drastically reduced others, fundamentally altering food webs. In San Francisco Bay, California, Amur River clams have become so abundant that they can filter a significant volume of the Bay in less than a day, removing the bacteria, phytoplankton, and zooplankton that are necessary to support the local food web. Zebra mussels are responsible for millions of dollars in water supply maintenance costs in the Great Lakes. In the Delaware Estuary, *Haplosporidium nelsoni*, a parasitic protozoan, has caused catastrophic die-offs of American Oyster. It is thought that this organism was transferred from Asia or the U.S. West Coast via ballast water (Ford, 1996). The Asian clam, *Corbicula fluminea*, dominates the bivalve community in the area between Trenton, New Jersey and the Chesapeake and Delaware Canal. In some areas, this exotic clam makes up 94 percent of the total benthic invertebrate biomass (Maiden, 1993).

---

26 For more information, see the Year of the Ocean Living Resources Discussion Paper.

27 For example, total finfish landings have declined from 2.9 million pounds in 1980 to less than 340,000 pounds in 1989, mainly as a result of "growth overfishing", a reduction in the size of fish caught and stock depletion. Of the species found in the Indian River Lagoon basin in Florida, 75 are listed as rare, threatened, endangered, or species of special concern by state or federal agencies. In Corpus Christi, Texas, the numbers of shrimp landed in the bay fishery have increased more than 300 percent since 1972. In 1996, 1,871 bay shrimp boat license holders plus 1,806 bait shrimp license holders trawled in these bays harvesting an already depleted stock.

Habitat may be directly affected by development and water control efforts, but degradation due to toxic chemicals, excessive nutrients, sediments, and oil can be just as devastating. Habitat alterations from these causes range from physical smothering to changes in population structure associated with exposure to chemicals in the water and sediments. Pollutants such as pesticides and herbicides threaten living resources by contaminating the food chain and eliminating food sources. Contaminants in runoff and toxic releases can alter aquatic habitat, harm animal health, reduce reproductive potential, cause disease, and contribute to behavioral abnormalities that may affect organism survival and suitability for human consumption.[28]

There is evidence that suggests certain pollutants or changes in marine water quality (e.g., increased nutrients) may initiate, maintain, and extend the duration of toxic algal blooms and further impact human health and marine organisms. These blooms are thought to be initiated from offshore patches of organisms that are transported to coastal waters where high nutrient levels sustain the bloom conditions. For example, in 1996, 149 manatees died in Tampa Bay, Florida, after exposure to a toxic red tide that remained behind the barrier islands well into the spring migrating season. In another case, high phosphorus levels are thought to be one of the conditions required to trigger *Pfiesteria* blooms such as occurred in North Carolina and Maryland, and resulted in associated fish kills and human health concerns (U.S. EPA, 1997).

## RESPONSES TO CHANGES IN MARINE ENVIRONMENTAL QUALITY

Three decades ago, water quality was at an all time low, with rivers catching on fire, harbor areas of cities being deserted, great numbers of shellfish beds closing on an annual basis, and people getting sick from swimming. In the 1970s, Congress passed several laws to address environmental problems, of which the most significant for the protection of marine waters were the Clean Water Act, the Marine Protection Research and Sanctuaries Act, and the Coastal Zone Management Act. However, laws alone do not suffice to cleanup, prevent, improve, or protect water quality—people must become actively involved. Among the many means to protect marine and coastal waters are:

- the traditional regulatory approach which includes the permitting of specific discharges;
- risk prioritization and pollution prevention; and
- the watershed approach which looks at the sources of pollutants as well as the system to which they are discharged.

Whether voluntary or as a result of regulations, actions taken to improve water quality should be based upon sound science, consider the needs of all users of marine environments, and take into account technological and economic constraints.

28 In Sarasota Bay, Florida, the alteration and degradation of juvenile fish habitats, seagrass beds, and wetlands are the most likely causes of the 50 percent decline in commercial landings of sea trout over the past 30 years. Over the past 50 years, bird populations in the Tampa Bay area have dramatically decreased due to water quality impacts on their natural habitats (U. S. EPA, 1997).

While some shellfish beds remain closed today, and some beaches continue to be closed for days at a time, overall water quality in the United States has vastly improved. While much progress has been made, the environmental problems facing ocean and coastal waters present formidable challenges to the scientific and technical communities, who seek to understand natural processes and delineate causes and effects, as well as to policy makers, regulators, and stakeholders, who prioritize actions and allocate limited funds.

### Legislative and Regulatory Framework[29]

In 1972, the Federal Water Pollution Control Act was passed. Subsequently reauthorized and renamed the Clean Water Act (CWA), this Act has set the basic structure for regulating discharges of pollutants into waters of the United States. The goal of the CWA is the "restoration and maintenance of the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. §1251(a)). Various sections of the CWA provide for monitoring programs, ecosystem management, non-point source pollution control, best management practices of pollutants, wetlands protection, and water quality controls. Under the CWA, it is illegal to discharge pollutants into U.S. waters without a permit. The U.S. Environmental Protection Agency (EPA) is responsible for establishing water quality standards for specific pollutants and developing discharges guidelines for specific industries.

The CWA has been successful in reducing pollutant loadings from point sources, but a bigger challenge remains in reducing pollutant loadings from non-point sources. Under the CWA, states are directed to develop management plans for non-point sources of pollution, including the identification of best management practices and programs to implement such practices on a watershed basis to the maximum extent practicable. The Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) and the CWA also established the National Estuary Program (NEP), which is a consensus-based approach designed to identifying key problems in a particular estuary, develop a plan to address those problems, and implement the actions in the plan. There are 28 NEPs nationwide, 17 of which are now implementing approved plans.

There are many users of the coastal areas of the United States. The Coastal Zone Management Act was enacted to provide for the management of the nation's coastlines by balancing economic development with environmental preservation to "preserve, protect, develop, and where possible, to restore or enhance the resources of the Nation's coastal zone" (16 U.S.C. §1452). This Act also provides for a state-administered regulatory program for non-point sources in coastal areas. The River and Harbor Act of 1899 states that all modifications to navigable waters require a permit. The issuance of these permits are subject to public review and the National Environmental Policy Act.

29 This section on Legislation/Regulation is only a sample of the most important legislation and regulations related to coastal and marine waters.

The Marine Protection, Research, and Sanctuaries Act establishes national marine sanctuaries for areas that have special significance based on their "conservation, recreational, ecological, historic, research, educational or aesthetic qualities" and controls dumping of wastes into ocean waters. The objectives of the national marine sanctuaries program are as follows:

(1) establish sanctuaries in areas of special national significance (currently there are 12 national marine sanctuaries)

(2) develop and implement coordinated protection and management plans for sanctuaries;

(3) facilitate public and private uses insofar as they are compatible with resource protection

(4) support scientific research and public education in the sanctuaries

As noted previously, dumping of sewage sludge and industrial wastes ceased in the United States as a result of the Ocean Dumping Ban Act of 1998. Disposal of dredged material into ocean waters is controlled by regulations under the Marine Protection, Research, and Sanctuaries Act.

As a result of the Exxon Valdez oil spill in 1989, Congress passed the Oil Pollution Act of 1990. This legislation established more stringent requirements for preparedness and prevention of spills which were implemented by regulations promulgated by the U.S. Coast Guard. Industry and government were mandated to take measures to reduce the risk of a catastrophic release of oil into the marine environment. As a result of this law, transporters of oil and production facilities were required to develop and implement response plans, participate in preparedness drills, and maintain safe shipping and handling practices.

The International Convention for the Prevention of Pollution from Ships, commonly known as the MARPOL Treaty, also governs the release of oil, hazardous substances, and garbage into the marine environment. Annex I of MARPOL deals with the prevention of pollution by oil and places requirements on new oil tankers; Annex II governs noxious liquids carried in bulk; Annex III governs packaged harmful substances; Annex IV deals with the control of sewage and other "grey water"; and Annex V deals with garbage (which includes plastics, metal, glass, galley wastes and other materials.)

The conservation of fish and wildlife is addressed through a number of statutes such as the Fish and Wildlife Coordination Act, which requires the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to review any action that may affect any body of water and to make recommendations for the conservation of fish and wildlife. This includes (1) determining standards for water quality, (2) studying methods for abating and preventing pollution and recovering useful products, and (3) collecting and distributing data on the results of investigations. The Sustainable Fisheries Act of 1996 mandates the protection of essential fish habitat, including protection from impacts other than fishing. Living marine resource management within the 200 nautical mile Exclusive Economic Zone is the responsibility of the federal government and regional Fishery Management Councils. Nearshore fisheries within approximately 3 nautical miles from U.S. shores are managed by coastal states and interstate marine fisheries commissions. This joint and overlapping jurisdiction requires that these councils work together to protect fisheries resources. The Endangered Species Act directs federal agencies to ensure that actions they authorize or conduct are not likely to jeopardize the continued existence of endangered or threatened species, or result in the destruction or modification of their critical habitat. The Marine Mammal Protection Act provides a framework to develop specific protection programs for marine mammals.[30]

In a 1997 report, the National Research Council (NRC, 1997) concluded that "Developing a coherent framework to guide the nation's activities in the ocean and coastal regions is especially important in this time of growing national interest in the ocean, which includes heightened awareness of the need to protect it, along with recognition of new opportunities to utilize marine resources." The National Research Council recommended that the general elements of the framework include: (1) creation of a National Marine Council which would improve coordination and facilitate issue resolution among federal agencies, (2) creation of regional marine councils to coordinate and facilitate issue resolution at the local level, (3) enhancement of individual federal ocean/coastal programs, and (4) adoption of management tools by the regional councils and agencies, such as zoning and the creation of refuges, and user charges.

## Technical Basis for Action and Research Programs

Many of the ocean's functions and processes remain a mystery. For example, studies indicate that the relative contribution of pollutant loading from atmospheric deposition can be significant. Yet to date, knowledge of atmospheric and surface water processes is not sufficient to determine, with confidence, the overall magnitude and impact of atmospheric deposition on marine waters. Knowledge gaps such as this have been recognized by researchers, planners, and governments. U.S. government funding of coastal research was $673[31] million between 1991 and 1993 (NSTC, 1995). In 1997, the Department of Defense, the Navy, and the Army spent nearly $90 million in basic ocean research and more than $50 million in applied ocean research.[32] State and local governments, universities, private nonprofit institutions, and industrial organizations also spend additional large, but unquantified, sums annually for activities that support coastal science.

The Clean Water Act, the Comprehensive Environmental Response, Compensation and Liability Act, and the Oil Pollution Act of 1990 created an upsurge in research and development efforts. These efforts have focused on prevention, clean up, and spill mitigation. Recent emphasis has centered around the human health aspects of marine environmental quality and on

30 See the Living Resources Year of the Ocean Discussion Paper.
31 DOD contributions to coastal science are not included in this figure.
32 These funding levels do not cover marine environmental quality at the basic research level; those funding levels are included in Chemistry by DDR&E.

incremental improvements in technology, resource reduction, equipment, pollution prevention, and response strategies. Such improvements have resulted in new regulations and the transfer of "state-of-the-art" technologies to other industries and sectors. Agencies have incorporated risk analysis and cost benefit analysis into their programs to ensure they are "reality based." To offset decreases in funding, agencies are exploring more opportunities to increase cooperation and share resources while conducting research and developing management strategies in marine environmental quality. The challenge for the future will be to continue this trend and to find new ways for government, industry, academia and nonprofit organizations to cooperate.

Government agencies and private industry in partnership have developed new technologies to prevent and reduce the impacts of pollution. For example, there have been significant improvements in ensuring that ports and waterways are safe for navigation, and evolving technologies allow the collection and dissemination of near-real time tide and current data to aid ship captains and port authorities. Traditional methods to contain, recover, and remove oil from the marine environment have been refined and new ones developed to reduce the environmental impacts of oil spills. Technologies in the oil and gas industry have contributed to vast reductions in the volume of oil and hydrocarbons released into the marine environment from these activities. Traditionally, research has focused on understanding the transport, fate, and effects of various types of oil once a release has occurred. The prevention of spills is now a priority, and risk prioritization studies assist government and industry in the identification of potential sources and situations in which accidental releases might occur. This research may have a high return as many spills have similar causes. Once identified, procedures can be modified, technologies improved, and situations avoided to prevent, reduce, or to contain spills.

To advance coastal environmental science and to manage coastal resources more efficiently, an integrated understanding of fundamental physical, chemical, and biological processes based on site-specific comparative studies of coastal ecosystems is needed. These studies need to account for the impacts of activities in associated watersheds and airsheds. Increased communication between researchers and policy makers, greater coordination among the many organizations responsible for governance and management, and the application of knowledge derived from one study to other systems, are necessary to address marine environmental quality issues, determine the effectiveness of such measures, and assess the value of healthy marine waters.

### Assessment of the Success of Environmental Protection Programs and Early Warning Systems: Research and Monitoring

In the past, research has been stimulated by catastrophes such as fish kills in North Carolina and the Chesapeake Bay caused by *Pfieisteria piscicida* or toxic algal blooms. Research into the cause and prevention of such events has yielded technological advances and furthered understanding of the ocean. For example, after the Exxon Valdez spill, government agencies, industry, and the scientific community worked to develop methods to prevent oil spills and to effectively clean up spills if they do occur. After the 1987 and 1988 beach closings in New York and New Jersey, governments, industry and environmental organizations worked together to implement better management measures to reduce the volume of plastics and other wastes washing ashore and posing risks to human health. This reactive approach has serious implications in terms of monetary and environmental costs[33]. Standardized and regular monitoring of waterbodies, the use of water quality indicators, and implementation of best management practices can assist in the prevention of major environmental crises.

Because the ocean is "downstream" of all homes, communities, rivers, and watersheds, the health of the ocean is inextricably linked to the health of all the watersheds in the country. Identifying and reducing sources of pollution in "upstream" watersheds will help to maintain and improve the health of the ocean. In October of 1996, the Index of Watershed Indicators was released (U.S. EPA, 1996b). This Index is designed to give the American people ready access to information about water pollution in their communities, and is a compilation of information that presents the first national picture of watershed health in the United States.

The Index is comprised of fifteen indicators or "data layers" that focus on either the condition of aquatic resources (e.g., fish and wildlife consumption advisories, source water quality for drinking water systems), or the vulnerability of the resources to certain activities (e.g., urban runoff potential, hydrologic modification, or wetlands loss). The Index will continue to be modified, incorporating new information such as atmospheric deposition of pollutants and eutrophication conditions within coastal waters.

A fundamental improvement in the way the United States monitors its environment is required if it is to meet the challenges of the next several decades. Current monitoring programs do not provide integrated data across multiple natural resources at the various temporal and spatial scales needed to develop policies based on scientific understanding of ecosystem processes. Many monitoring programs identify violations of permits or provide status reports. These networks and programs can be better integrated to provide information needed for effective ecosystem management across a range of spatial scales (CENR, 1996). For example, the EPA is developing new testing methods, monitoring protocols, and water quality standards for pathogens in swimming areas to bring some uniformity to water quality warnings nationwide. Models for storm events are being developed which will enable local communities to predict when pathogen levels are likely to exceed water quality standards due to storm sewer overflows, thus enabling local officials to close beaches in order to prevent potential illness. Proactive monitoring efforts can identify potential problem areas, allowing steps to be taken prior to the collapse of an ecosystem or an event such as a fishkill.

### Management Approaches and the Long Term Challenges

Significant progress has been made since the early 1970s when many of the environmental laws protecting the ocean were passed (e.g., 1997 marked the 25th anniversary of the passage of the Clean Water Act, which is responsible for among other things for preventing

33 Coastal communities in New Jersey, for example, spend hundreds of thousands of dollars a year to remove marine debris from their beaches.

millions of gallons of raw sewage from entering the ocean). While much progress has been made in protecting the ocean, there is still much that is unknown about marine and coastal waters and much that needs to be done to protect them and their resources. The challenges may be daunting, but they are manageable. Stakeholders working together in partnerships is a key component to furthering progress in protecting, restoring, and maintaining the health and productivity of ocean resources. The major environmental problems that need continued emphasis through protection and enhancement programs include:

- nutrient over-enrichment: eutrophication
- pathogen contamination
- toxic chemicals
- alteration of freshwater inflow
- loss and degradation of habitat
- declines in fish and wildlife populations
- introduction of invasive species
- accidental spills

The control of non-point sources is key to making further progress in protection of ocean waters and habitat. Point source management measures have greatly improved water quality. Industrial and municipal discharges of waste water are controlled under the National Pollutant Discharge Elimination System and this effort has greatly reduced pollutants such as toxic chemicals and untreated sewage entering marine and coastal waters. However, major challenges remain in identifying causes and effects of various pollutant sources, addressing non-point sources of pollution, reducing wetlands loss, and finding and implementing solutions to these and the other coastal environmental problems listed above. Several examples of current actions to address these problems are provided below.

*Nutrient Over-enrichment*

Increased incidences in 1997 of fish kills and fish with lesions in tributaries to the Chesapeake Bay highlighted the growing national concern over the impacts of outbreaks of toxic *Pfiesteria piscicida* and other harmful algal blooms. Marine biotoxins and harmful algae represent a significant and expanding threat to human health, marine mammals, and fisheries resources throughout the United States. In addition to causing threats to public health and wildlife, the death and decay of algal blooms can lead to oxygen depletion in the water, resulting in widespread mortalities of fish, shellfish, and invertebrates. When oxygen depletion reaches a sufficiently high level, a "dead zone", or area where marine life cannot survive, may occur (as in the 7,000 square mile Gulf of Mexico dead zone).

There is strong evidence connecting harmful algal blooms with nutrient pollution—excessive nitrogen and phosphorus—in the water. In general, three significant sources of nutrient pollution have been identified: discharges from septic systems or sewage treatment plants, agricultural runoff from fertilizer or animal wastes, and air deposition of nitrogen, primarily from electric utility power plants and vehicle emissions. EPA, NOAA, and other federal agencies are working together with states to better understand and control harmful algal blooms in general and *Pfiesteria* in particular. This includes investigating what steps can be taken to reduce nutrient pollution in an effort to help prevent these outbreaks and their effects.

*Dredged Material Management*

The disposal of dredged material can be a controversial issue but one that must be addressed in order to keep the nation's ports and harbors open. An action plan developed by an interagency federal working group is now being implemented for improving the management of dredged materials to ensure timely and effective dredging while meeting environmental goals (U.S. DOT, 1994). Eighteen specific recommendations were identified for improving dredged material management, one of which was to improve federal agency coordination. Consequently, a National Dredging Team of federal agencies was created and Regional Dredging Teams are being established to assist in coordination and issue resolution. In addition, Local Planning Groups are being established which will include all interested stakeholders. These groups will be charged with developing long term dredged material management plans. Finally, a national dredging policy has been established which recognizes the need for timely and effective dredging to assure the viability of the nation's ports and that the aquatic environment is a critical asset which must be protected.

*Marine Debris Monitoring Program*

An interagency workgroup has developed a statistically-based national marine debris monitoring protocol to quantify amounts of debris and identify debris sources. Implementation of this protocol began in 1996, under the National Marine Debris Monitoring Program.[34] The use of a statistical protocol will assist in enabling the assessment and implementation of practices to prevent marine debris from entering marine waters. This in turn will protect marine life from harm due to marine debris and reduce costs borne by coastal communities to remove marine debris from beaches. To date, this monitoring program has been established on the Atlantic and Gulf Coasts, and similar programs have been adopted in other areas of the world such as Ireland, countries in the Caribbean, and Canada.

*Beaches Environmental Assessment, Closure and Health (BEACH) Program*

Swimming at the nation's coastal areas continues to be one of Americans' top vacation choices, yet many beaches are not adequately monitored for disease causing microorganisms. As a result, vacationers may be putting themselves at risk of illness, which can ruin more than just their day at the beach. Through the new BEACH Program, initiated in May 1997, EPA in partnership with state, tribal, and local governments will be working to keep beachgoers better informed of the water quality conditions where they are swimming. The adoption of updated water quality standards for bacteria, faster testing methods, enhanced monitoring and notification

34 Implemented by the Center for Marine Conservation under a grant from the U.S. EPA.

programs, and new scientific research into disease causing microorganisms under the BEACH Program, will help all beachgoers enjoy a happier, healthier time at the ocean.

*Uniform National Discharge Standards*

EPA has established a successful partnership with the Department of Defense to develop Uniform National Discharge Standards (UNDS) for liquid discharges from armed forces vessels. Currently, vessel discharges are regulated throughout the country under varying state water quality standards. These regulations will enable the Armed Forces to design vessels to one protective uniform standard, instead of attempting to conform to a diverse array of state standards.

The aim of the UNDS regulations is three-fold. First, uniform, environmentally protective standards will enhance the operational flexibility of Armed Forces vessels. Second, the Navy has an extensive research and development program aimed at constructing environmentally sound ships for the 21st century; the UNDS development process will stimulate innovative pollution prevention and control technologies that will help the Navy achieve this goal. Third, most of the innovative pollution prevention technologies developed for UNDS eventually will be available for transfer to the private sector.

*Accidental Spills*

The Oil Pollution Act has led to increased post-spill monitoring and improved restoration of affected habitats by facilitating recovery of damages by state and federal natural resource trustees from responsible parties. Money recovered by trustee agencies goes directly to restoring the resource or acquiring the equivalent resource on behalf of the public. Improvements in understanding how and when to use physical, chemical, and biological treatment of oil have helped to minimize the environmental damage caused by large oil spills. Improved response time to spills and technological advances have increased the opportunities for response agencies to limit the injury to marine resources. However, despite significantly reducing the risk, large-scale releases of oil continue to occur in the marine environment. There is an ongoing need to support research and development, and the training required to respond to oil spills. In addition, there is a recognized need to share technical capabilities with the international community through government-to-government requests or through the International Maritime Organization.

*Research Programs*

While progress is being made in identifying solutions to the complex problems confronting coastal waters, further progress requires fundamental research in a number of areas to address threats such as widespread over-enrichment and habitat degradation. Presently, research programs concerned with coastal systems and related processes/effects/controls are not guided by a comprehensive national framework. Such a framework could assess scientific priorities related to the most serious problems and optimize cooperation and coordination among federal agencies, states, local communities, and the academic community. Although significant advances in the scientific understanding of coastal ecosystems has been generated from numerous studies of specific systems during the past four decades (e.g., estuarine or wetland systems), the resulting knowledge of the fundamental properties and processes of this nation's coastal ecosystems suffers from the fragmented regional nature of these studies. For example, the impacts of air deposition on coastal and marine waters and the range of transport are just beginning to be understood.

*Watershed Protection and Community-Based Protection Programs*

The problems facing the nation's coastal waters are scientifically complex, are caused by a diverse array of factors, and involve resource intensive solutions. These coastal problems cannot be addressed through traditional regulatory approaches, although this is still a component of the solution. The new paradigm for the 1990s and into the next century is the need to look holistically at the entire resource being protected and to examine all of the contributing factors to the resource's degradation within the watershed. Linked with this comprehensive examination is the critical need to involve the community in the identification of problems and the implementation of solutions. One example of this approach is the National Estuary Program which is designed to protect and restore estuaries of national significance through partnerships between government agencies, industry, and the people who depend on those resources for their livelihood and quality of life. The National Estuary Program was established because conventional pollution control programs were not adequate for dealing with complex estuary problems. Management conferences of the established NEPs do not have regulatory authority, therefore, recommendations reached by consensus must be implemented by existing authorities at the federal, state, and local levels or through voluntary action. Another example is the Florida Keys National Marine Sanctuary Program, which developed a comprehensive water quality protection plan through a comprehensive examination of the entire "watershed, " and through communication with a broad array of stakeholders.

*Clean Water Action Plan*

Federal agencies are coordinating efforts to develop a comprehensive Clean Water Action Plan that builds on the successes of the Clean Water Act over the past 25 years and addresses three major goals: (1) enhanced protection from public health threats posed by water pollution; (2) more effective control of polluted runoff; and (3) promotion of water quality protection on a watershed basis (White House, 1997).

## CONCLUSION

The ocean plays a critical role in sustaining the life of this planet. Every activity, whether natural or anthropogenic, has far reaching impacts on the world at large. For example, excessive emissions of greenhouse gases may contribute to an increase the sea level, and cause potential flooding or an increase in storm frequency; this flooding can reduce wetland acreage and increase sediment and nutrient flows into the Gulf of Mexico, causing adverse impacts on water quality and reducing habitat for commercial fisheries. This in turn drives up the cost of fish at local markets nationwide.

The environment and the economic health of marine and coastal waters are linked at the individual, community, state, regional, national and international levels. The interdependence of the economy and the environment are widely recognized. The United States has moved beyond viewing health, safety, and pollution control as additional costs of doing business to an understanding of broader stewardship, recognizing that economic and social prosperity would be useless if the coastal and marine environments are compromised or destroyed in the process of development (President's Council on Sustainable Development, 1996).

Much about the ocean, its processes, and the interrelationship between land and sea is unknown. Many harvested marine resources depend upon a healthy marine environment to exist. Continued research is needed so that sound management decisions can be made when conflicts among users of ocean resources arise. Although much progress has been made over the past 30 years to enhance marine environmental quality and ocean resources, much work remains. The challenge is to maintain and continue to improve marine water quality as more people move to the coasts and the pressures of urbanization increase. Through education, partnerships, technological advances, research, and personal responsibility, marine environmental quality should continue to improve, sustaining resources for generations to come.

> "It does not matter where on Earth you live, everyone is utterly dependent on the existence of that lovely, living saltwater soup. There's plenty of water in the universe without life, but nowhere is there life without water. The living ocean drives planetary chemistry, governs climate and weather, and otherwise provides the cornerstone of the life-support system for all creatures on our planet, from deep-sea starfish to desert sagebrush. *That's why the ocean matters.* If the sea is sick, we'll feel it. If it dies, we die. Our future and the state of the oceans are one."

*Sea Change A Message of the Oceans*
Sylvia Earle, 1995.

## REFERENCES

Boyce et al. 1992. *American Economic Review*, December. 1992.

CDC. 1997. Centers for Disease Control. Report on seafood contamination from vessel sewage. November 1997.

Chambers, J.R. 1991. "Habitat degradation and fishery declines in the U.S." *In Coastal Wetlands*, S. H. Bolton and O.T. Magoon, eds. American Society of Civil Engineers, New York. 514 pp.

Coe, James, and Donald. B. Rogers. 1996. *Marine Debris, Sources, Impacts, and Solutions.* Springer. 432p.

Constanza, R., R. d'Arge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limberg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt. 1997. "The value of the world's ecosystem services and natural capital." *Nature* 387:253-260.

Constanza, R., et al. 1997. *Science*. May

Earle, Sylvia A. 1995. *Sea Change A Message of the Oceans*. G.P. Putman's Sons. 362p.

Hagler, B. 1993. Environmental Assessment by RCG, Inc.

Maiden, Alvin L. 1993. Final Report of Survey of Benthos: Delaware Estuary: from the area of the C & D Canal through Philadelphia to Trenton. Environmental Consulting Services. 191p.

Marine Mammal Commission. 1995. 1995 Annual Report to Congress.

NSTC. 1995. *Setting a New Course for U.S. Coastal Ocean Science.* National Science and Technology Council. 111p.

NMFS. 1996. Our Living Oceans—The Economic Status of U.S. Fisheries. 1996. U.S. Department of Commerce, NOAA National Marine Fisheries Service Tech. Memo. NMFS F/SPO-22.

NOAA. 1987. *The National Coastal Pollutant Discharge Inventory. Pollutant Discharge Concentrations for Industrial Point Sources*. National Oceanic and Atmospheric Administration.

NOAA. 1995. The National Shellfish Register of Classified Growing Waters. National Oceanic and Atmospheric Administration.

NOAA. 1997. National Fish (and Shellfish) Consumption Advisory Database. 1997 edition. July 1997. National Oceanic and Atmospheric Administration.

NOAA. 1997 (on-line). "Population: Distribution, Density and Growth". Thomas J. Culliton. NOAA's State of the Coast Project. National Oceanic and Atmospheric Administration.

Norse, Elliott. 1993. *Global Marine Biological Diversity*, Island Press, 1993, Ed., Available from the Center for Marine Conservation in Washington, DC.

NRDC. 1997. Testing the Waters. Natural Resources Defense Council. 1997. Website: http:\\ www.nrdc.org

NRC. 1994. *Priorities for Coastal Ecosystem Science*. National Research Council. Washington, DC: National Academy Press.

NRC. 1997. *Striking a Balance Improving Stewardship of Marine Areas.* National Research Council. 177p. Washington, DC: National Academy Press.

Ocean Planet Exhibit. 1995. Website: http://seawifs.gsfc.nasa.gov/OCEAN...L/peril_oil_pollution.html#sources

President's Council on Sustainable Development. 1996. Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future. Washington, D.C.: U.S. Government Printing Office.

"Saving our Bays, Sounds and the Great Lakes: the National Agenda."

Shipping Study. 1995. Shipping Study: The Role of Shipping & the Introduction of Multiple Species to Coastal Waters of the U.S. other than the Great Lakes and an Analysis of Control Options, April, 1995

Smith, Margurite and Sheryl Nance-Nach. September 1995. "The Best Places to Live in America." *Money* 24:9.

TBNEP Scientist. 1997. Tampa Bay National Estuary Program. Contact Holly Greening (813)893-2765.

Thibodeau, Francis R. and Bart D Ostro. 1981. "An Economic Analysis of Wetland Protection," *Journal of Environmental Management*. 12:19-30 (data converted from $1977).

Titus, James, et al. 1991. "Greenhouse Effects and Sea Level Rise: Potential Loss of Land and the Cost of Holding Back the Sea." *Coastal Management*. 19:171-204.

U.S. EPA. 1984. U.S. Environmental Protection Agency. Report to Congress: Non-point Source Pollution in the U.S. Environmental Protection Agency, Office of Water. EPA841-R-84-100. 123p.

U.S. EPA. 1991. Ocean Dumping Report to Congress. Environmental Protection Agency, EPA503-9-91-009. 58p.

U.S. EPA. 1994a. Report to Congress on Inventory of 403(c) Ocean Discharges. U.S. Environmental Protection Agency.

U.S. EPA. 1994b. 1992 Permit Compliance System (PCS). Washington, DC: Environmental Protection Agency, Office of Wastewater Enforcement and Compliance (OWEC).

U.S. EPA. 1994c. U.S. Environmental Protection Agency. National Water Quality Inventory. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds. EPA503-9-94-006.

U.S. EPA. 1996. Liquid Assets: A Summertime Perspective on the Importance of Clean Water to the Nation's Economy. Environmental Protection Agency, Office of Water. EPA800-R-96-002.

U.S. EPA. 1996b. Index of Watershed Indicators. The Index is available in a hard copy report, and on the Internet at http://www.epa.gov/surf/iwi. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. October 1996.

U.S. EPA. 1997. Key Management Issues discussion papers: A Nationwide Natural Resource Issue as reported by the Nation's Estuary Programs. Environmental Protection Agency. August 1997.

U.S. EPA. 1997b. 1995 Toxic Release Inventory. Office of Pollution Prevention and Toxics. EPA745-R-97-005. Environmental Protection Agency. April 1997.

U.S. DOT. 1994. The Dredging Process in the United States: An Action Plan for Improvement. Department of Transportation. December 1994.

Valigura, R.A., W.T. Luke, R.S. Artz and B.B. Hicks. 1996. Atmospheric Nutrient Input to Coastal Areas- Reducing the Uncertainties, NOAA Coastal Ocean Program Decision Analysis Series No. 9, June 1996. National Oceanic and Atmospheric Administration.

Watzin, M.C. and J.G. Gosselink. 1992. The fragile fringe: coastal wetlands of the Continental United States. Louisiana Sea Grant College Program, Louisiana State University, Baton Rouge, LA; U.S. Fish and Wildlife Service; and National Oceanic and Atmospheric Administration.

White House. 1997. Clean Water Initiative. White House Press Release October 18, 1997.

## DOMESTIC LEGAL REGIME

### Contents



The legal regime covering this topic is based on a collection of important federal statutory authorities. The following is a brief description of some of those authorities relating to marine environmental quality. The list is selective and is designed to illustrate some major marine environmental quality acts. The list is not meant to be comprehensive.

**Act to Prevent Pollution from Ships**, as amended, (APPS), 33 U.S.C. §§ 1901 et seq.

a. Oil and Noxious Liquid Substances.

The Act to Prevent Pollution from Ships as originally enacted implemented Protocols I and II, and Annexes I and II, of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL). Annex I of MARPOL establishes requirements to prevent the discharge of oil except in accordance with specific conditions. Annex II provisions cover the discharge of noxious liquid substances. (Annex III, which addresses the prevention of pollution by harmful substances carried by sea in packaged forms, or in freight containers, portable tanks or road and rail wagons, is implemented by the hazardous material transportation acts, 49 U.S.C. §§ 5101 et seq., inter alia.)

APPS applies to all U.S. flag ships anywhere in the world and to all foreign flag vessels operating in the navigable waters of the United States or while at a port or terminal under the jurisdiction of the United States. The oil and noxious liquid substances provisions apply only to seagoing ships. The regulations implementing Annex I and Annex II of MARPOL limit discharges of oil and noxious substances, establish report requirements for discharges, and establish specific requirements for monitoring equipment and record keeping aboard vessels. In particular, the regulations require that vessels covered by APPS and MARPOL keep Oil Record Books in which all discharges, disposal and transfers of oil are kept.

b. Garbage and Plastics.

APPS was amended by the Marine Plastic Pollution Research and Control Act of 1987, which implemented the provisions of Annex V of MARPOL relating to garbage and plastics. Annex V of MARPOL and the regulations implementing it apply to all vessels, whether seagoing or not, regardless of flag on the navigable waters of the United States and in the exclusive economic zone of the United States. It applies to U.S. flag vessels wherever they are located.

Under the regulations implementing APPS, the discharge of plastics, including synthetic ropes, fishing nets, plastic bags and biodegradable plastics, into the water is prohibited. Discharge of floating dunnage, lining and packing materials is prohibited in the navigable waters and in areas offshore less than 25 nautical miles from the nearest land. Food waste or paper, rags, glass, metal, bottles, crockery and similar refuse cannot be discharges in the navigable waters or in waters offshore inside 12 nautical miles from the nearest land. Finally, food waste, paper, rags, glass, and similar refuse cannot be discharged in the navigable waters or in waters offshore inside three nautical miles from the nearest land. There are some exceptions for emergencies. Under APPS, the definition of ship includes fixed or floating platforms. There are separate garbage discharge provisions applicable to these units. For these platforms, and for any ship within 500 meters of these platforms, disposal of all types of garbage is prohibited. Additionally, all manned, oceangoing U.S. flag vessels of 12.2 meters or more in length engaged in commerce, and all manned fixed or floating platforms subject to the jurisdiction of the United States, are required to keep records of garbage discharges and disposals.

**Clean Air Act**, as amended, (CAA), 42 U.S.C. §§ 7401 et seq.

The CAA is divided into six principal subchapters. Subchapter I addresses air pollution from stationary sources and requirements for states to develop plans to meet health-based standards. (Also, subchapters IV-A, V and VI deal with specific stationary source programs.) Part A of subchapter I contains the basic provisions to control air pollution from stationary sources. Based on statutory criteria, the Environmental Protection Agency (EPA) is required to list criteria pollutants and for each such pollutant establish primary and secondary national ambient air quality standards (NAAQSs). Each state (or EPA, if the state declines) must submit to EPA a state implementation plan with individual emission limitations and procedures to ensure timely attainment of the NAAQSs for each air quality region within the state.

Part A also includes, among other things, key specialized stationary source programs. For example, EPA must adopt emission standards for categories of hazardous air pollutants (HAPs) in accordance with a specified schedule. (HAPs are listed in the statute.) Section 112(m) of the CAA directs EPA, in cooperation with the National Oceanic and Atmospheric Administration, to assess the extent of atmospheric deposition of HAPs (and, in the discretion of EPA, other air pollutants) to the Great Lakes, Chesapeake Bay, Lake Champlain and coastal waters (defined, for purposes of the subsection, as estuaries under the National Estuary Program and National Estuarine Research Reserves). The assessment program is to, among other things, establish a monitoring network, investigate sources and deposition rates, evaluate any adverse effects to public health or the environment, and assess the contribution of such deposition to violations of water quality standards established pursuant to the Clean Water Act. EPA is to submit biennial reports to Congress on the matter and issue a determination as to whether the other provisions of section 112 are adequate to prevent serious adverse effects to public health and serious or widespread environmental effects associated with HAP deposition. If EPA determines that the authorities of section 112 are not adequate, the agency is directed to promulgate such further emission standards or control measures under section 112 as may be necessary and appropriate.

Part B of Subchapter I is repealed; Part C addresses the "prevention of significant deterioration" program, designed to limit the deterioration of air quality in regions with air cleaner than the minimum federal air quality standards. Part D addresses plan requirements for non-attainment areas.

Subchapter II addresses emission standards for moving sources.

Subchapter III addresses administration and enforcement. Amendments to Subchapter III made in 1990 require EPA, following consultation with the Department of the Interior and the U.S. Coast Guard, to establish regulatory requirements to control air pollution from Outer Continental Shelf sources (except in the Gulf of Mexico, over which the Department of the Interior has jurisdiction).

Subchapter IV-A addresses acid deposition. This subchapter was added in 1990 to reduce emissions of pollutants, primarily sulfur dioxide and nitrogen dioxide, leading to the formation of acid precipitation.

Subchapter V addresses permits, requiring each state to submit to EPA for approval a permit program covering basically every pollution source subject to the CAA. If a state fails to submit and implement an approved program, EPA is to step in.

Subchapter VI addresses stratospheric ozone depletion.

The CAA also establishes a great waters program, which looks specifically at the impacts of air deposition of nutrients and toxics in coastal waters.

**Clean Vessel Act of 1992**, subtitle F, §§ 5601 to 5608, of Title V of Pub. L. 102-587, amending 16 U.S.C. §§ 777c and 777g and enacting 33 U.S.C. §1322 note

The purpose of the Clean Vessel Act is to provide funds to states for the construction, renovation, operation and maintenance of pumpout stations and waste reception facilities. The Act requires the Department of the Interior (DOI) to issue guidance on what constitutes adequate and reasonably available pumpout facilities and waste reception facilities. In order to receive a grant, coastal states are to conduct a survey to determine the number and location of such stations and facilities and the number of recreational vessels in its coastal waters with toilets and develop and submit to the DOI for approval a plan for any construction or renovation necessary to provide adequate and reasonably available stations and facilities. Funding authorization for such grants expired in FY 1997.

**Coastal Barrier Resources Act of 1982**, as amended, (CBRA), 16 U.S.C. §§ 3501 et seq.

The purpose of CBRA is to promote more appropriate use and conservation of coastal barriers along the Atlantic, Gulf, and Great Lakes coastlines. "Coastal barriers" are defined as bay barriers, barrier islands, and other geological features composed of sediment that protect landward aquatic habitats from direct wind and waves. They provide essential habitats for wildlife and marine life, natural storm buffer zones, and areas of scientific, recreational, historic, and archeological significance. CBRA seeks to minimize the loss of human life, wasteful federal expenditures on shoreline development, and damage to wildlife, marine life, and other natural resources by restricting future Federal financial assistance, establishing the coastal barrier resources system (CBRS), and considering the means of achieving long-term conservation of barrier resources.

**Coastal Zone Management Act of 1972**, as amended, (CZMA), 16 U.S.C. §§ 1451 et seq.

The CZMA strives to preserve and protect coastal zone resources. Through the CZMA, states are encouraged to develop coastal zone management programs (CZMPs) that allow economic growth that is compatible with the protection of natural resources, the reduction of coastal hazards, the improvement of water quality, and sensible coastal development. The CZMA provides financial and technical incentives for coastal states to manage their coastal zones consistent with CZMA standards and goals.

State coastal zones include the coastal waters and adjacent shorelands that extend inland to the extent necessary to control activities that have a direct, significant impact on coastal waters. For federal approval, a CZMP must: 1) identify the coastal zone boundaries; 2) define the permissible land and water uses within the coastal zone that have a direct and significant impact and identify the state's legal authority to regulate these uses; 3) inventory and designate areas of particular concern; 4) provide a planning process for energy facilities; 5) establish a planning process to control and decrease shoreline erosion; and 6) facilitate effective coordination and consultation between regional, state, and local agencies. The National Oceanic and Atmospheric Administration grants the requisite federal approvals for CZMPs and oversees subsequent implementation of the programs.

A state with a federally approved CZMP is eligible for financial assistance and gains a legal mechanism to control Federal permits and activities that affect the state's coastal zone. Federal agency activities that affect any land or water use or natural resource of the coastal zone must be consistent to the maximum extent practicable with the enforceable policies of the state CZMP. Federally licensed or permitted activities that affect any land or water use or natural resource of the coastal zone must be consistent with the enforceable policies of the CZMP. The Secretary, however, can override a state's determination of inconsistency if the Secretary finds that the federally licensed or permitted activity is consistent with the objectives of the CZMA or is otherwise necessary in the interest of national security.

The CZMA establishes the National Estuarine Research Reserve System (NERR). States may seek Federal approval and designation of certain areas as NERRs if the areas qualify as biogeographic and typological representations of estuarine ecosystems and are suitable for long-term research and conservation. Once an area is designated as a NERR, federal financial assistance is available for acquisition of property and management, research, and education related to the NERR.

See also section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990.

**Comprehensive Environmental Response, Compensation, and Liability Act of 1980**, as amended, (CERCLA), 42 U.S.C. §§ 9601 et seq.

Hazardous substances that are toxic to living organisms result from industrial processes and are released into the environment either intentionally or by accident. CERCLA is designed to respond to these releases and protect public health and environmental quality including natural resources.

CERCLA provides for the following two possible actions to protect the public and the environment from the harmful effects of a hazardous substance spill. Any combination of these two may be used at a particular spill.

1) Response—CERCLA authorizes the Environmental Protection Agency (EPA) to clean up the spilled substance either at the expense of the responsible party or with funds from the Superfund.

CERCLA § 104(a)(1). Example of steps include: dredging contaminated sediments, repairing leaking containers, collecting rain water runoff and relocating displaced residents.

2) Damages for natural resource injuries—CERCLA authorizes the trustees for natural resources, to seek damages from responsible parties to restore or replace natural resources injured by exposure to hazardous substances. CERCLA
§§ 107(a)(4)(C) and 107(f).

**Federal Water Pollution Control Act**, as amended, also called the **Clean Water Act**, as amended (CWA), 33 U.S.C. §§ 1251 et seq.

The CWA establishes the basic scheme for restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. The primary mechanism in the CWA regulating the discharge of pollutants is the National Pollutant Discharge Elimination System (NPDES), which is administered by the Environmental Protection Agency (EPA). Under the NPDES program, a permit is required from EPA or an authorized state for the discharge of any pollutant from a point source into the waters of the United States. This includes discharges associated with oil and gas development on federal leases beyond state waters. An NPDES permit for certain stormwater discharges also is required. Permit discharge limits are technology-based and, where technology-based limits would not protect desired water quality for a particular water body in which the discharge takes place, based on state water quality standards, which are developed by the states using EPA guidance and are intended to protect the designated uses of the water body. In the case of discharges to the territorial sea or beyond, permits are also subject to the ocean discharge criteria developed under section 403 of the act. Permits for discharges into the territorial sea or internal waters may be issued by states following approval of their permit program by EPA; in the absence of an approved state permit program, and for discharges beyond the territorial sea, EPA is the permit-issuing authority.

The CWA was amended in 1987 to include the current non-point source (NPS) program. Under this program (section 319), states must develop management programs to address NPS runoff, including the identification of best management practices and measures. In addition, section 319 authorizes grants to assist the states in implementing their approved management programs.

The CWA generally prohibits discharges of oil and hazardous substances into coastal or ocean waters except where permitted under the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships. The U.S. Coast Guard (USCG) investigates and responds to discharges of oil and hazardous substances into coastal or ocean waters in accordance with the National Contingency Plan (NCP). The USCG, with the cooperation of EPA, generally administers the NCP when oil or a hazardous substance is discharged into coastal or ocean waters. Regional contingency plans and area contingency plans are developed to implement the NCP.

The CWA (section 312) requires vessels with installed toilet facilities and operating on the navigable waters of the U.S. to contain operable marine sanitation devices certified as meeting standards and regulations promulgated under section 312. Section 312 also allows establishment of zones where discharge of sewage from vessels is completely prohibited. Amendments made to section 312 in 1996 will require, where appropriate, the use of marine pollution control devices for operational, non-sewage, discharges from vessels of the Armed Forces.

Publicly owned sewage treatment facilities must, at a minimum, meet effluent reductions by secondary treatment, except for certain facilities discharging to coastal waters for which EPA has approved a waiver under section 301(h).

Section 320 of the CWA establishes the National Estuary Program, which uses a consensus-based approach for protecting and restoring estuaries. There are currently 28 estuaries in the program.

The Army Corps of Engineers (COE) implements the section 404 permit program. Under section 404, a permit is required for the discharge of dredged or fill materials into the waters of the U.S. that lie inside of the baseline for the territorial seas and fill materials into the territorial seas within three miles of shore. Although COE has the permitting responsibility under the section 404 program except in certain waters of two states (Michigan and New Jersey), which have assumed the authority, EPA is authorized to review and comment on the impact of proposed dredge and fill activities and to prohibit discharges that would have an unacceptable impact on municipal water supplies, shellfish beds and fishery areas, wildlife and recreational areas. EPA, in consultation with COE, is charged with developing guidelines to be used in evaluating discharges subject to section 404. (See 40 C.F.R. Part 230.) The section 404 permit requirement is the cornerstone for the current wetlands regulatory program. If COE or EPA determines that a certain property is a jurisdictional wetlands, no one can discharge dredged or fill materials into it without a section 404 permit. COE and EPA also have cooperative agreements with the Natural Resources Conservation Service and rely on its determinations as to the presence of wetlands on agricultural lands.

**Fish and Wildlife Coordination Act**, 16 U.S.C. §§ 661 et seq.

The Fish and Wildlife Coordination Act requires that whenever a federal agency proposes to impound, divert or otherwise control or modify a body of water for any purpose (including issuing permits or licenses), the agency must consult with the U.S. Fish and Wildlife Service, the National Marine Fisheries Service and the relevant state wildlife resource agency regarding prevention of loss or injury to wildlife resources.

**National Coastal Monitoring Act,** as amended, 33 U.S.C. §§ 2801 et seq.

The National Coastal Monitoring Act, also known as title V of the Marine Protection, Research, and Sanctuaries Act of 1972, provides joint authority for the Environmental Protection Agency and the National Oceanic and Atmospheric Administration to establish a comprehensive national program for consistent monitoring of the nation's coastal ecosystems. The title provides that the program is to include, but is not limited to: identification and analysis of the status of environmental quality in the nation's coastal ecosystems (including, but not limited to, assessment of ambient water quality, benthic environmental quality, and health and quality of living resources); identification of sources of environmental degradation affecting the nation's coastal ecosystems; assessment of the impact of governmental programs and management strategies and measures designed to abate or prevent the environmental degradation of the nation's coastal ecosystems; assessment of the accumulation of floatables along coastal shorelines; analysis of short-term and long-term trends in the environmental quality of the nation's coastal ecosystems; and the development and implementation of intensive coastal water quality monitoring programs (after designation of intensive coastal monitoring areas).

**National Contaminated Sediment Assessment and Management Act**, 33 U.S.C. § 1271

Section 1271 of the National Contaminated Sediment Assessment and Management Act requires the Environmental Protection Agency, in consultation with NOAA and the Department of the Army, to conduct a comprehensive national survey of data regarding sediment quality and a continuing program to assess such quality.

**National Environmental Policy Act of 1969 (NEPA)**, 42 U.S.C. §§ 4321 et seq.

NEPA requires, among other things, that for every major federal action significantly affecting the quality of the human environment, the agency prepare a detailed statement regarding:

(i) the environmental impact of the proposed action;

(ii) any adverse environmental effects that cannot be avoided should the proposal be implemented;

(iii) alternatives to the proposed action;

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and

(v) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

This document is called an environmental impact statement (EIS). It is in essence a detailed discussion of the environmental consequences of a given proposed agency action, and it must be made available to the agency decision-maker on the matter, the public, and other agencies.

Under the regulations implementing NEPA, an environmental document called an environmental assessment (EA) is used to determine whether a federal action rises to the level of a "major federal action significantly affecting the quality of the human environment," thus triggering the requirement of preparation of an EIS. Based on the EA, if an action does not rise to that level, a finding of no significant impact (FONSI) is made.

**National Marine Sanctuaries Act**, as amended, (also known as Title III of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended), 16 U.S.C. §§ 1431 et seq.

The National Marine Sanctuaries Act, as amended, authorizes the Department of Commerce to designate as national marine sanctuaries areas of the marine environment of special national significance due to their conservation, recreational, ecological, historical, research, educational or aesthetic qualities. The Act provides authority for comprehensive and coordinated conservation and management of these marine areas. It provides for civil penalties for violation of the act or regulations or permits issued under it and for civil suits to recover damages if sanctuary resources are injured or destroyed.

**Nonindigenous Aquatic Nuisance Prevention and Control Act**, as amended, 16 U.S.C. §§ 4701 et seq.

The Nonindigenous Aquatic Nuisance Prevention and Control Act, as amended, directs the Secretary of the department that houses the U.S. Coast Guard (USCG) (currently the Department of Transportation) to issue regulations to prevent the introduction and spread of aquatic nuisance species into the Great Lakes through ballast water. These regulations are to be issued in consultation with the Aquatic Nuisance Task Force, composed, inter alia, of the Under Secretary of Commerce for Oceans and Atmosphere, the Director of the U.S. Fish and Wildlife Service, the Administrator of the Environmental Protection Agency, the Commandant of the USCG and the Assistant Secretary of Army (Civil Works). Civil and criminal penalties are available for regulatory violations.

The Act also requires the task force to implement a prevention, monitoring and control program for aquatic nuisance species in U.S. waters. States can develop comprehensive aquatic nuisance species management plans, which can be implemented with federal grants and financial assistance if the plans are approved by the task force or the Assistant Secretary of the Army (Civil Works).

The act further requires the Departments of Defense and Transportation to implement ballast water management programs for seagoing Department of Defense and USCG vessels to minimize risk of introduction of non-indigenous species from releases of ballast water. The act also requires the Departments of the Interior and Commerce to conduct a ballast water management demonstration program to demonstrate preventive technologies and practices.

**Ocean Dumping Act**, as amended, (ODA) (Titles I and II of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended), 33 U.S.C. §§ 1401 et seq.

The ODA provides the basic authority for the Environmental Protection Agency (EPA) and the Corps of Engineers (COE) to regulate ocean dumping (Title I) and for the Department of Commerce (DOC), through the National Oceanic and Atmospheric Administration, to carry out research on the effects on ocean systems of ocean dumping and other man-induced changes (Title II).

Title I of the ODA: 1) prohibits any person, without a permit, from transporting from the U.S. any material for the purpose of dumping it into ocean waters (defined to mean those waters of the open seas lying seaward of the baseline from which the territorial sea is measured), and 2) in the case of a vessel or aircraft registered in the U.S. or flying the U.S. flag or in the case of a U.S. agency, prohibits any person, without a permit, from transporting from any location any material for the purpose of dumping it into ocean waters. Title I also prohibits any person, without a permit, from dumping any material transported from a location outside the U.S. into the territorial sea, or the contiguous zone extending 12 nautical miles seaward from the baseline of the territorial sea to the extent that it may affect the territorial sea or the territory of the U.S. EPA issues permits regulating the ocean dumping of all material except dredged material, which is permitted by COE. COE permits are subject to EPA review and concurrence. The specific environmental criteria used to evaluate permit applications are developed by EPA; in the case of dredged material, this is done in coordination with COE.

In developing criteria for the evaluation of permit applications, the statute provides that the following must be considered: 1) the need for the proposed dumping; 2) the effect of the dumping on human health and welfare, fisheries resources, marine ecosystems, and shorelines; 3) the persistence and permanence of the effects of the dumping; 4) the effect of dumping particular volumes and concentrations; 5) appropriate locations and methods of disposal or recycling, including land-based alternatives; and 6) the effect on alternate uses of the oceans.

The ocean dumping of sewage sludge and industrial waste is prohibited. In addition, radiological, chemical or biological warfare agents, high-level radioactive waste, or medical waste may not be dumped. States may generally adopt and enforce requirements for ocean dumping activities that occur in their jurisdictional waters.

Title II of the ODA requires the DOC, in coordination with the department in which the U.S. Coast Guard is operating and EPA, to conduct a comprehensive and continuing program of monitoring and research on the effects of dumping of material into ocean or other coastal waters or into the Great Lakes. The title further requires the DOC, in close consultation with other appropriate departments, to conduct a comprehensive and continuing program of research into the possible long-range effects of pollution, overfishing and man-induced changes of ocean ecosystems. The title specifies that the program must include continuing monitoring programs to assess the health of the marine environment, including but not limited to the monitoring of bottom oxygen concentration contaminant levels in biota, sediments and the water column, diseases in fish and shellfish, and changes in types and abundance of indicator species.

**Oil Pollution Act of 1990 (OPA)**, 33 U.S.C. §§ 2701 et seq., inter alia

OPA amends section 311 of the Federal Water Pollution Control Act (the Clean Water Act or CWA), 33 U.S.C. 1321 et seq., to clarify federal response authority, increase penalties for spills, establish U.S. Coast Guard response organizations, require tank vessel and facility response plans, and provide for contingency planning in designated areas. OPA, however, does not preempt states' rights to impose additional liability or other requirements with respect to the discharge of oil within a state or to any removal activities in connection with such a discharge.
OPA is a comprehensive statute designed to expand oil spill prevention, preparedness, and response capabilities of the federal government and industry. OPA establishes a new liability regime for oil pollution incidents in the aquatic environment and provides the resources necessary for the removal of discharged oil. OPA consolidates several existing oil spill response funds into the Oil Spill Liability Trust Fund (Trust Fund), resulting in a $1-billion fund to be used to respond to, and provide compensation for damages caused by, discharges of oil. In addition, OPA provides new requirements of response planning by both government and industry and establishes new construction, manning, and licensing requirements for tank vessels. OPA also increases penalties for regulatory noncompliance and broadens the response and enforcement authorities of the federal government.

Title I of OPA contains liability provisions governing oil spills modeled after the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601 et seq., and section 311 of the CWA. Specifically, section 1002(a) of OPA provides that the responsible party for a vessel or facility from which oil is discharged, or which poses a substantial threat of a discharge, is liable for:

- certain specified damages resulting from the discharged oil; and
- removal costs incurred in a manner consistent with the National Contingency Plan.

The scope of damages for which there may be liability under section 1002 of OPA includes:

- natural resource damages, including the reasonable costs of assessing these damages;
- loss of subsistence use of natural resources;
- real or personal property damages;
- net loss of tax and other revenues;
- loss of profits or earning capacity; and
- net cost of additional public services provided during or after removal actions.

**<u>Rivers and Harbors Act of 1899</u>**, as amended, (RHA), 33 U.S.C. §§ 401 <u>et seq</u>.

The RHA prohibits the unauthorized obstruction of navigable waters of the United States. The construction of any structure or the excavation or fill in the navigable waters of the United States is prohibited without a permit from the Army Corps of Engineers. The Act also prohibits the discharge of refuse and other substances into navigable waters, but has been largely superseded by the Clean Water Act.

**<u>Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990,</u>** 16 U.S.C. § 1455b

Section 6217 of Coastal Zone Act Reauthorization Amendments of 1990 required the 29 coastal states with federally approved coastal zone management plans in 1990 to develop and submit coastal non-point source (NPS) pollution control programs for approval by the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA). The submissions were to lay out a state program to restore and protect coastal waters by providing for the implementation of management measures developed by EPA. The statute gave states 30 months from the date of publication of the final EPA guidance to submit a program to NOAA and EPA for approval. The statute required that penalties be levied if a state failed to submit an approvable program within the allotted time. There has been no need to assess penalties as yet, as all the states have submitted programs found to be conditionally approvable.

**<u>Shore Protection Act of 1988</u>**, 33 U.S.C. §§ 2601 <u>et seq</u>.

Under the Shore Protection Act of 1988, municipal or commercial waste cannot be transported by a vessel in coastal waters without a permit from the Department of Transportation. Municipal or commercial waste includes solid waste as defined by the Resource Conservation and Recovery Act, but excludes waste generated by the vessel during normal operations, construction debris, dredged or fill material, and sewage sludge. The loading, securing and off loading of these wastes must be conducted in a manner to minimize any waste deposited into coastal waters.

**<u>Title IV of the Marine Protection, Research, and Sanctuaries Act of 1972</u>**, as amended, 16 U.S.C. §§ 1447a to 1447f

The purpose of Title IV of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended, is to establish regional research programs, under effective Federal oversight, to: 1) set priorities for regional marine and coastal research in support of efforts to safeguard the water quality and ecosystem health of each region; and 2) carry out such research through grants and improved coordination. The regions are: the Gulf of Maine, greater New York bight, mid-Atlantic, South Atlantic, Gulf of Mexico, California, North Pacific, Alaska and insular Pacific.

Specifically, a regional marine research board is to be established for each region, consisting of eleven members -- three appointed by the National Oceanic and Atmospheric Administration (NOAA), two by the Environmental Protection Agency (EPA), and six by governors of states located within the region. Each board is to develop and submit to NOAA and EPA for approval a comprehensive marine research plan for the region, to be updated at least every four years. Each board is also to: 1) provide a forum for coordinating research among research institutions and agencies, 2) provide for review and comment on its research plan by affected users and interests, 3) ensure that the highest quality of research projects will be conducted to carry out the plan; and 4) prepare, for transmittal to Congress by NOAA and EPA, a periodic report on the marine environmental research issues and activities within the region.

Each marine research plan is to include: 1) an overview of the environmental quality conditions in the coastal and marine waters of the region and expected trends in these conditions; 2) a comprehensive inventory and description of all marine research related to water quality and ecosystem health expected to be conducted during the four-year term of the plan; 3) a statement and explanation of the marine research needs and priorities applicable to the marine and coastal waters of the region over the upcoming ten-year period with emphasis on the upcoming three-to-five-year period; 4) an assessment of how the plan will incorporate existing marine, coastal and estuarine research and management in the region; and 5) a general description of marine research and monitoring objectives and timetables for achievement through the funding of projects under this title so as to meet the priorities specified in the plan in accordance with 3) above.

Each board may annually submit a grant application to NOAA to fund projects aimed at achieving the research priorities set forth in the relevant research plan. The title provides that the boards shall cease to exist on October 1, 1999, unless extended by Congress. Authorization of appropriations for the title expired at the end of fiscal year 1996.

**Other Statutes Relating to Marine Environmental Quality:**

- Endangered Species Act of 1973, as amended, 16 U.S.C. §§ 1531 et seq.: See Ocean Living Resources Year of the Ocean Discussion Paper.

- Magnuson-Stevens Fishery Conservation and Management Act, as amended, 16 U.S.C. §§ 1801 et seq.: See Ocean Living Resources Year of the Ocean Discussion Paper.

- Marine Mammal Protection Act, as amended, 16 U.S.C. §§ 1361 et seq.: See Ocean Living Resources Year of the Ocean Discussion Paper.

- Outer Continental Shelf Lands Act, as amended, 43 U.S.C. §§ 1331 et seq.: See Ocean Energy and Mineral Resources Year of the Ocean Discussion Paper.

- Hazardous Materials Transportation acts, as amended, 49 U.S.C. §§ 5101 et seq., inter alia, which, inter alia, implement Annex III of MARPOL (prevention of pollution by harmful substances carried by sea in packaged forms, or in freight containers, portable tanks or road and rail wagons).

- Solid Waste Disposal Act, as amended, also known as the Resources Conservation and Recovery Act, 42 U.S.C. §§ 6901 et seq., which governs treatment, storage and disposal of solid and hazardous waste. The act also has as a goal the reduction of generation of hazardous waste.

- Toxic Substances Control Act, as amended, 15 U.S.C. §§ 2601 et seq., which is the first comprehensive legislation governing toxic substances, including providing the Federal government authority to prevent unreasonable risk of injury to health or the environment, particularly imminent hazards.

- Water Resources Development acts, 33 U.S.C. §§ 2280 et seq., inter alia, which are the Corps of Engineers authorization acts. Among other things, mitigation of damages to fish and wildlife resources resulting from water resources projects is addressed.

## LIST OF ACRONYMS

| | |
|---|---|
| CWA | Clean Water Act |
| DOT | Department of Transportation |
| EPA | Environmental Protection Agency |
| MMC | Marine Mammal Commission |
| NEP | National Estuary Program |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NRC | National Research Council |
| UNDS | Uniform National Discharge Standards |
| U.S.C. | United States Code |

# 1998 Year of the Ocean

## COASTAL TOURISM AND RECREATION

**Contents**

## INTRODUCTION

Coastal tourism and recreation are important parts of the largest and most rapidly growing activity in the world--- international tourism. Tourism and recreation-related development is one of the major factors shaping development patterns in the coastal zones of the United States. Foreign tourism to the United States, much of it coastal-motivated, provides significant economic benefits that relate directly to the U.S. position in an increasingly competitive global economy (Houston, 1995). Hence, any analysis of U.S. interests in coasts and oceans must take account of this very significant grouping of interrelated activities. Government at all levels must assume appropriate proactive roles to shape and guide coastal tourism development. This paper reviews the importance of coastal tourism and recreation to the United States and its citizens and identifies gaps where action is needed.

In this presentation, the term "coastal tourism and recreation" embraces the full range of tourism, leisure, and recreationally oriented activities that take place in the coastal zone and the offshore coastal waters. These include coastal tourism development (hotels, resorts, restaurants, food industry, vacation homes, second homes, etc.), and the infrastructure supporting coastal development (retail businesses, marinas, fishing tackle stores, dive shops, fishing piers, recreational boating harbors, beaches, recreational fishing facilities, and the like). Also included is ecotourism and recreational activities such as recreational boating, cruises, swimming, recreational fishing, snorkeling and diving. Coastal tourism and recreation in this presentation likewise includes the public and private programs affecting all the aforementioned activities.

Of all the activities that take place in coastal zones and the near-shore coastal ocean, none is increasing in both volume and diversity more than coastal tourism and recreation. Both the dynamic nature of this sector and its magnitude demand that it be actively taken into account in government plans, policies, and programs related to the coasts and ocean. Indeed, virtually all coastal and ocean issue areas affect coastal tourism and recreation either directly or indirectly. Clean water, healthy coastal habitats, and a safe, secure, and enjoyable environment are clearly fundamental to successful coastal tourism. Similarly, bountiful living marine resources (fish, shellfish, wetlands, coral reefs, etc.) are of critical importance to most recreational experiences. Security from risks associated with natural coastal hazards such as storms, hurricanes, tsunamis, and the like is a requisite for coastal tourism to be sustainable over the long term.

The United States is currently a major beneficiary of international tourism, which is the most rapidly expanding economic sector in the world today. In 1995, travel and tourism are estimated to have provided $746 billion to the U.S. gross domestic product (GDP), about 10% of U.S. output, making travel and tourism the second largest contributor to GDP just behind combined wholesale and retail trade (Houston, 1995). Travel and tourism is America's largest employer, employing 14.4 million annually (in contrast, for example, all U.S. manufacturing industries from IBM to General Motors to Intel employ only 18 million people (Houston, 1995).

Although precise figures are difficult to obtain, estimates based on foreign tourism data from coastal states like Florida and California suggest that as many as one-half of foreign tourists are drawn to the U.S. because of the attractive coastal shorelines and beaches found in this country. In spite of the attractiveness of inland national parks like Yellowstone and the Grand Canyon, 85 percent of all U.S. tourist revenues are earned by coastal states and 90 percent of all tourist spending occurs in these states (Houston, 1996).

However, attractive coastal amenities exist in many foreign locations as well. Indeed, tourists from Northern Europe can travel to Mediterranean or Caribbean beaches at least as easily as they can to U.S. coastal resorts. Japanese tour groups have choices that include Australia's Gold Coast or Fiji's very attractive beaches in addition to those found in Hawaii. Coastal tourism is becoming a highly competitive business as nations actively seek to draw increased numbers of visitors (and increased foreign earnings) to their shores. Moreover, given today's rapid pace of communications, the existence of poor water quality or degraded or eroding beaches is quickly communicated among networks of travel agents and others in the tourism marketing business.

The nation's coasts and coastal waters are of great value to the American people both for their personal enjoyment and for the economic benefits these areas generate for coastal communities, coastal states, and for the nation as a whole—benefits that can be sustainable indefinitely with proper foresight and enlightened public policies. But, these benefits cannot be taken for granted. Coastal habitats and the resources they support must be protected and, where necessary, restored. The quality of coastal waters must be maintained at a sufficiently high level to provide a healthy and aesthetically pleasing environment for water-based recreation. Similarly, swimming beaches must be maintained at an attractive and functional level even in the presence of accelerating sea-level rise and associated erosion, and possible increases in the frequency of coastal storms. The maintenance of safe conditions for recreational boating and underwater recreation (e.g., adequately marked waterways, timely weather information, rescue services, hyperbaric chambers, etc.) is also of great importance.

## Organization of the Paper

Following a review of the importance of coastal tourism and recreation to the U.S. economy, including the contribution of foreign coastal tourism, a description of the existing policy framework affecting coastal tourism and recreation is provided. This covers such topics as:

- governmental promotional efforts regarding tourism;
- coastal planning and management (especially for siting of tourism facilities and provision for public access);
- efforts at attaining clean water and healthy coastal ecosystems;
- beach restoration programs;
- management of coastal security (including natural hazards and marine safety); and
- special management challenges posed by ecotourism activities.

A discussion of the adequacy of the existing management framework in each of these areas is provided. Existing tools, programs, and arrangements for achieving sustainable coastal tourism are addressed, with emphasis on relevant developments on sustainable tourism at the international level. The final section of this paper presents options for consideration regarding the areas covered, and opportunities for cooperative action with coastal states and communities, the private sector, and nongovernmental organizations.

## COASTAL TOURISM AND RECREATION AND THE U.S. ECONOMY

### Growth in International Travel and Tourism

Travel and tourism is the world's largest industry. As reported by the World Tourism Organization, travel and tourism involved more than 528 million people internationally and generated $322 billion in receipts in 1994. In 1995, travel and tourism generated an estimated $3.4 trillion in gross output—creating employment for 211.7 million people, producing 10.9 percent of world gross domestic product, investing $693.9 billion in new facilities and equipment, and contributing more than $637 billion to global tax revenues (quoted in an undated publication by the World Trade and Tourism Council, pp. 33-34).

The mammoth global tourism industry is a "massive consumer of energy and resources" (Rearden, 1993, p. 166), and is expected to continue to grow significantly in the future. In 1995, the World Tourism Organization forecasted international arrivals worldwide to reach 661 million by the year 2000, up from 528 million in 1994, with arrivals predicted to reach 937 million by 2010 (Savignac, 1995). By 2005, it is estimated that the industry will have expanded globally, generating employment for 305 million people, producing 11.4 percent of world gross domestic product, investing $1,613 billion in new facilities and equipment, and contributing more than $1,369 billion in tax revenue (WTTC et al., p. 34). This growth in world tourism is related to three main factors: increased personal incomes and leisure time, improvements in transportation systems, and greater public awareness of other areas of the world due to improved communications (UNEP, 1992, p. 3).

Foreign tourism has been a very important factor for the U.S. economy. In 1994, 45.5 million international visitors came to the United States, according to the Department of Commerce, and spent $60 billion dollars (Wildavsky, 1995). The U.S. travel and tourism industry, with 6 million jobs, represents the second-largest employer in the United States after health care (Wildavsky, 1995). In 1986, the United States was the world's leading tourism destination (Miller, 1993). However, since that time, the U.S. leadership position in world tourism has been eroding; in 1996, France became the world's leading tourism destination. In 1995, the Commerce Department projected a 2.5 million dip in the number of international visitors to the United States and a dip in tourism revenues of 2.7 percent (Wildavsky, 1995). Continuing economic difficulties in Europe and the strengthening of the U.S. dollar could account for some of this decline.

### Balance of Payments Contributions of International Travel and Tourism

In 1994, the Wall Street Journal estimated that the United States receives over 45 percent of the developed world's travel and tourism revenues and 60 percent of its profits (Houston, 1996). While the United States runs a substantial merchandise trade deficit, it has a trade surplus in the service sector, with travel and tourism accounting for the largest and most rapidly growing part of this surplus. According to Business Week, "foreign visitors spend about $80 billion a year in the United States, producing a $26 billion U.S. trade surplus in travel and tourism" (quoted in Houston, 1996). Likewise, this publication reports 1.4 million U.S. jobs are supported by foreign tourism—ten times the number of jobs in the U.S. steel industry.

Foreign tourism to the United States in 1995 was expected to generate a trade surplus of $26 billion compared to a surplus of $17 billion in 1992 and a deficit of $7 billion in 1986. U.S. employment due to international tourism has been projected to grow by as much as 18 percent annually during the 1995-2000 period, doubling the number of tourism-related jobs every four years. The Department of Commerce has estimated that foreign tourist spending in the United States will rise to $132 billion dollars in the year 2000 (Houston, 1996).

### Tax Revenue Contributions of International Travel and Tourism

It has been estimated that travel and tourism produces tax revenues for all levels of government of about $58 billion annually (Houston, 1996). Of this total, foreign tourism is responsible for tax revenues of about $7.5 billion, about $4 billion of which goes to the federal government. Houston has observed that federal expenditures for beach re-nourishment have averaged only $34 million a year between 1950 and 1993 (in 1993 dollars), noting that the federal government receives tax revenues from foreign tourism that are 180 times its expenditure on the nation's beaches.

### Promotion of International Tourism to the United States

The United States lags far behind other nations on spending on tourism promotion. Ronald Allen, chairman of Delta Air Lines, Inc., notes "...The Republic of Ireland, with a population of less than 4 million people, spends $45 million in public funds annually to promote tourism. This country, with 260 million people, spends less than $17 million in federal money" Wildavsky, 1995, p. 2280). Spain, with its attractive beaches and climate, spends 10 times more than the United States in advertising to attract international tourists. The United States ranks 31st in the world in international tourist market advertising (Houston, 1996, p. 3).

Indeed, there has been a debate at the national level in the United States on whether a greater national presence concerning tourism promotion is needed, with industry advocates arguing for a greater role to eliminate "creeping neglect [of the industry] by public policy makers" (Wildavsky, 1995, p. 2280). Opposition to this has been expressed by economists and others who argue that private companies, not taxpayers, should bear the costs of promotional activities that benefit the U.S. tourism industry (Wildavsky, 1995).

## Coastal and Marine Tourism in the United States

The precise magnitude of foreign and domestic tourism in U.S. coastal and marine areas is not clear, since no separate statistics are kept for foreign or domestic tourists to these areas. Figures on foreign tourism receipts are generally based on surveys of departing travelers, generating data which are "imperfect and cannot be compared over time with precision" (Wildavsky, 1995, p. 2279). Data on tourism in coastal areas cannot easily be disaggregated from national-level statistics, but impressionistic evidence as well as a number of recent works on the subject suggest continued growth of tourism in coastal and marine areas in the United States and worldwide (see, for example, Miller, 1993; Miller and Auyong, 1991). Detailed information on the economic impact of domestic tourism has been difficult to find, but growth in all forms of recreation in coastal areas in which both foreign and domestic tourists partake is readily apparent. Such activities include beach going, recreational boating, cruises, marine mammal watching, recreational fishing, underwater recreation, bird watching, nature appreciation, and the like.

In terms of U.S. tourism, studies have shown that beaches are the leading tourist destination while national parks and historic sites are the second most popular destination (Houston, 1996). Consistent with these findings, approximately 180 million people visit the coast for recreational purposes, with 85 percent of tourist related revenues generated by coastal states. In addition to growing numbers of visitors, the permanent population of U.S. coastal regions is also increasing at a faster rate than the population as a whole. The population of coastal counties has increased by approximately 25 percent since 1970 (Cunningham and Walker, 1996; Houston, 1996).

In California, for example, Wilson and Wheeler (1997) provide the following estimates for the annual contribution of various ocean industries to the California economy. Their study shows that tourism (predominantly coastal) is the largest contributor at $9.9 billion, with the next largest contributor being ports at $6.0 billion. Offshore oil accounted for $860 million, and fisheries and mariculture combined contributed $550 million. Similarly, between June 1995 and May 1996, 2.5 million visitors to Monroe County, Florida (in the Florida Keys) spent about $1.2 billion. Recreation and tourism (all coastal) accounted for over 60 percent of output/sales, 45 percent of income, and over 46 percent of all employment (English et al., 1996).

Recently the Environmental Protection Agency (EPA) undertook a national study on the benefits of water quality improvement in terms of numbers of people involved and the economic value of the activities in which they participate (EPA, 1996). This study provides some valuable quantitative information on the importance of coastal tourism and recreation:

- Saltwater fishing generates expenditures of over $5 billion annually, a total economic output of $15 billion, total earnings (wages) of over $4 billion, and over 200,000 jobs.

- Over 77 million Americans participate in recreational boating (NMMA, 1996). The number of recreational boats in the United States almost doubled from 1970 to 1990 (16.2 million), and is expected to increase by a further four million by the year 2000

(EPA, 1996). In 1996, Americans spent approximately \$17.7 billion on boats and directly related items (NMMA, 1996).

- Over 80 million Americans participate in outdoor (non-pool) swimming, with visitors to beaches and lakes increasing from 18 million in 1981 to 23 million in 1989. In seven states, beachgoers spent \$74 billion with the most popular recreational activities being swimming, sunbathing, and walking in coastal areas (EPA, 1996).

- Birdwatching is estimated by the U.S. Fish and Wildlife Service to generate spending of about \$18 billion per year by over 24 million "birders" and other wildlife watchers, a generous proportion of which occurs in coastal regions (EPA, 1996).

A number of the estuary programs that make up EPA's National Estuary Program have undertaken studies of the economic activity generated by the coastal and estuaries resources in their region. Some findings related to coastal tourism and recreation are given below (EPA, 1997):

**Corpus Christi, Texas**. Nature tourism in Corpus Christi is the fastest growing component of a tourism sector that generates \$23 billion annually. Recreational fishing provides aggregate net benefits to the area of \$83 million, including \$37 million per year in state and local taxes, with a regional economic impact of \$546 million. Non-fishing coastal recreational activity adds another \$23 million in state and local taxes, and \$340 million in regional economic impact.

**Long Island Sound, New York**. The economic impact of water quality-dependent uses in Long Island Sound, including boating, commercial and sport fishing, and swimming, is estimated at more than \$5 billion annually. Commercial and recreational fishing contributed more than \$1.2 billion to the total, while beachgoing has a direct benefit of more than \$800 million annually.

**Indian River Lagoon, Florida**. The Indian River Lagoon region is a popular resort and vacation destination which received over six million visitors in 1995 and provided economic benefits of approximately \$730 million.

**Santa Monica Bay, California.** Tourism is the Los Angeles region's second largest industry with 392,000 full and part-time jobs contributing \$3.6 billion annually to the region's payroll. With nearly four million tourists annually, and over 45 million beach visits per year, Santa Monica Bay contributes significantly to the regional economy.

**San Francisco Bay, California**. The economy of the 12 counties bordering this estuary exceeds \$175 billion and supports more than four million jobs. Many of these jobs are dependent on the estuary's natural resources or are water-related. Revenues from maritime activities exceed \$5.4 billion each year, and marinas annually generate some \$167 million. Tourism, which generates over \$4 billion annually, is likewise strongly tied to the aesthetic values of the estuary.

# POLICY FRAMEWORKS FOR COASTAL RECREATION AND TOURISM: AN ASSESSMENT

## Understanding Tourism

A perusal of the literature on tourism suggests that it is easy to make generalizations: on the positive side, to extol its huge economic development potential; on the negative side, to decry impacts on the environment, overuse of resources and energy, ignorance of local culture, and absence of local benefits. For analytical purposes, it is best, however, to consider tourism in neutral terms as an agent of development and change which may have both positive and negative effects, as the following quote suggests:

> "As Butler (1990) points out, tourism, like other industries, is an agent of development and change and must be recognized as such. It is consumptive like any other industry and the level of consumption is determined by the scale and style of tourism development. At low levels and with careful design, tourism may be able to operate at a sustainable level. However, controlling the level and style of development over the long term presents challenges which, to this point, have not been successfully met. Because of its potentially high impact, tourism should be considered in the same manner as any other industry and should be subjected to the same environmental and social impact assessment processes during the planning stages" (Woodley, 1993, p. 137).

Butler suggests the following working definition of sustainable development in the context of tourism: "tourism which is developed and maintained in an area (community, environment) in such a manner and at such a scale that it remains viable over an indefinite period and does not degrade or alter the environment (human and physical) in which it exists to such a degree that it prohibits the successful development and well being of other activities and processes" (Butler, 1993, p. 29).

Tourism has often been ignored by public sector agencies. Where it has been considered as a specific development feature, it has often been viewed as a "soft" option, which can be pursued relatively easily and which does not require much in terms of specific planning or resources (Butler, 1993). While this view has changed somewhat in recent years as the magnitude and importance of tourism has begun to be appreciated, ignorance about tourism and many of the processes associated with it is still widespread.

The lack of attention by public agencies to tourism is especially problematic in the case of marine and coastal tourism. In most countries, there usually is no coordination between programs that promote and market tourism and those that manage coastal and marine areas. Integrated coastal management often tends to be done within environmental or planning agencies. On the other hand, agencies dealing with the promotion of tourism are not involved with the evaluation of its effects or with advance planning and management of the adverse impacts of tourism through avoidance, mitigation, and compensation strategies (Cicin-Sain, 1993). Hence, one of the greatest challenges facing coastal managers in the United States and elsewhere is how to integrate tourism development within the ambit of integrated coastal management, and thus increase the likelihood of long-term sustainability (Cicin-Sain and Knecht, 1998).

### The Role of the Federal Government in Coastal Tourism Management

As an economic activity, tourism is difficult to influence and manage directly. Like most coastal development in market economies, tourism-related development is driven largely by the private sector and its assessment of economic opportunities. Miller and Auyong (1991) point out that tourism involves mainly three sets of actors: tourists, locals (those who reside in the region of tourism destinations but are unconnected to the tourism industry), and two categories of brokers (those in the private sector who are engaged in the business of tourism, and those in the public sector who in one way or another monitor, manage, or govern tourism). Tourism tends to be globally driven by market forces influenced by such factors as advertising (by public or private agents at the tourist destination), the perceptions of the traveling public about security, amenity values, etc., and, in the case of international tourists, by currency factors.

Notwithstanding these difficulties, there is much that the federal government, working with the states and localities, does to ensure that coastal tourism is conducted in a sustainable manner, thereby ensuring long term economic and environmental benefits for coastal communities and the nation. Sustainable development of coastal tourism is dependent on:

1. *good coastal management practices* (particularly regarding proper siting of tourism infrastructure and the provision of public access);

2. *clean water and air, and healthy coastal ecosystems*;

3. *maintaining a safe and secure recreational environment though the management of coastal hazards (such as erosion, storms, floods), and the provision of adequate levels of safety* for boaters, swimmers, and other water users;

4. *beach restoration efforts* that maintain the recreational and amenity values of beaches; and,

5. *sound policies for wildlife and habitat protection.*

While there are separate federal programs dealing with each of these areas, some more successfully than others, in recent years there has been a growing realization among a number of federal agencies that these factors are interconnected and that all are needed to achieve healthy ecosystems and sustainable economies in coastal communities. To cite just one example, the Sustain Healthy Coasts 5-year Implementation Plan, developed by NOAA's Office of Ocean and Coastal Resource Management (March 1997), defines the following objective: "Foster well-planned and revitalized coastal communities that are compatible with the natural environment, minimize the risk from natural hazards, and provide access to coastal resources for the public's use and enjoyment."

In the sections that follow, existing efforts by federal agencies the categories outlined above are reviewed and assessed. The small but growing sector of ecotourism, and the need to manage this activity carefully to avoid adverse impacts on protected species and sensitive habitats, is also discussed.

## Coastal Management and Planning

The United States has the oldest national coastal management and planning program in the world, initiated under the Coastal Zone Management Act of 1972. The program, administered by NOAA's Office of Ocean and Coastal Resource Management, now includes coastal management programs in 31 U.S. states and territories, covering 97.2 percent of the U.S. shoreline (Uravitch, 1997). The program uses incentives (in the form of grants to the states and the "federal consistency" provision) to assist states in the preparation and implementation of coastal management plans. These state efforts have been multifaceted and have addressed, through a variety of means (regulatory, planning, public awareness raising), all uses of coastal areas.

Three management practices under the Coastal Zone Management (CZM) program are especially important for ensuring sustainable tourism development: (1) provisions for the management of coastal development; (2) provisions to improve public access to the shoreline; and (3) provisions to protect (and, where necessary, to restore) coastal environments.

*Management of Coastal Development*

All CZM programs have elements which, in effect, help manage coastal development. Two of these are especially relevant to tourism development: (1) encouragement of water-dependent uses in the coastal zone and (2) the appropriate siting of new facilities in the coastal zone.

*Encouragement of water-dependent uses*

State CZM programs actively encourage and facilitate the use of land adjacent to the shoreline for those purposes which require such a location. This policy helps ensure that proposals for tourism and marine recreation projects receive appropriate consideration in the government review process. It also helps ensure that meritorious coastal tourism developments are not crowded out of the coastal zone by uses that do not require a shoreside location.

*Appropriate siting of facilities*

Construction of new facilities in the coastal zone must meet the setback requirements of state CZM programs. While states differ in their requirements, the trend is to relate setback lines to annual erosion rates and, thus, to require the greatest setbacks from the high tidemark in those areas having the largest erosion rates. Facilities siting policies also help ensure that new tourism construction is not located in hazardous areas from the standpoint of coastal storm damage and flooding.

*Improvement of Public Access to the Shoreline*

A strong emphasis in the federal Coastal Zone Management Act relates to the importance of ensuring adequate public access to the nation's shorelines for recreational pursuits. All 31 state programs are actively pursuing this goal. Recognizing the limitations of simply planning for access, Congress added section 306A to the CZMA in 1980 to allow states to acquire land and fund low cost construction projects to provide public access ways to the beach and coastal waters (Cunningham and Walker, 1996).

Since 1980, for example, the California Coastal Program has acquired over 2,300 public access ways along the coast while the San Francisco Bay Conservation and Development Commission has increased public access around the perimeter of San Francisco Bay from 4 miles in 1977 to more than 96 miles in 1990 (Cunningham and Walker, 1996). Under the CZM program, states and localities use grant funding and regulatory tools to secure improved public access for recreational purposes.

*Protection of Coastal Habitats*

The existence of healthy coastal habitats (wetlands, beaches and dunes, sea grass beds, mangroves, coral reefs, estuaries) is important to coastal recreation and tourism. State CZM programs represent one of the important management avenues in obtaining this protection. Within specified coastal zone boundaries, states and/or their local governments regulate activities which could adversely impact these habitats. Other federal programs, such as those under the Clean Water Act's Section 404 (dredge and fill program) and Section 320 (National Estuary Program), the Marine Protection Research and Sanctuaries Act (which controls ocean dumping), the Coastal Barrier Resources Act, the National Seashore Program, the Endangered Species Act, and the Marine Mammal Protection Act, also serve to protect coastal habitats. Furthermore, a national system of estuarine research reserves aimed at providing a representative system of natural field laboratories for management-related research and monitoring also exists as an adjunct to the national CZM program.

## Management of Clean Water and Healthy Ecosystems

Clean water and healthy coastal ecosystems are essential to the maintenance of coastal tourism and recreation. Foreign tourists and the recreating domestic public stop going to areas where the waters are polluted, beaches are closed, or fish are tainted. For example, it is reported that the State of New Jersey lost $800 million in tourism revenues following reports that medical wastes had washed up on some of its beaches (Bookman, 1997). According to EPA estimates, coastal and marine waters support 28.3 million jobs, generate $54 billion in goods and services, contribute $30 billion to the U.S. economy through recreational fishing, and provide a destination for 180 million Americans to recreate each year (EPA web page, November 1997).

In the past 25 years, there have been extensive efforts made by federal agencies, especially EPA and NOAA, in association with the coastal states, to improve coastal water quality. Under programs authorized by the Clean Water Act of 1972 (as amended) and administered by EPA, significant improvements in water quality have been realized. Point sources have been largely controlled under the National Pollution Discharge Elimination System (NPDES). Significant challenges remain regarding the control of non-point sources of water pollution (resulting from such sources as agricultural practices, urban and storm water run-off, and air deposition), especially in coastal areas abutting agricultural lands. EPA's non-point source program (under Section 319 of the Clean Water Act), and NOAA's program under Section 6217 of the CZM Act, have been used in combination in a number of coastal states to begin more effective measures to control non-point sources of pollution.

Protection of the marine environment is one of the critical services provided by the U.S. Coast Guard. This includes prevention of environmentally threatening marine accidents and responses aimed at minimizing adverse effects should accidents occur., This also includes protection of living marine resources and marine sanctuaries. The implementation of the Oil Pollution Act of 1990 is resulting in safer ships entering U.S. ports, safer vessel operators, and hence, cleaner coastal waters. NOAA's National Ocean Service provides safe navigation services, such as nautical charts, and information on water levels and currents, that help prevent marine accidents. It also performs hazardous material spill response activities. NOAA's role in pollution monitoring (National Status and Trends Program) and damage assessment are also important aspects of managing clean water and healthy ecosystems.

In addition, special planning and management efforts, largely directed at improving water quality and habitats, have been made in many of the nation's estuaries under the aegis of EPA's National Estuary Program (NEP). Under the NEP, 28 estuaries, designated as estuaries of national significance, have been the beneficiaries of substantially increased research and management attention. Management conferences convened in each estuarine area are used to oversee the characterization of each estuary, and the preparation and implementation of Comprehensive Conservation and Management Plans (CCMPs). These include resource and water-quality related goals and the action plans necessary to meet these goals. An enduring commitment from NEP stakeholders at all levels is vital to the successful implementation of the CCMPs and the long-term health and sustainability of these estuarine resources. This commitment must include the acquisition and leveraging of sufficient funds by state and local governments, follow-through on commitments agreed to by the implementors, and the full use of appropriate authorities. The continuing involvement of the federal government, notably the EPA, in the oversight and support of the NEP is also likely to be critical to the long-term success of the program.

The direct contribution to coastal economies made by cleaning up coastal waters is often not fully recognized. A recent report by the EPA indicates that in seven estuaries alone[1], tourism and beach going activities generate economic benefits of more than $16 billion to their respective regions (EPA, 1997). Clearly, these benefits depend on the maintenance of clean coastal waters and attractive ecosystems.

While substantial progress has been made in improving coastal water quality since 1972, much remains to be done. Meanwhile, reauthorization of the Clean Water Act has been stalled for several years, the national policy framework for dealing with non-point source pollution remains somewhat unclear, and funding levels for water quality improvement programs are inadequate. Furthermore, the nation needs to decide if the current largely voluntary approach to non-point source pollution will be sufficient, especially for dealing with agricultural run-off problems.

## Management of Coastal Hazards

In siting coastal resorts and other facilities, there is understandably a predilection for locating in beautiful but high-risk zones that are as close as physically possible to the edge of the sea, or otherwise take advantage of scenic views and proximity to beaches and ocean recreation. Of course, it is precisely these areas that are most vulnerable to both long-term and episodic coastal hazards: such as erosion, storms, and floods.

While government cannot be expected to protect individuals from their own recklessness, it does have a responsibility to provide the information necessary to permit informed decisions to be made with regard to the kinds and degrees of risk associated with living in various parts of the coastal zone. Furthermore, coastal areas that are clearly hazardous as building sites should be reserved for other uses. Government also has the responsibility to provide adequate warnings of impending storms or other hazardous conditions, and to develop plans for coping with such emergencies. Several government programs exist to meet these needs as discussed below.

At the federal level, FEMA's National Flood Insurance Program (NFIP) and the Coastal Zone Management Program exist, in part, to address these problems. The NFIP offers flood insurance to coastal landowners in communities that have met government standards for building in coastal areas (elevating structures above a designated flood level, designation of high hazard areas where no building is allowed, etc.). FEMA is also responsible for supporting and facilitating the work of state emergency preparedness offices in the preparation of coastal evacuation plans and plans to deal with disasters such as hurricanes both during the event and during the clean-up and reconstruction phases. NOAA's National Weather Service devotes considerable resources to the job of providing timely "state-of-the-art" forecasts and predictions of hurricanes and other coastal storms.

[1] Casco Bay (Maine), Long Island Sound (New York, Connecticut), Massachusetts Bay (Massachusetts), Albermarle-Pamlico Sounds (North Carolina), Galveston Bay (Texas), San Francisco Bay (California), and Santa Monica Bay (California))

Through the federal CZM program, coastal states build in their own regulatory approaches such as construction setback lines, storm-resistant building codes, acquisition programs for hazardous areas, and the like. Recognizing the connections that should exist between the planning and management efforts under CZM, and cognizant of the lessons being learned during storm events by the emergency management programs, NOAA and FEMA are initiating a series of workshops to strengthen the coordination between these programs.

Advanced planning and follow-up are required to maintain a safe and secure environment for visitors. Tourists take their safety for granted when they go to the beach or visit a coastal resort or even rent a sailboat for the day.. Yet the coast is inherently a place with real risks, even under good weather conditions. Swimmers can drown and boats can collide or go aground, poisonous jellyfish can sting. And, of course, episodic large storms and hurricanes can have devastating consequences in coastal areas heavily populated with visitors.

Increasing numbers of Americans find themselves on the nation's waterways in connection with recreational boating, fishing, traveling to and from coral reefs for snorkeling and diving, and so on. Maintaining an adequate level of safety and accident prevention requires properly marked channels, rescue services, oversight of boating safety requirements (e.g., life jackets and other emergency equipment), and monitoring and enforcement of boating operations, including so-called "thrill craft." While some of these duties can be performed by local and state authorities, the maintenance of safe and well-marked waterways and maritime safety in general has traditionally been a federal government responsibility. In any event, the federal government is in the best position to ensure than an adequately comprehensive safety program is in place in coastal areas. The U.S. Coast Guard is the primary federal agency with responsibility for coastal search and rescue, enforcement of maritime laws, and maintenance of a national waterway marking system. The Coast Guard is also the coordinator of the national recreational boating safety program aimed at ensuring the safety of boats and associated equipment, and their safe operation by boaters. Through the production of accurate nautical charts and related products, NOAA provides essential information for navigating the nation's coastal waters.

## Beach Restoration Programs

The federal government, acting through the U.S. Army Corps of Engineers, has long played an important role in the maintenance and restoration of the nation's beaches and shores. Experience in shore protection efforts has shown that soft solutions involving beach re-nourishment have produced better, more economical results than hard solutions such as seawalls and groins in many circumstances.

Seawalls and revetments first developed as the field of coastal engineering emerged. , While these measures are often successful at protecting the development and infrastructure behind a beach, they do not address the real cause of beach erosion, which is a lack of sediment in the system. As understanding of coastal systems has grown through research and data collection programs, solutions to such problems has progressed. Today, beach re-nourishment represents a sound engineering solution that is economically feasible and environmentally sensitive. Only in areas with very high erosion rates and substantial shoreside facilities to protect are hard structural solutions considered.

The shift of population to coastal counties and the increased demand for coastal tourism destinations has exacerbated many existing beach erosion problems. Development in areas with high erosion rates (U.S. Army Corps of Engineers, 1971) and building on or in front of sand dunes, rather than behind them, are major factors contributing to increased beach erosion problems. Relative sea-level rise caused primarily by subsidence is another major factor in some areas. The interruption of sand flowing along the coast by natural or stabilized inlets is also an aggravating factor.

The Corps has conducted assessments of many of the nation's important beaches and has assisted coastal communities in the funding of beach nourishment projects. The bulk of the costs of these projects have been borne by the federal government with the local share generally being about 30 to 35 percent of the total cost. Just as the federal government is reconsidering its policies in this regard, coastal erosion and increasing relative sea-level rise in some parts of the country (notably the middle Atlantic and Gulf coasts) are increasing the need for beach replenishment projects.

As statistics cited earlier show, America's beaches are an important element in this country's attractiveness as an international tourist destination. A case in point concerns Miami Beach which virtually had no beach left by the mid 1970s as a result of erosion. Beach re-nourishment (at the cost of $52 million) in the late 1970s rejuvenated Miami Beach and enabled its beach to be reopened to the public. Beach attendance subsequently increased from 8 million in 1978 to 21 million in 1983. Annual governmental revenue obtained from foreign tourism in Miami Beach alone is about 40 times the cost of the beach re-nourishment project that has lasted over 15 years (Houston, 1995).

Given the role played by beach tourism in the nation's balance of payments and its impact on government revenues and regional and local economies, it is crucial that these assets be maintained at levels that promote and enhance their recreational use. If budgetary constraints make it necessary to reduce federal assistance for beach restoration and maintenance, a gradual and predictable approach should be adopted and states and coastal communities assisted in developing viable alternative funding arrangements.

### Coastal Tourism and the Need to Coordinate Federal Policies And Programs

While the issues discussed above are usually considered separately, all are of central importance to sustainable coastal tourism. Any one, be it poorly planned development, poor coastal water quality, unsafe or hazardous conditions, or eroding beaches, could seriously impact the tourism potential of a coastal area. Furthermore, policies and programs in each of these areas need to be developed and implemented in an integrated fashion, each taking account of the others. Failure to do this can result in such undesirable outcomes as erosion control structures that impair the recreational experience, or poorly designed development that causes water pollution or beach erosion.

### Management of Ecotourism

Ecotourism or nature tourism is: "Tourism that involves traveling to relatively undisturbed or uncontaminated natural areas with the specific object of studying, admiring, and enjoying the scenery and its wild plants and animals, as well as any existing cultural areas."[2] While still relatively small, ecotourism is one of the fastest growing segments of the tourism industry and presents special management challenges.

Internationally, ecotourism is growing at a moderate rate with the financial impacts greatest in rural areas near important ecotourism activities (Eagles, 1997). In 1988, international ecotourists numbered 236 million worldwide, with an estimated economic impact of $233 billion (U.S.) (Eagles, 1997). In 1994, the number of international ecotourists rose to 317 million with direct economic impact of $250 billion (U.S.) (Ecotourism Society, 1997).

Although specific data on coastal ecotourism are difficult to obtain, market surveys in the United States show good prospects for ecotourism growth. In 1992, a U.S. Travel Data Center survey indicated that 7 percent of U.S. travelers had taken at least one trip that they considered ecotourism and 30 percent claimed they would take one within the next three years (Eagles, 1997).

In the United States, some coastal states have begun promoting ecotourism and nature-based tourism through the preparation of guides to ecotourism attractions and other publications. For example, the Marine Advisory Service of the Delaware Sea Grant College Program produced a guidebook to ecotourism sites in the state (Falk, Small, and Rector, 1997). In 1996, the State of South Carolina, with the collaboration of the South Carolina Sea Grant Consortium, produced a handbook entitled *Guidelines and Recommendations for Nature-Based Tourism Planning and Practice in South Carolina* (Bacon and Kibler, 1996). Yet another example is the California Coastal Conservancy, which devoted its Summer 1997 issue of *California Coast & Ocean* to nature tourism.

Ecotourism in association with marine and estuarine protected areas, especially the National Marine Sanctuary Program and National Estuarine Research Reserve Program, has a great potential (Koss, 1995). However, for ecotourism activities to be sustainable, they must be managed properly and with special care. Unless properly managed, the impacts of ecotourism (for example, to remote pristine areas) may be worse than those of tourism to clearly defined and confined resorts (Butler, 1993, p. 28).

In the United States, for example, concerns have been raised about the impacts of ecotourism on marine mammals, which are protected under the Marine Mammal Protection Act.

---

2 Caballos-Lascurain, 1988, as quoted in Lindberg, 1993, p. 3

Commercial cruises to observe and "feed wild dolphins" operating in such areas as Texas, South Carolina, and Florida, were found to harm dolphins by making them reliant on accepting food from humans and decreasing their ability to survive in the wild. Threats to the marine mammal populations and to humans in these situations include: (1) substantially altering the natural behavior of marine mammals, including foraging for food and migration, (2) the loss of wariness by humans, which places the animals at increased risk of injury or death from interaction with vessels, (3) animals receiving inappropriate or contaminated food, and (4) increased injuries to humans as the habituated animals become predictably more aggressive when they lose their wariness of humans and compete for handouts (NOAA/NMFS/OPR, 1994, 1995, and 1998).

## Management of Coastal Recreation Activities

The last decade has seen a great increase in the nature and magnitude of coastal recreation activities, which as has been shown, generate billions of dollars in economic activity. Recreational uses of a consumptive nature include hunting, fishing, shellfishing, shell collection, and the like, while non-consumptive uses include swimming, surfing, sun-bathing, boating, wind-surfing, jet skiing, bird watching, snorkeling, diving, glass-bottom boating, and many more. As coastal recreation activities have proliferated, the need for active management has increased as well.

At least three sets of concerns related to the management of coastal recreation activities must be dealt with, namely, environmental/resource concerns, amenity concerns, and safety concerns. Environmental/resource constraints include the maintenance of good water quality, and habitats and living resources which are free of health hazards, and which have good air quality, healthy coral reefs, healthy shellfish areas, etc. Amenity concerns include adequate controls on congestion, noise, landscape degradation, and the like. Safety concerns include adequate lifeguard systems, first aid facilities, telephones, codes of conduct for beach users, and notice systems for beach and water hazards (such as jellyfish, underwater obstructions, etc.) and for weather-related risks (such as high waves, undertows, dangerous currents, etc.).

In most cases, the responsibility for meeting these concerns is divided between the beach "owner" (often a local government or state government, but sometimes federal or private), resort and/or recreation facility operators, and state environmental or health departments. In general, nationwide standards for recreational beach operation do not exist, even with respect to beach closings. This would appear to be an area where additional attention at the national level is needed.

A promising start in this area is a new program recently launched by the EPA and designated the Beaches Environmental Assessment, Closure, and Health (BEACH) Program. This program is designed to encourage government agencies at all levels to strengthen beach water quality standards and testing methods using predictive water pollution models, to better inform the public about beach water quality conditions, and to make information about the risks associated with swimming in contaminated beach water available to the public.[3]

## Emerging Tools and Techniques

Although coastal tourism constitutes a strong force (both positive and negative) in shaping coastal communities and local, regional, and national economies, coastal tourism is generally not seen as a specific sector requiring policy, planning, and management attention and resources. This is due, in part, to the fact that data and information tend not be gathered and aggregated under this heading. Hence, the magnitude and importance of leisure and recreationally motivated development in the coastal zone tends to be understated, understudied, and under-managed.

However, certain aspects of this situation may be changing. Since the Earth Summit in Rio de Janeiro in 1992, a number of new initiatives for sustainable tourism practices have appeared. For example, in 1993, a new periodical entitled *Journal of Sustainable Tourism* appeared, focusing on applying the principles of sustainable development to the tourism field. In 1997, on the occasion of the five-year review of the implementation of Earth Summit agreements, three organizations: The World Travel and Tourism Council, the World Tourism Organization, and the Earth Council; jointly published *Agenda 21 for the Travel and Tourism Industry: Towards Environmentally Sustainable Development* (WTTC et al, no date). This report presents a summary of Agenda 21 (one of the main outputs of the Earth Summit), and the role that travel and tourism can play in achieving the goals of Agenda 21. It also outlines a program of action. Planning for sustainable tourism development is one of the priority areas of the program, which calls for complementarity between tourism and coastal development by adopting suitable policies such as the Global Blue Flag Program (WTTC et al.). The Blue Flag Program is a European campaign started in the 1980s which encourages local authorities to provide clean and safe beaches for local populations and international tourists. Blue Flag awards go to beaches that achieve certain standards in water quality, beach management and safety, and environmental information and education.

A guide for tourism managers has also been developed by the World Tourism Organization (WTO, 1996) on the formulation and use of indicators of sustainable tourism. Indicators signal unacceptable levels of impacts or stress, and these can in turn lead to the development of standards to govern tourism activities. Core indicators developed by the WTO include use intensity (persons per meter of accessible beach), species counts (number of species, change in composition), pollution levels (fecal coliform, heavy metal counts, etc.), and accident rates (WTO, 1996).

New tools are also being developed in connection with coastal tourism and natural disasters, such as hurricanes. The University of Florida, for example, in cooperation with the Florida Hotel and Motel Association, has prepared *The Hurricane Preparedness Handbook for*

[3]The EPA web site HYPERLINK is http://www.epa.gov/ost/beaches/overview.html.

*Hotels and Motels*. In a slightly different direction, Clemson University (Department of Parks, Recreation, and Tourism Management) has prepared a handbook to guide communities and their tourism industries through crises of various types including those associated with natural hazards such as hurricanes (Sonmez et al. ). As outlined in its introduction, this guidebook "is intended to serve as a guideline to facilitate tourism recovery by protecting or rebuilding a local area's image of safety and attractiveness; reassuring potential visitors of the safety of the area; reestablishing the area's functionality and attractiveness; and aiding the local travel and tourism industry members in their economic recovery efforts" (Sonmez et al., p. v).

## FINDINGS

As detailed above, coastal tourism and recreation involve major economic activity in U.S. coastal and ocean areas, and must be planned and managed with special care to insure that the environmental quality on which coastal tourism and recreation depend is maintained and enhanced. Major findings and areas of future work are summarized below:

**1. Economic importance of coastal tourism and recreation.** Coastal tourism and recreation provide a huge positive economic benefit in the United States, both in terms of jobs and earnings and in terms of balance of payments and governmental revenues. As discussed, over 90 percent of foreign tourism spending is concentrated in coastal states where beaches are the leading tourism destination (Houston, 1996). For example, Miami Beach reported more tourist visits (21 million) than were made to any National Park Service property (Houston, 1995). The federal government, moreover, receives about 6 times as much tax revenues annually from foreign tourism spending at Miami Beach than it spends to restore beaches in the entire nation (Houston, 1996). Yet, these values often go unrecognized, and are not the subject of concerted attention by federal, state, and local policymakers.

**2. There is little information on marine and coastal tourism.** There is no systematic collection of data and information on the magnitude, nature, and economic and social impacts of tourism and recreation in the nation's coastal zone. This is, in part, responsible for a general under-appreciation of this set of activities and for the failure to devote adequate planning and management attention to the relevant issues that are raised for coastal tourism and recreation. To properly guide coastal tourism in a sustainable development manner, better data focused on coastal and marine areas will be needed. The types of information needed include:

- Systematic collection and interpretation of coastal tourism data on a coastal county basis;
- Collection and interpretation of data on coastal and marine recreation activities;
- Expansion of existing databases, such as, for example, the Sea Grant Coastal Recreation and Tourism web service (organized by Oregon State University, in collaboration with many other Sea Grant programs);

- Conduct of studies on the dynamics of tourism in coastal and marine areas. For example, what constitutes an optimal type and scale of coastal tourism? Who gets what, when, and where from expanded tourism? What is the distribution of benefits from tourism? (Richter, 1983).

**3. U.S. promotional efforts to attract foreign tourists to U.S. coastal areas lag significantly behind those of other nations.** Foreign tourists use U.S. coastal areas very frequently and contribute significantly to jobs, earnings, and tax revenues in coastal communities. Foreign competition in marketing other world coastal destinations, however, is increasing. In contrast to many other governments, the U.S. government spends very little in tourism promotion.

**4. Federal policies and programs essential for the maintenance of healthy coastal tourism and recreation (coastal planning and management, clean water, beach nourishment, management of coastal hazards and of coastal safety) are interrelated and should be treated as a whole.** The economic viability and sustainability of coastal tourism and recreation are directly affected by at least four sets of federal policies and programs:

- Coastal planning and management (CZM) programs, especially in relation to the appropriate siting of tourism development and in ensuring public access, are of central importance in sustainable coastal tourism.

- Clean water and healthy ecosystem programs are vital to sustainable coastal tourism.

- Programs to ensure a safe coastal environment, especially with reference to natural hazards such as hurricanes and storms and to the maintenance of safe marine recreational and boating conditions, are essential for sustainable coastal tourism.

- Programs to maintain recreational beaches, by means of beach re-nourishment to combat erosion and relative sea-level rise, are also of central concern to sustainable coastal tourism.

- Programs to protect wildlife and coastal habitats are also essential to sustainable coastal tourism.

While a variety of federal efforts are focused on different programs of importance to coastal tourism, these have not been successfully coordinated. To remedy this situation, consideration could be given to the creation of an interagency initiative devoted to coastal tourism among the major federal agencies with programs in this area (e.g., NOAA (NOS [OCRM, NMS, NERRS], NMFS, OAR), the Department of Interior (Coastal Barrier Program, Fish and Wildlife Service, National Park Service), EPA, FEMA, Army Corps of Engineers, Coast Guard, etc.). Related options could entail the mobilization of a public-private partnership to work in conjunction with the federal inter-agency group (involving such entities as state coastal programs, state tourist offices, aquaria, and waterfront redevelopers), and the development of a public awareness and outreach program focused on the determinants of successful coastal tourism.

**5. Little guidance (in the form of standards, codes of conduct, manuals, etc.) is currently available to states and communities for guiding appropriate tourism development in coastal areas.** While individual coastal communities and coastal states have taken initiative in preparing guides and codes of conduct related to coastal tourism and recreation, many others have not yet done so. The federal government can play a useful role here in providing guidance to states and communities in their attempts to manage coastal tourism and recreation appropriately. Useful activities include the development of standards, guides, and manuals for managing coastal tourism, in cooperation with relevant non-governmental organizations, the private sector, and international entities working on these issues. Also, management standards for recreational beaches, for example, those developed for the European Blue Flag program, could play a valuable role in improving conditions at some U.S. beaches.

## REFERENCES

Bacon, R. and Kibler, T. 1996. "Nature-Based Tourism Development in South Carolina." South Carolina Sea Grant Extension Program, South Carolina.

Bramwell, B. 1991. "Shades of Green Tourism." *Leisure Management*, Spring: 41-42.

Bookman, Charles, 1997. Personal communication, November 20, 1997.

Butler, R.W. 1993. "Tourism: An Evolutionary Perspective." *Tourism and Sustainable Development: Monitoring, Planning, Managing*. J. Nelson, R. Butler, and G. Wall, Eds. University of Waterloo: Heritage Resources Centre Joint Publication Number 1.

Caballos-Lascurain, Hector. 1988. "The Future of Ecotourism." *Annals of Tourism* Research 18: 26-40.

Cicin-Sain, B. 1993. "Sustainable Development, Integrated Coastal Management and Tourism: Challenges to Mediterranean Countries," MEDCOAST '93 Proceedings, Antalya, Turkey.

Cicin-Sain, B. and Robert W. Knecht. 1991. "The Role of Government in Tourism Development." Proceedings, International Conference on Marine and Coastal Tourism. Honolulu, Hawaii.

Cicin-Sain, B. and Robert W. Knecht. 1998. *Integrated Coastal and Ocean Management: Concepts and Experiences*. Washington, D.C.: Island Press.

Cunningham, C and Walker, K. 1996. "Enhancing Public Access to the Coast through the CZMA." *The Journal of Marine Education*, Volume 14, Number 1. pp 8-11.

Eagles, P.F.G., 1997. Understanding the Market for Sustainable Tourism. Internet source: http://www.ecotourism.org/textfiles/eagles.txt

Ecotourism Society. 1997. Ecotourism Statistical Fact Sheets. Internet source: http://www.ecotourism.org/textfiles/stats.txt

English, Donald B.K., Warren Kriesel, Vernon R. Leeworthy, and Peter C. Wiley, 1996. *Economic Contribution of Recreating Visitors to the Florida Keys/Key West.* Report. Prepared in collaboration among NOAA (Strategic Environmental Assessments Division, Office of Ocean Resources Conservation and Assessment, National Ocean Service; also Office of Ocean and Coastal Resource Management/Sanctuaries and Reserves Division/Florida Keys National Marine Sanctuary), USDA-Forest Service (Outdoor Recreation and Wilderness Assessment Group, Southern Forest Research Station), Department of Agricultural and Applied Economics, University of Georgia); the Nature Conservancy Florida Keys Initiative, the Monroe County Tourist Development Council, Bicentennial Volunteers, Inc.

Environmental Protection Agency (EPA) 1996. *Benefits of Water Quality Improvement.*

Environmental Protection Agency (EPA) 1997. *Natural Resource Valuation: A Report by the Nation's Estuary Program.*

Falk, James M., Cindy Small and Rob Rector. 1997. *Delaware Eco-Discoveries: The 1997 Guide to Nature-Based Travel in Delaware.* Published by Atlantic Publications, Inc. in cooperation with the Delaware Sea Grant College Program and the Southern Delaware Convention and Tourism Commission, Lewes, DE.

Farrell, B. H. and D. Runyan. 1991. "Ecology and Tourism." *Links*, 1: 3.

Houston, James R., "The Economic Value of Beaches," CERCular, Coastal Engineering Research Center, Vol. CERC-95-4, December 1995.

Houston, James R., "International Tourism and US Beaches," *Shore and Beach* (1996).

Koss, Jennifer, 1995. "Ecotourism and Marine Protected Areas," Master's thesis, Marine Policy Program, Graduate College of Marine Studies, University of Delaware.

Lindberg, Kreg. 1993. *Policies for Maximizing Nature Tourism's Ecological and Economic Benefits.* Washington, D.C. World Resources Institute.

Miller, M. 1993. "The Rise of Coastal and Marine Tourism." Special Issue on Ecotourism in Marine and Coastal Areas," *Ocean and Coastal Management*, 21 (1-3): 183-199.

Miller, M. and J. Auyong, 1991. "Coastal Zone Tourism: A Potent Force Affecting Environment and Society." *Marine Policy*, 15 (2): 75-99.

National Marine Manufacturers Association. 1996. *Boating 1996* (prepared by the Marketing Services Department of the National Marine Manufacturers Association, 200 East Randolph Drive, Suite 5100, Chicago, Illinois 60601).

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, *Report to Congress on Results of Feeding Wild Dolphins: 1988-1994*, July 1994. 23 p. with appendix.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, 1995. "Flipper's Myth Proves Harmful". *MMPA Bulletin* (6):3.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, 1998. "NMFS Continues Campaign to Halt Feeding and Harassment of Wild Dolphins'. *MMPA Bulletin* (10):1.

Rearden, Philip. 1993. "Cultural Aspects of Tourism and Sustainable Development: Tourism and the Hilltribes of Northern Thailand." *Tourism and Sustainable Development: Monitoring, Planning, Managing*. J. Nelson, R. Butler, and G. Wall, Eds. University of Waterloo: Heritage Resources Centre Joint Publication Number 1.

Richter, Linda K., "Tourism Politics and Political Science: A Case of Not So Benign Neglect," *Annals of Tourism Research*, Vol. 10 (1983), pp. 313-335.

Savignac, Antonio Enriquez. 1995. "Foreword." *World Tourism Directory '95/'96, Part 1: Europe*. Third Edition. New Providence: K.G. Saur and Reed Travel Group.

Scace, Robert C. 1993. "An Ecotourism Perspective." *Tourism and Sustainable Development: Monitoring, Planning, Managing*. J. Nelson, R. Butler, and G. Wall, Eds. University of Waterloo: Heritage Resources Centre Joint Publication Number 1.

Sonmez, S.F, Backman, S.J and Allen, L.A. No Date. *Managing Tourism Crises: a Guidebook*. Department of Parks, Recreation and Tourism Management. Clemson University, Clemson, South Carolina.

United Nations Environment Programme, World Tourism Organization, and Foundation for Environmental Education in Europe. 1996. Awards for Improving the Coastal Environment: The Example of the Blue Flag. United Nations Environment Programme, Paris, France; World Tourism Organization, Madrid, Spain; and Foundation for Environmental Education in Europe, Kobenhaum, Denmark. 50 pp.

Uravitch, Joseph, Office of Coastal Programs, NOAA/OCRM, 1997. Personal communication, November 5, 1997, Silver Spring, Maryland.

Wildavsky, B. 1995. "Travel Advisory." *National Journal*, September 6, 1995.

Wilson, Pete and Douglas P. Wheeler. 1997. *California Ocean Resources: An Agenda for the Future.* Sacramento, California, The Resources Agency of California, Ocean Resources Management Program.

Woodley, A. 1993. "Tourism and Sustainable Development: The Community Perspective." J. Nelson, R. Butler, and G. Wall, Eds. University of Waterloo: Heritage Resources Centre Joint Publication Number 1.

World Tourism Organization. 1996. "What Tourism Managers Need to Know: A Practical Guide to the Development and Use of Indicators of Sustainable Tourism." World Tourism Organization, Madrid, Spain. 73 pp.

World Travel and Tourism Council (WTTC), World Tourism Organization, and Earth Council. No date. Agenda 21 for the Travel and Tourism Industry: Towards Environmentally Sustainable Development. World Travel and Tourism Council, London, United Kingdom; World Tourism Organization, Madrid, Spain; and Earth Council, San Jose, Costa Rica. 78 pp. (presented at the June 1997 United Nations General Assembly, "The Earth Summit plus Five," New York City)

## DOMESTIC LEGAL REGIME

### Contents

- Abandoned Shipwreck Act (43 U.S.C. §§ 2101 et seq.)
- Antiquities Act of 1906 (16 U.S.C. §§ 431 et seq.)
- Archaeological Resources Protection Act of 1979 (16 U.S.C. §§ 470aa et seq.)
- Coastal Barrier Resources Act (16 U.S.C. §§ 3501 et seq.)
- Coastal Zone Management Act (16 U.S.C. §§ 1451 et seq.)
- Federal Water Pollution Control Act, as amended, also called the Clean Water Act as amended (CWA), 33 U.S.C. §§ 1251 et seq.
- National Flood Insurance Reform Act
- National Marine Sanctuaries Act (16 U.S.C. §§1431 et seq.)
- National Park Service Organic Act (16 U.S.C. §§ 1)
- National Wildlife Refuge System (16 U.S.C. § 668dd)
- National Historic Preservation Act (16 U.S.C. §§ 470 (et seq.)
- National Wilderness Preservation System (16 U.S.C. § 1131)
- Oil Pollution Act of 1990 (33 U.S.C. §§ 2701 et seq., inter alia)

The legal regime covering this topic is based on a collection of important federal statutory authorities. The following is a brief description of some of those authorities relating to recreation and tourism. The list is selective and is designed to illustrate some major recreation and tourism acts. The list is not meant to be comprehensive.

**Abandoned Shipwreck Act (ASA)**, 43 U.S.C. §§ 2101 et seq.

Under the ASA, the United States asserts title to shipwrecks that are embedded in the submerged lands of a state. The federal government transfers title to the state whose submerged lands contain the shipwreck, except when the wreck is located on public or Indian land, or is a U.S. warship that has not been affirmatively abandoned. The public is given notice of the location of any shipwreck when title is asserted under the ASA.

Pursuant to the ASA, states manage a broad range of living and nonliving resources in their waters and submerged lands. Shipwrecks protected under the ASA offer recreational and educational opportunities for divers, tourists, users of biological sanctuaries, and historical researchers. States are encouraged to provide public access to the shipwrecks through the adoption of guidelines for the creation of underwater parks.

The Secretary of the Interior, through the National Park Service, publishes guidelines to maximize the enhancement of shipwrecks as cultural resources; foster a partnership among sport divers, salvors, and other interests to manage shipwreck resources; facilitate access and utilization of the shipwrecks; and recognize the interests of groups engaged in shipwreck discovery and salvage.

**Antiquities Act of 1906**, 16 U.S.C. §§ 431 et seq.

The Antiquities Act has two main components: (1) a criminal enforcement component, which provides for the prosecution of persons who appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity on lands owned or controlled by the United States; and (2) a component that authorizes, through the issuance of a permit, the examination of ruins, the excavation of archeological sites, and the gathering of objects of antiquity on lands owned or controlled by the United States. The Antiquities Act has been applied in the marine environment. Where the United States has ownership or control of the submerged lands in or on which submerged cultural resources are located, the Antiquities Act permitting provision can be used to regulate salvage. It appears, however, that its reach may be limited to regulating salvage only in marine protected areas in which the United States has the authority to protect submerged cultural resources.

**Archaeological Resources Protection Act of 1979 (ARPA)**, 16 U.S.C. §§ 470aa et seq.

The Archaeological Resources Protection Act, is another historic preservation statute that has been applied to the marine environment. ARPA was specifically designed to prevent looting and destruction of archeological resources. Like the Antiquities Act, ARPA has both an enforcement and a permitting component. The enforcement provision provides for the imposition of both criminal and civil penalties against violators of the Act. ARPA's permitting component allows for the recovery of certain artifacts consistent with the standards and requirements of the Federal Archeology Program. While ARPA is applicable to the marine environment, its reach in this context is limited. Pursuant to the express language of the Act itself, ARPA can only be applied to such areas as national parks (with federally-owned submerged lands) and wildlife refuges. Additionally, ARPA specifically states that it does *not* apply to activities occurring on the outer continental shelf.

**Coastal Barrier Resources Act (CBRA)**, 16 U.S.C. §§ 3501 et seq.

The purpose of the CBRA is to promote more appropriate use and conservation of coastal barriers along the Atlantic, Gulf, and Great Lakes coastlines. Coastal barriers are defined as bay barriers, barrier islands, and other geological features composed of sediment that protect landward aquatic habitats from direct wind and waves. They provide essential habitats for wildlife and marine life, natural storm buffer zones, and areas of scientific, recreational, historic, and archeological significance. The CBRA seeks to minimize the loss of human life, wasteful federal expenditures on shoreline development, and damage to wildlife, marine life, and other natural resources by restricting future federal financial assistance, establishing a coastal barrier resources system, and considering the means of achieving long-term conservation of barrier resources.

**Coastal Zone Management Act (CZMA)**, 16 U.S.C. §§ 1451 et seq.

The CZMA encourages states to develop coastal zone management programs that allow for growth and development that is compatible with the protection of natural resources. The CZMA provides financial and technical incentives for states to manage their coastal zones consistent with CZMA standards and goals.

The CZMA mentions in several places concepts related to recreation and tourism. For example, the congressional findings cite recreational and esthetic resources as being of value to the present and future well-being of the nation. The findings note that increasing and competing demands upon lands and waters of the coastal zone, including requirements for recreation, have resulted in the loss of important cultural, historic, and esthetic values in the coastal zone, which are essential to the well-being of all citizens. Further, the findings state, new and expanding demands for recreation activities in coastal and ocean waters are placing stress on these areas and are creating the need for resolution of serious conflicts among important and competing uses and values in these waters.

Management programs under the CZMA are required to include, among other things, certain elements related to recreational concerns, including planning processes for the protection of, and access to, public beaches and other public coastal areas of environmental, recreational, historical, esthetic, ecological, or cultural value, as well as procedures whereby specific areas may be designated for the purpose of preserving or restoring them for their conservation, recreational, ecological, historical or esthetic values.

The CZMA also allows the Secretary to make grants to coastal states to meet objectives including preservation or restoration of areas notable for their conservation, recreational, ecological, or esthetic values, and the provision of public access to beaches and other public coastal areas.

The CZMA also includes the National Estuarine Research Reserve System (NERRS), which consists of a network of representative estuarine ecosystems suitable for long-term research. In order to be designated as part of the NERRS, a reserve must serve to enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation.

**Federal Water Pollution Control Act**, as amended, also called the **Clean Water Act**, as amended (CWA), 33 U.S.C. §§ 1251 et seq.

The CWA establishes the basic scheme for restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. The primary mechanism in the CWA regulating the discharge of pollutants is the National Pollutant Discharge Elimination System (NPDES), which is administered by the Environmental Protection Agency (EPA). Under the NPDES program, a permit is required from EPA or an authorized state for the discharge of any pollutant from a point source into the waters of the United States. This includes discharges associated with oil and gas development on federal leases beyond state waters. An NPDES permit for certain stormwater discharges also is required. Permit discharge limits are technology-based and, where technology-based limits would not protect desired water quality for a particular water body in which the discharge takes place, based on state water quality standards, which are developed by the states using EPA guidance and are intended to protect the designated uses of the water body. In the case of discharges to the territorial sea or beyond, permits are also subject to the ocean discharge criteria developed under section 403 of the act. Permits for discharges into the territorial sea or internal waters may be issued by states following approval of their permit program by EPA; in the absence of an approved state permit program, and for discharges beyond the territorial sea, EPA is the permit-issuing authority.

The CWA was amended in 1987 to include the current non-point source (NPS) program. Under this program (section 319), states must develop management programs to address NPS runoff, including the identification of best management practices and measures. In addition, section 319 authorizes grants to assist the states in implementing their approved management programs.

The CWA generally prohibits discharges of oil and hazardous substances into coastal or ocean waters except where permitted under the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships. The U.S. Coast Guard (USCG) investigates and responds to discharges of oil and hazardous substances into coastal or ocean waters in accordance with the National Contingency Plan (NCP). The USCG, with the cooperation of EPA, generally administers the NCP when oil or a hazardous substance is discharged into coastal or ocean waters. Regional contingency plans and area contingency plans are developed to implement the NCP.

The CWA (section 312) requires vessels with installed toilet facilities and operating on the navigable waters of the U.S. to contain operable marine sanitation devices certified as meeting standards and regulations promulgated under section 312. Section 312 also allows establishment of zones where discharge of sewage from vessels is completely prohibited. Amendments made to section 312 in 1996 will require, where appropriate, the use of marine pollution control devices for operational, non-sewage, discharges from vessels of the Armed Forces.

Publicly owned sewage treatment facilities must, at a minimum, meet effluent reductions by secondary treatment, except for certain facilities discharging to coastal waters for which EPA has approved a waiver under section 301(h).
Section 320 of the CWA establishes the National Estuary Program, which uses a consensus-based approach for protecting and restoring estuaries. There are currently 28 estuaries in the program.

The Army Corps of Engineers (COE) implements the section 404 permit program. Under section 404, a permit is required for the discharge of dredged or fill materials into the waters of the U.S. that lie inside of the baseline for the territorial seas and fill materials into the territorial seas within three miles of shore. Although COE has the permitting responsibility under the section 404 program except in certain waters of two states (Michigan and New Jersey), which have assumed the authority, EPA is authorized to review and comment on the impact of proposed dredge and fill activities and to prohibit discharges that would have an unacceptable impact on municipal water supplies, shellfish beds and fishery areas, wildlife and recreational areas. EPA, in consultation with COE, is charged with developing guidelines to be used in evaluating discharges subject to section 404. (See 40 C.F.R. Part 230.) The section 404 permit requirement is the cornerstone for the current wetlands regulatory program. If COE or EPA determines that a certain property is a jurisdictional wetlands, no one can discharge dredged or fill materials into it without a section 404 permit. COE and EPA also have cooperative agreements with the Natural Resources Conservation Service and rely on its determinations as to the presence of wetlands on agricultural lands.

## National Flood Insurance Reform Act of 1994 (NFIRA)

The NFIRA established the Flood Mitigation Assistance (FMA) program. The purpose of FMA is to plan and carry out activities designed to reduce the risk of flood damage to structures covered under contracts for flood insurance under this title. Section 1366 of the NFIRA assigns the FEMA Director the authority and responsibility for carrying out the program. 42 U.S.C. § 4104c. Section 1367 establishes the National Flood Mitigation Funds to fund FMA grants. 42 U.S.C. § 4104d.

The Flood Mitigation Assistance program, unlike the Stafford Act programs, are pre-disaster programs. There are three types of FMA grants. *Planning grants* assist states and communities in developing flood mitigation plans. Under section 1366 of the NFIRA, a FEMA- approved Flood Mitigaton Plan (FMP) is required in order for a state or community to receive a FMA project grant. *Project grants* fund eligible flood mitigation projects. FEMA encourages states to prioritize the mitigation activities outlined in their FMPs and fund projects that will greatly reduce or eliminate the risk of flood damage to buildings, manufactured homes, and other NFIP-insurable structures. Mitigation of repetitively or substantially damaged structures is a high priority. *Technical assistance grants* assist states in providing technical assistance to applicants in applying for the program or in implementing approved projects.

## National Marine Sanctuaries Act (NMSA), 16 U.S.C. §§1431 et seq.

The NMSA provides the Secretary of Commerce with the authority to designate and manage nationally significant marine areas as national marine sanctuaries. The NMSA lists recreational and esthetic qualities as among the things that might give an area special national significance.

The NMSA's stated purposes and policies include comprehensive and coordinated conservation and management; enhancing public awareness, understanding, appreciation and wise use of the marine environment; and facilitating, to the extent compatible with the primary objective of resource protection, all public and private uses of resources not prohibited pursuant to other authorities.

Among the factors the Secretary must consider in determining whether an area merits designation as a national marine sanctuary are present and potential uses of the area that depend on maintenance of the area's resources, including commercial and recreational fishing, other commercial and recreational activities, and research and education; the public benefits to be derived from sanctuary status, with emphasis on the benefits of long-term protection of nationally significant resources, vital habitats, and resources which generate tourism.

**National Park Service Organic Act**, 16 U.S.C. §§ 1, 2-4

This act creates the National Park Service (the Service) in the Department of the Interior. The Service is charged with promoting and regulating the use of federal areas known as national parks, monuments, and reservations. Such areas are established by Congress through specific legislation.

**National Wildlife Refuge System**, 16 U.S.C. § 668dd

This section of law consolidates the authorities relating to the various categories of areas administered by the Secretary of the Interior for the conservation of fish and wildlife by designating all such areas part of the National Wildlife Refuge System (the System). The law prohibits knowingly disturbing, injuring, cutting, burning, removing, destroying, or possessing any real or personal property of the United States, including natural growth, in any area of the system, or taking or possessing any fish, bird, mammal, or other wild animals within any such area without a permit. The Secretary may permit areas within the System to be used for hunting, fishing, and public recreation when the Secretary determines such uses are compatible with the major purposes for which such areas were established.

Another section of law, 16 U.S.C. § 460k, recognizes the mounting public demands for recreational opportunities on areas administered by the Secretary of the Interior for fish and wildlife purposes, including areas within the System. This section provides that the Secretary may administer such areas as public recreation areas when the Secretary determines that public recreation is an appropriate incidental or secondary use. Such public recreation may be permitted only to the extent that it is not inconsistent with the primary objectives for which the particular area was established.

**National Historic Preservation Act (NHPA)**, 16 U.S.C. §§ 470, et seq.

The NHPA is the largest piece of federal historic preservation legislation. It has two major components that affect the responsibilities of federal agencies managing submerged lands. First, under section 106 of the NHPA, federal agencies are to consider the effects of their undertakings (including the issuance of permits, the expenditure of federal funding and federal projects) on historic resources that are either eligible for listing or are listed on the National Register of Historic Places. Section 110 of the NHPA imposes another obligation on federal agencies that own or control historic resources. Under this section, federal agencies must consider historic preservation of historic resources as part of their management responsibilities.

**National Wilderness Preservation System**, 16 U.S.C. § 1131

This program establishes a system of federally owned "wilderness areas," which are administered for the use and enjoyment of the American people in such a manner as will leave the areas unimpaired for future use and enjoyment as wilderness. Such areas are managed by the Department of the Interior and by the agency that had jurisdiction over the area before its inclusion in the National Wilderness Preservation System.

**Oil Pollution Act of 1990 (OPA)**, 33 U.S.C. §§ 2701 et seq., inter alia

OPA amends section 311 of the Federal Water Pollution Control Act (the Clean Water Act or CWA), 33 U.S.C. 1321 et seq., to clarify federal response authority, increase penalties for spills, establish U.S. Coast Guard response organizations, require tank vessel and facility response plans, and provide for contingency planning in designated areas. OPA, however, does not preempt states' rights to impose additional liability or other requirements with respect to the discharge of oil within a state or to any removal activities in connection with such a discharge.

OPA is a comprehensive statute designed to expand oil spill prevention, preparedness, and response capabilities of the federal government and industry. OPA establishes a new liability regime for oil pollution incidents in the aquatic environment and provides the resources necessary for the removal of discharged oil. OPA consolidates several existing oil spill response funds into the Oil Spill Liability Trust Fund (Trust Fund), resulting in a $1-billion fund to be used to respond to, and provide compensation for damages caused by, discharges of oil. In addition, OPA provides new requirements of response planning by both government and industry and establishes new construction, manning, and licensing requirements for tank vessels. OPA also increases penalties for regulatory noncompliance and broadens the response and enforcement authorities of the federal government.

Title I of OPA contains liability provisions governing oil spills modeled after the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601 et seq., and section 311 of the CWA. Specifically, section 1002(a) of OPA provides that the responsible party for a vessel or facility from which oil is discharged, or which poses a substantial threat of a discharge, is liable for:

- certain specified damages resulting from the discharged oil; and
- removal costs incurred in a manner consistent with the National Contingency Plan.

The scope of damages for which there may be liability under section 1002 of OPA includes:

- natural resource damages, including the reasonable costs of assessing these damages;
- loss of subsistence use of natural resources;
- real or personal property damages;
- net loss of tax and other revenues;
- loss of profits or earning capacity; and
- net cost of additional public services provided during or after removal actions.

# LIST OF ACRONYMS

| | |
|---|---|
| CCMP | Comprehensive Conservation and Management Plan |
| CZM | Coastal Zone Management |
| EPA | Environmental Protection Agency |
| FEMA | Federal Emergency Management Agency |
| NEP | National Estuary Program |
| NERRS | National Estuarine Research Reserve System |
| NFIP | National Flood Insurance Program |
| NMFS | National Marine Fisheries Service |
| NMS | National Marine Sanctuary |
| NOAA | National Oceanic and Atmospheric Administration |
| NOS | National Ocean Service |
| OAR | (Office of) Oceanic and Atmospheric Research |
| OCRM | (Office of) Ocean and Coastal Resource Management |

# 1998 Year of the Ocean

## IMPACTS OF GLOBAL CLIMATE CHANGE—WITH EMPHASIS ON U.S. COASTAL AREAS

### Contents

## EXECUTIVE SUMMARY

The Earth's weather and climate are the result of the redistribution of heat. The major source of heat to the surface of the Earth is the sun, principally through incoming visible radiation most of which is absorbed by the Earth's surface. This radiation is redistributed by the ocean and the atmosphere with the excess radiated back into space as longer wavelength, infrared radiation. Clouds and other gases, primarily water vapor and carbon dioxide, absorb the infrared radiation emitted by the Earth's surface and remit their own heat at much lower temperatures. This "traps" the Earth's radiation and makes the Earth much warmer than it would be otherwise.

Most of the incoming solar radiation is received in tropical regions while very little is received in polar regions especially during winter months. Over time, energy absorbed near the equator spreads to the colder regions of the globe, carried by winds in the atmosphere and by currents in the ocean. Compared to the atmosphere, the ocean is much denser and has a much greater ability to store heat. The ocean also moves much more slowly than the atmosphere. Thus, the ocean and the atmosphere interact on different time scales. The ocean moderates seasonal and longer variations by storing and transporting, via ocean currents, large amounts of heat around the globe, eventually resulting in changing weather patterns.

The ocean also plays an important role in climate change. Long-term impacts of climate change in coastal areas, such as sea level rise or storm surges, could result in the increased erosion of shores and associated habitat, increased salinity of estuaries and freshwater aquifers, altered tidal ranges in rivers and bays, changes in sediment and nutrient transport, and increased coastal flooding. Such changes have considerable implications for U.S. coastal areas where the majority of the country's population and significant economic activity is concentrated.

The purpose of this document is to consider how the ocean influences weather and climate and how climatic changes could impact valuable coastal areas. It also addresses the barriers to progress and the opportunities presented by the 1998 Year of the Ocean to better understand and predict weather and climate variability and to address the coastal impacts of global climate change. This topic spans such a broad array of considerations that it will be split into three parts: seasonal to interannual climate impacts, decadal to centennial climate impacts, and coastal global climate change impacts. Options for consideration to further advance efforts in each topical area are included.

### Seasonal to Interannual Climate Impacts

The global atmosphere and world ocean are an interactive system. The most important air-sea interaction signal comes from the El Niño/Southern Oscillation (ENSO) which originates in the tropical Pacific. In a warm episode (El Niño), the pool of warm water that is normally found in the western Pacific expands eastward, carrying with it portions of the precipitation normally found in the far western Pacific. This shift in the distribution of tropical convection leads to shifts in jet stream tracks, resulting in climatic anomalies around the world. The ENSO cycle is rooted in the instability of the coupled atmosphere-ocean system and occurs over an irregular, quasi-periodic cycle which varies between three and seven years.

Seasonal to interannual forecasts of the climate variability from ENSO can now predict climate changes for up to a year. The improved skill and lead time of these forecasts can result in savings of hundreds of millions of dollars a year both in the U.S. economy and abroad. Advanced knowledge of ENSO allows farmers to make decisions to maximize agricultural yields. ENSO forecasts will also improve fisheries management because ENSO episodes strongly influence marine catches from Chile to Alaska. In addition, the benefits of improved predictions to the water resources and energy sectors of the economy are potentially as large as those for agriculture and fishing.

To produce useful seasonal to interannual climate forecasts, it is necessary to both implement an operational climate forecasting system and to continue to invest in process and modeling research that leads to improved predictability. In addition, enhanced global observation and data processing systems will continue to be required to support the research and to initialize and validate model predictions.

The National Oceanic and Atmospheric Administration (NOAA) currently provides operational seasonal forecasts based on a combination of dynamical model and statistical predictions for up to one year in advance for the United States. Although NOAA actively coordinates its efforts with other federal agencies, the global nature of the climate signal requires involvement with universities and international agencies. These partnerships are necessary so that societies from around the world can benefit from the enhanced predictability and learn to use the information for broad-based environmental and economic gain.

## Decadal to Centennial Climate Impacts

The ocean has a huge capacity to transport and store heat and carbon dioxide ($CO_2$), and exchange huge quantities of water and $CO_2$ with the atmosphere at the sea surface. Ocean transports play a large role in the present climate and its variability. Coupled ocean-atmospheric models used to predict global temperature changes have shown that the ocean has the potential to delay the impact of greenhouse gas emissions and thus affect changes in atmospheric conditions. Models complemented by observations provide the means to distinguish between natural variability on decadal to centennial time-scales and anthropogenic (human influenced) climate change. For example, a recent modeling study, which looked at a long term record of observed and simulated atmospheric temperature, suggests that the recent increases could be related to $CO_2$ changes.

Observations describe variations in the climate system while models provide the mechanism to understand why such variations occur, and to predict future evolution of the climate system. To improve our understanding of the climate system, an integrated research program has been established to improve models to better represent climate processes and to collect long-term instrumental and proxy observations in the ocean. The benefits to society of this approach are: (1) improved detection of climate change signals in the ocean; (2) improved models of natural and anthropogenic climate variability; (3) quantification of the predictability of long-time scale climate variability; and (4) reduced uncertainties in $CO_2$ warming scenarios.

### Global Climate Change Impacts on U.S. Coastal Areas

The United States' coastline stretches for approximately 158,000 kilometers (93,600 miles), bounding some of the most valuable and heavily used areas in the nation that could be affected by climate change. Within these coastal areas lie natural and human resources of tremendous value. These include about 38,900 square kilometers (15,000 square miles) of coastal wetlands, which provide crucial wildlife habitat and filter toxins from rivers, and 6,500 square kilometers (2,500 square miles) of developed barrier islands, which support recreational communities. U.S. coastal areas also support a variety of important economic activities, including fisheries and aquaculture, tourism, recreation, industry, and transportation.

U.S. coastal areas are experiencing greatly increased pressures as a result of rapid population growth and accompanying development. Nutrient and bacteria pollution from urban and agricultural runoff, changes in hydrology and salinity to naturally balanced systems, shore erosion, and over-development all currently stress our coasts. The effects of climate change would only add to these stresses.

While global climate has fluctuated throughout time, a global warming scenario could speed this process possibly causing accelerated sea-level rise (ASLR), alterations of rainfall patterns and storm frequency or intensity, and increased siltation. The Intergovernmental Panel on Climate Change (IPCC) has forecasted a rise in global sea level of 5 mm/yr, within the range of uncertainty of 2-9 mm/yr; or 20, 49, or 86 cm by 2100. Climate change and a rise in sea level or changes in storms or storm surges could result in the increased erosion of shores and associated habitat, increased salinity of estuaries and freshwater aquifers, altered tidal ranges in rivers and bays, changes in sediment and nutrient transport, a change in the pattern of chemical and microbiological contamination in coastal areas, and increased coastal flooding.

Some coastal ecosystems are particularly at risk, including saltwater marshes, coastal wetlands, coral reefs, coral atolls, and river deltas. Other critical coastal resources, such as mangroves and sea-grass beds, submerged systems including submerged aquatic vegetation and mudflats, are at risk from climate change impacts, and exacerbated by anthropogenic factors. Changes in these ecosystems could have major negative effects on tourism, freshwater supplies, fisheries, and biodiversity that could make coastal impacts an important economic concern. Coastal structures, including homes would also be more vulnerable to increased sea-levels. FEMA has estimated that the number of homes in the coastal floodplain would more than double under the highest of sea-level rise scenarios. This growth will be the result of the increase in the area of the coastal floodplain due to sea-level rise, as well as the growth of coastal population, which will increase the number of homes built in the coastal floodplain.

Management strategies in coastal areas can be divided into three categories: accommodate, protect, and retreat. The successful implementation of these planned management strategies will depend to a large measure on the extent of their integration into the implementation of other national and sectoral management plans, including integrated coastal management plans. However, because of scientific uncertainties, the long-term nature of the problem and large investments required, state and local governments have hesitated to effectively address the issues relating to climate change. Consequently, management responses to climate change impacts have been gradual since the early 1980s, but pioneering efforts have been important for U.S. policy makers. A major educational challenge is to convince the public of the urgency for taking measures now, through integrated coastal management, to deal with long-term coastal climate change impacts.

## INTRODUCTION

Developing an understanding of both weather and climate means developing an understanding of the Earth's heat budget, i.e., how the energy from incoming solar radiation is redistributed around the globe. The major source of heat to the surface of the earth is the Sun, principally through incoming visible radiation. Heat is generated in the Earth's interior, for example through the decay of radioisotopes; however, this contribution to the heat balance of the surface of the Earth, where most life exists, is small compared to the solar flux. Clouds, ice caps and snow make the Earth a relatively bright planet such that about 30 percent of the incoming solar radiation received at the top of the atmosphere is reflected back into space. A very small fraction is absorbed directly by gases and aerosols as it passes through the atmosphere. Most of it is absorbed by the Earth's surface. This radiation is redistributed by the ocean and the atmosphere and the excess is radiated back into the atmosphere and space as longer wavelength, infrared radiation.

If our atmosphere consisted of just nitrogen and oxygen, the global average surface temperature of the planet would be about 33°C (60°F ) colder than it is now and the Earth would be a frozen wasteland. This is not the case because of the presence of clouds and small quantities of other gases, primarily water vapor and carbon dioxide, that absorb much of the infrared radiation emitted by the Earth's surface and reemit their own heat, as radiation, at much lower temperatures. This "traps" the Earth's radiation and is the mechanism for planetary warming, "the greenhouse effect" (Figure 1).

Aside from the gases in the atmosphere, clouds also play a major role in climate. By reflecting solar radiation away from Earth, some clouds act to cool the planet while other types of clouds warm the Earth by trapping heat near the surface. For years, it was not known whether clouds warmed or cooled the planet. Recent satellite measurements have proven that clouds exert an overall powerful cooling effect on the Earth. In some areas, however, such as the tropics, heavy clouds may markedly warm the regional climate.

Clouds and greenhouse gases fit into a global radiation budget, a budget that must balance itself. Most of the incoming solar radiation is received in tropical regions while very little is received in polar regions especially during winter months. Over time, energy absorbed near the equator spreads to the colder regions of the globe, carried by winds in the atmosphere and by currents in the ocean. The small amount of energy retained in the atmosphere is redistributed, basically, by winds. The time it takes for the atmosphere to mix around the globe is approximately one month. In its simplest form, an understanding of weather is an attempt to understand winds. Compared to the atmosphere, the ocean is much denser and has a much greater ability to store heat. The ocean also moves much more slowly than the atmosphere and distributes heat at a much slower rate. Because the ocean covers nearly two-thirds of the surface of the earth, the combined effect of the ocean's heat capacity and its coverage of the Earth's surface means that much of the heat received from the sun that is retained within the biosphere is stored in the ocean.

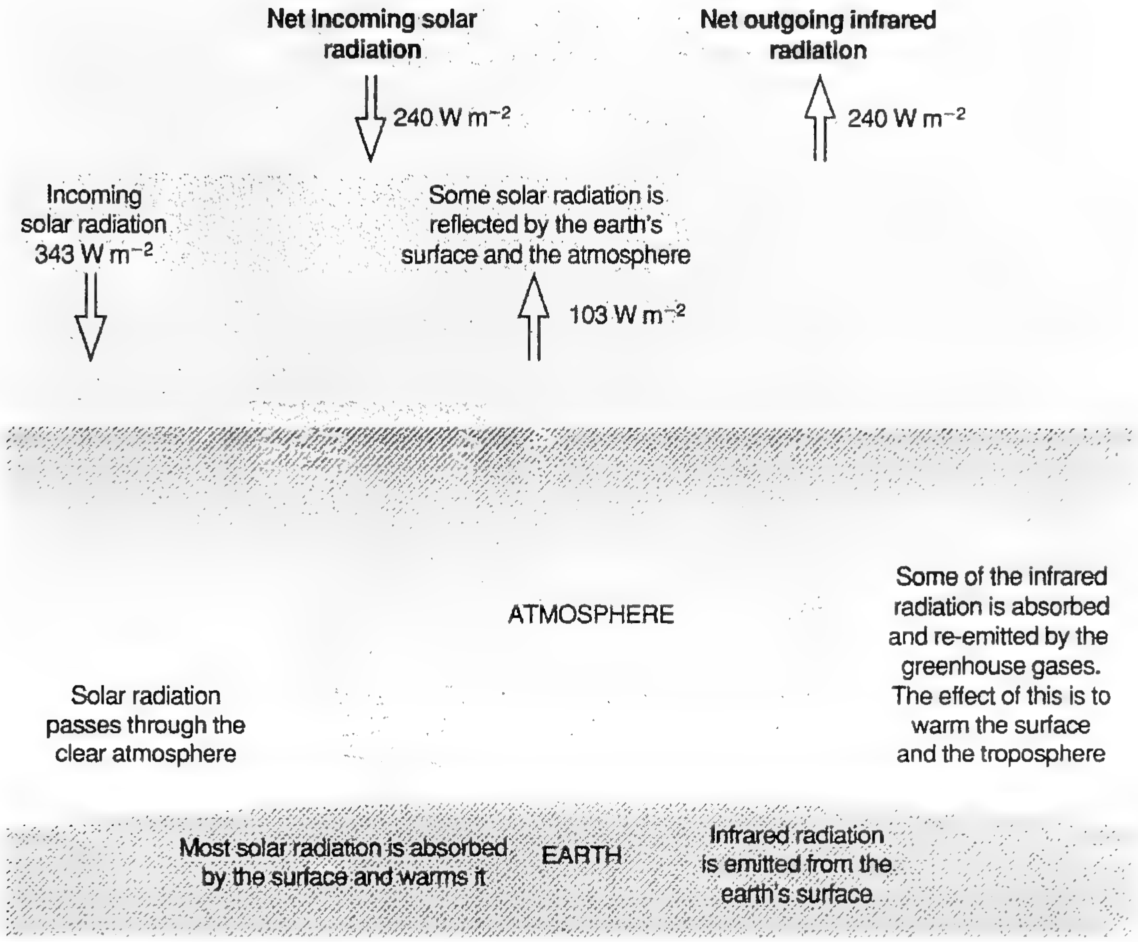



**Figure 1.** A simplified diagram illustrating the global long-term radiative balance of the atmosphere.

The ocean and the atmosphere interact on different time scales. As the time scales change from weather time scales (minutes to weeks) to the longer time scales of climate, the interaction between the ocean and the atmosphere changes as more of the ocean becomes involved. Thus, on weather time scales generally only sea surface temperatures (SST) are involved. At time scales of seasons to years, the upper layers of the ocean (a few hundred meters) have an influence, while at time scales of decades and longer the entire ocean plays a role. The transport of heat by surface ocean currents, for example, modifies mid-latitude temperatures across ocean basins so that land areas on the eastern boundaries of ocean basins are generally warmer than areas at the same latitude on the western boundary.

The purpose of this document is to consider how the ocean influences weather and climate and to address the barriers to progress and the opportunities presented by the 1998 Year of the Ocean to better understand and predict weather and climate variability. This topic includes seasonal to interannual forecasts, as well as prediction of long term climate change such as temperature and sea level. Because this paper spans such a broad array of considerations, it will be split into three parts: seasonal to interannual climate impacts, decadal to centennial climate impacts, and coastal global climate change impacts. The ocean's influence on weather has its largest economic and social impact on coastal areas and will be considered in the coastal section.

## SEASONAL TO INTERANNUAL CLIMATE IMPACTS

### Introductory Considerations

The ocean's influence on climate can be split into normal seasonal cycle influences and departures from normal. Commerce, agriculture, and industry have all evolved to operate best with normal seasonal changes. However, changes from the seasonal normal, for example floods and droughts, can lead to economic disruptions and human suffering. Thus, predictions of climate differences from the expected or normal pattern on seasonal and longer time scales can be of great importance to society.

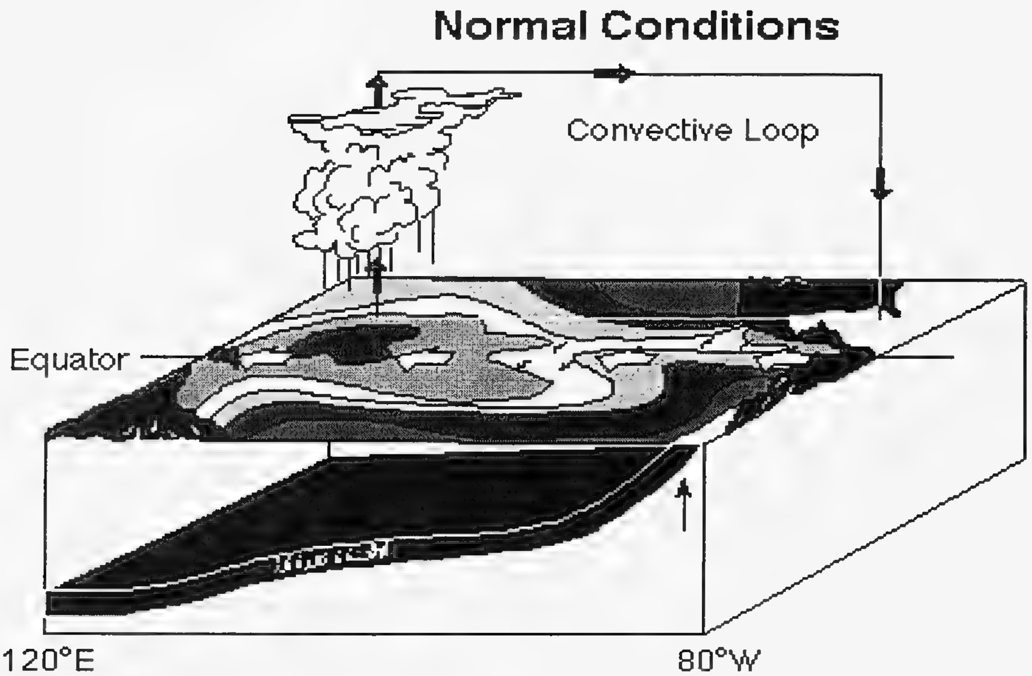
The best understood, strongest, and somewhat consistent interannual air-sea climate signal comes from the El Niño/Southern Oscillation (ENSO) which originates in the tropical Pacific. Under normal conditions, the prevailing trade winds blow from east to west and thus contribute to higher ocean temperatures in the west. Associated with these temperatures are a higher sea level and deeper thermocline in the west than the east. (The thermocline is the boundary between warmer surface waters and the colder water below.) In addition, convective rainfall is located in the far western Pacific Ocean over the warmer sea surface temperatures (see the upper panel of Figure 2). In a warm episode (El Niño), the trade winds weaken and warmer water expands eastward, carrying with it portions of the precipitation. This change includes a reduction of the sea level and thermocline depth in the west and an increase in the east (see the lower panel of Figure 2). There are also cold episodes which are generally the inverses of the warm episode shown in the figure. The term ENSO will be used to refer to both a warm and a cold episode; El Niño will be used to specify a warm episode, and La Niña will be used to specify a cold episode.

The shift in the distribution of winds, surface temperatures, and tropical convection leads to changes in the atmospheric circulation with the possibility of regional droughts, floods, and temperature changes in areas well beyond the tropical Pacific. The typical dependence for El Niño is shown in Figure 3 for Northern Hemisphere winter and summer. In northern middle latitudes, the strongest relationship occurs in the Northern Hemisphere winter when the atmospheric circulation is strongest. The figure shows that El Niño tends to cause warmer than normal winter temperatures in the U.S. Pacific northwest and higher than normal winter precipitation along the U.S. Gulf Coast. La Niña generally impacts the same areas as El Niño but with opposite effects. The ENSO cycle is rooted in the instability of the coupled atmosphere-ocean system. The instability produces repetition of an irregular, quasi-periodic cycle which varies between three and seven years.

The ENSO research effort includes studies on the evolution of sea surface temperatures (SST) as part of the oceanic response to atmospheric forcing and meteorological studies on regional and large-scale air-sea interactions. Thus, monitoring and prediction of sea surface temperatures is an important part of monitoring and predicting ENSO. SST anomalies for 1950 to present are shown for a region with strong ENSO variability (10°N-10°S, 150°W-90°W) in Figure 4. The anomalous SSTs shown here are computed as the difference between measured monthly SSTs and the normal expected monthly SSTs for the period 1950-79. The figure shows positive and negative SST anomalies. Although the distinction between normal, El Niño, and La Niña is not rigorously defined, SSTs which persist for at least six months above roughly 0.75°C can be considered to indicate El Niño, while those that persist below -0.75°C can be considered to indicate La Niña. The figure also shows an overall warming of the tropical ocean by 0.5°C in the decades of the 1980s and 90s with stronger El Niño episodes occurring in the latter part of the record. The strongest complete El Niño occurred in 1982-83. However, if current predictions are validated, the present El Niño episode may become even larger and persist into 1998, which has been designated the Year of the Ocean.

ENSO (El Niño and La Niña) episodes cause changes in the normal global atmospheric circulation. The changes lead to changes in precipitation and temperature which strongly depend on season and location as shown in Figure 3. Areas that are strongly impacted during Northern Hemisphere fall and winter are the south of Africa, Australia, South America, and the U.S. The occurrence of El Niño or La Niña does not guarantee a specific precipitation or temperature response, but only increases the likelihood that a deviation from normal will occur.

Although crop yields depend on many factors, rainfall during part of the growth cycle is often critical. Despite the uncertainties, links between both El Niño and La Niña and crop yields have been established in a number of regions. As an example, winter crop yields in Texas, Oklahoma, Kansas, and Colorado show that the presence of El Niño, with its likelihood of increased rainfall, can increase yields by 15 percent, while La Niña, with its likelihood of decreased rainfall, can decrease yields by 15 percent.



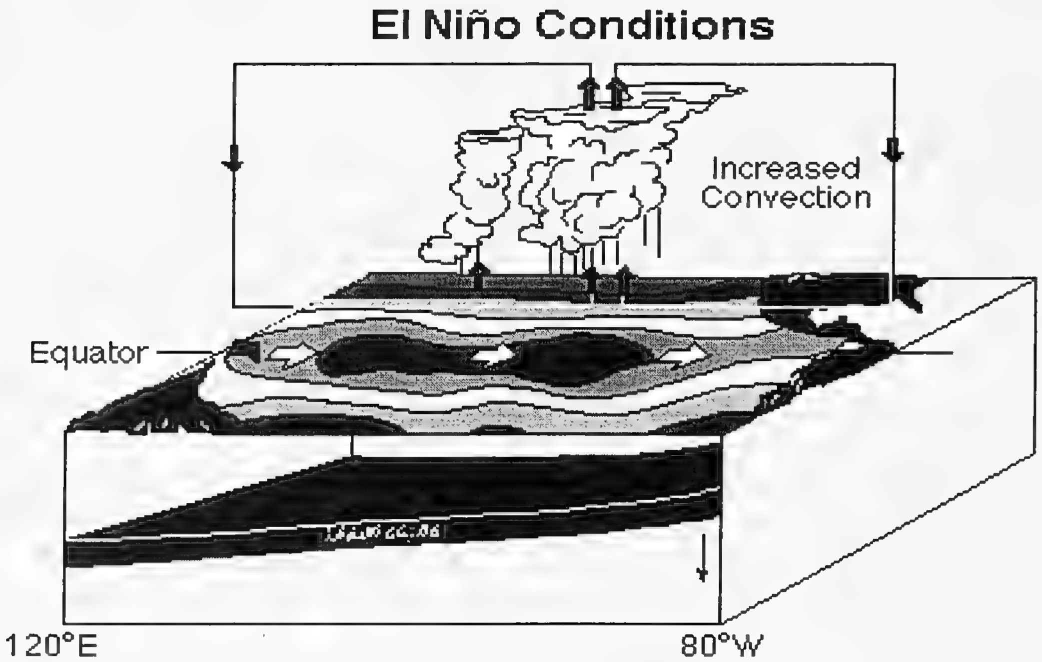




**Figure 2.** Normal (top) and El Niño (bottom) conditions. El Niño conditions include a reduction in the trade winds, an increase in SSTs, and an eastward shift of the precipitation.

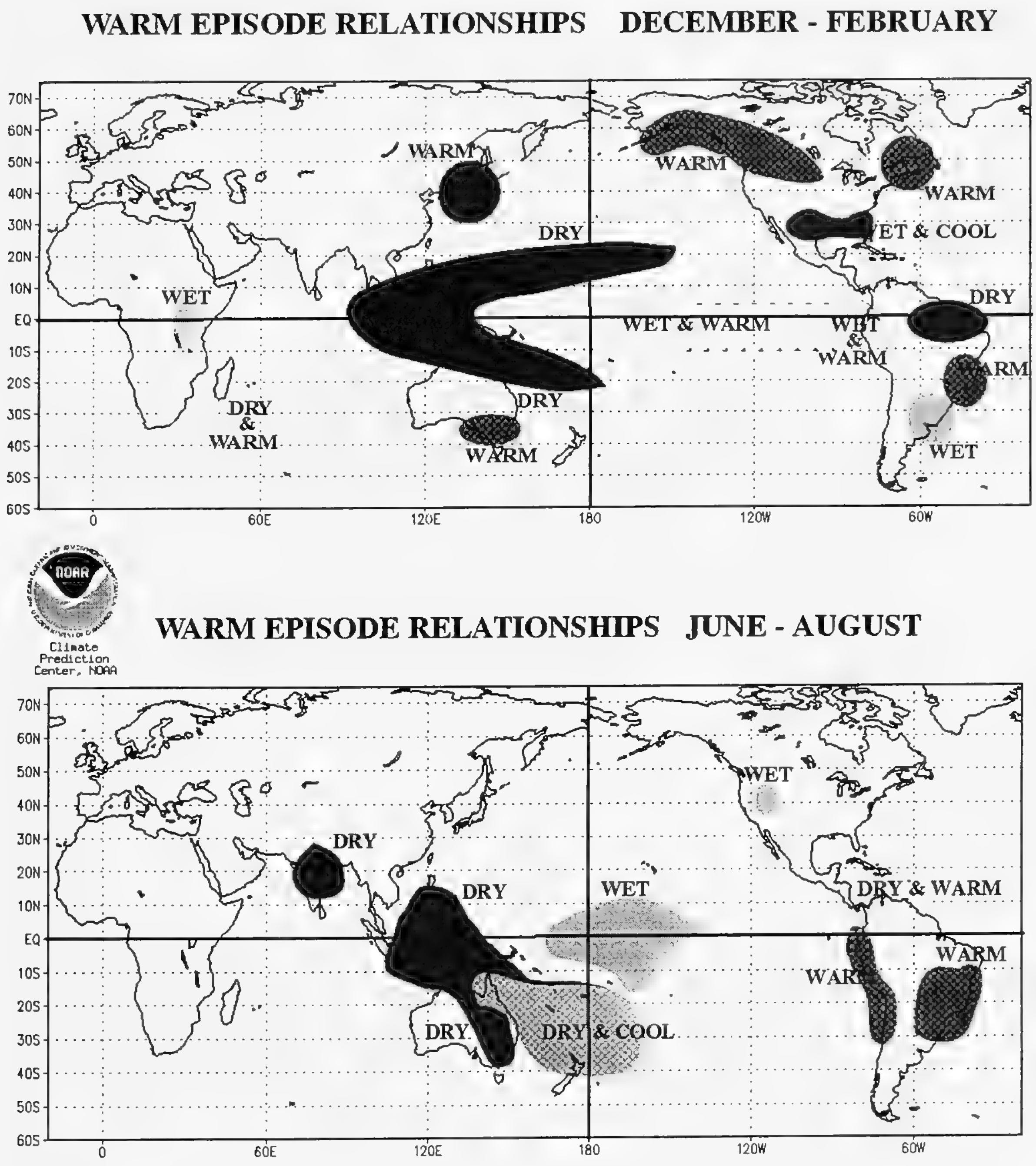



**Figure 3.** Expected changes in temperature and precipitation during a warm ENSO (El Niño) during December through February (top) and June through August (bottom).

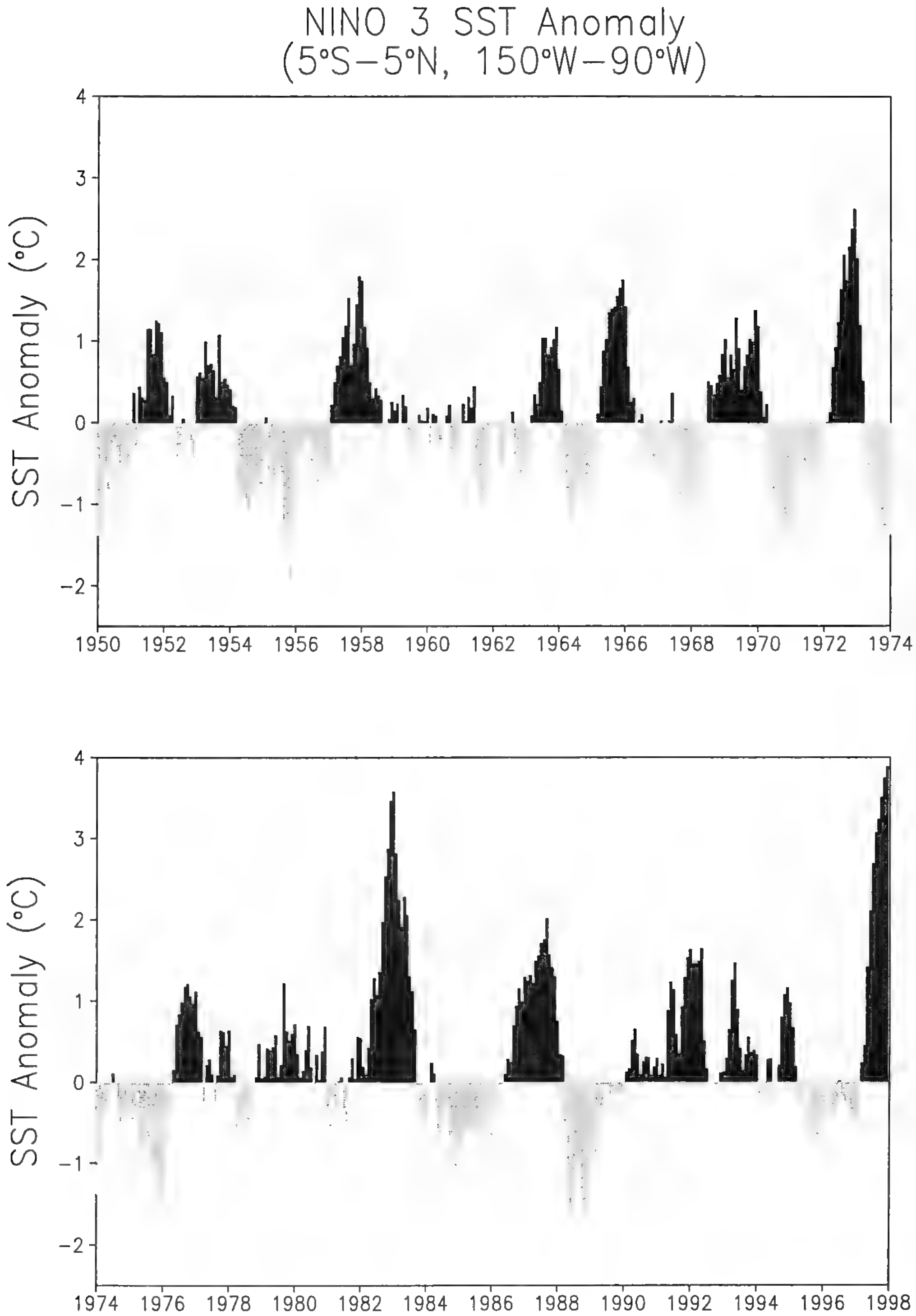



**Figure 4.** Monthly sea surface temperature (SST) anomalies (departure from climatological normal) in °C. The climatological normal period was 1950-70.

During normal years, winds along the equator and along the coast of Peru and the west coast of North America, push surface waters offshore bringing cold, nutrient rich waters from below to the surface— a process known as upwelling. These cold, nutrient rich waters stimulate plant growth resulting in well-established plankton populations and the species which feed on them that include fish, birds, and marine mammals. During El Niño periods, the winds change, upwelling decreases, and the normal plankton population decreases. The animals which feed on the plankton either move elsewhere or die. For example, the 1972-73 El Niño coupled with overfishing caused a collapse of the anchovy fishery off Peru. In addition, in the Pacific northwest, El Niño leads to changes in the salmon fisheries. This is linked to more northward migration of mackerel which prey on juvenile salmon.

ENSO episodes can now be predicted to a level of skill and with enough lead time that hundreds of millions of dollars a year can be saved both in the U.S. economy and abroad. A recent interdisciplinary study estimated the value of improved ENSO forecasts to U.S. agriculture to be between $240 and $325 million per year. A draft study estimates the benefits of a perfect forecast in crop storage to be $240 million annually for corn alone. Advanced knowledge of ENSO will allow farmers to make decisions to maximize agriculture yields. ENSO forecasts have the potential to improve fisheries management because ENSO episodes strongly influence marine catches from Chile to Alaska. In addition, ENSO-induced changes in precipitation can lead to increases in the threat of mosquito-borne diseases such as malaria. The U.S. Centers for Disease Control and Prevention and the World Health Organization are building programs to utilize climate forecasts for enhanced health surveillance and early-warning systems.

Benefits to the water resources and energy sectors are potentially large. The availability of fresh water for irrigation and household use is fundamental to economic well being and varies dramatically during ENSO episodes. ENSO episodes have been linked to regional droughts and an increase in the number of forest fires due to decreased precipitation. Decisions on the purchase and distribution of fuels could be made more cost effective, or estimates of fuel demand based on anticipated climate trends could contribute to more efficient decisions regarding options for purchasing different energy supplies.

To produce useful seasonal to interannual climate forecasts, it is necessary to implement an operational climate forecasting system. It is also necessary to continue to invest in process and modeling research that leads to improved predictability of temperature and precipitation. In addition, enhanced global observing and data processing systems will continue to be required to support the research and to initialize and validate model predictions.

### Status of the Relevant Science and Technical Base

Because of limited observational capabilities before the 1980s, it was not even possible to know if an El Niño episode was underway until several months after the episode began. Progress in climate prediction in the 1980s and early 1990s has been stimulated by the development of models used for ENSO prediction, by empirical and theoretical studies to better understand the global impact of ENSO studies, and by the establishment of an ocean observing system (primarily in the Pacific) for initializing and verifying models for ENSO prediction.

The in situ observing system in the Pacific Ocean improved dramatically during the 1985-94 Tropical Ocean Global Atmosphere (TOGA) period (see Figure 5). The most important component of this system is the National Oceanic and Atmospheric Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL) Tropical Atmosphere Ocean (TAO) moored buoy array which provides basin-wide real-time measurements of surface and subsurface ocean temperature and surface atmospheric winds. These data are augmented by other in situ observations of these same quantities plus additional variables such as upper level atmospheric winds, sea level, and sea level pressure. In addition, remotely sensed observations systems from geostationary and polar environmental satellites give true global coverage of many atmospheric and oceanic variables. The present observing system is a fully multinational effort which is supported by more than two dozen countries.

Models used in ENSO prediction range from purely statistical models to fully coupled dynamic ocean-atmosphere models. Most of the experience in dynamical forecasting is based on an intermediate class of models which simulate only climate differences from normal in order to avoid problems with model climate drift. Some of the simpler models do not make full utilization of all the available data. The more complex coupled general circulation models make better use of the available data and are producing superior ENSO forecasts.

Many developing countries are strongly affected by ENSO episodes because their economies are dependent upon agricultural sectors as a major source of food supply, employment, and foreign exports. In these countries, droughts predicted up to several months in advance, coupled with the response of local farmers, have already contributed to maintenance of food supplies. For example in the Brazilian state of Ceara, agricultural officials used the predictions of the 1991-92 EL Niño to change the timing and types of crops planted. That year Ceara had harvests at near normal levels compared to the massive crop failures experienced during the 1986-87 El Niño.

For procedures such as these to work, it is desirable to have full and open access to data and analysis products among all participating nations, organizations, and institutions. In some cases, national security interests restrict the exchange of information. Moreover, a weakness of ENSO investigations is the limited cooperation among interdisciplinary groups. For example, coupled ocean-atmosphere models include analyses of ocean temperature, salinity, and currents. These data fields would be useful to biologists who wish to understand impacts of ENSO on the distribution of marine species.

The Tropical Ocean Global Atmosphere Program concentrated on ENSO with great success. However, other interannual signals in other tropical oceans and at high latitudes were ignored. For example, changes in the tropical Pacific account for only part of the variability observed over North America in temperature and precipitation. There are also emerging efforts to understand the variability and predictability of the American and the Asian-Australian monsoon

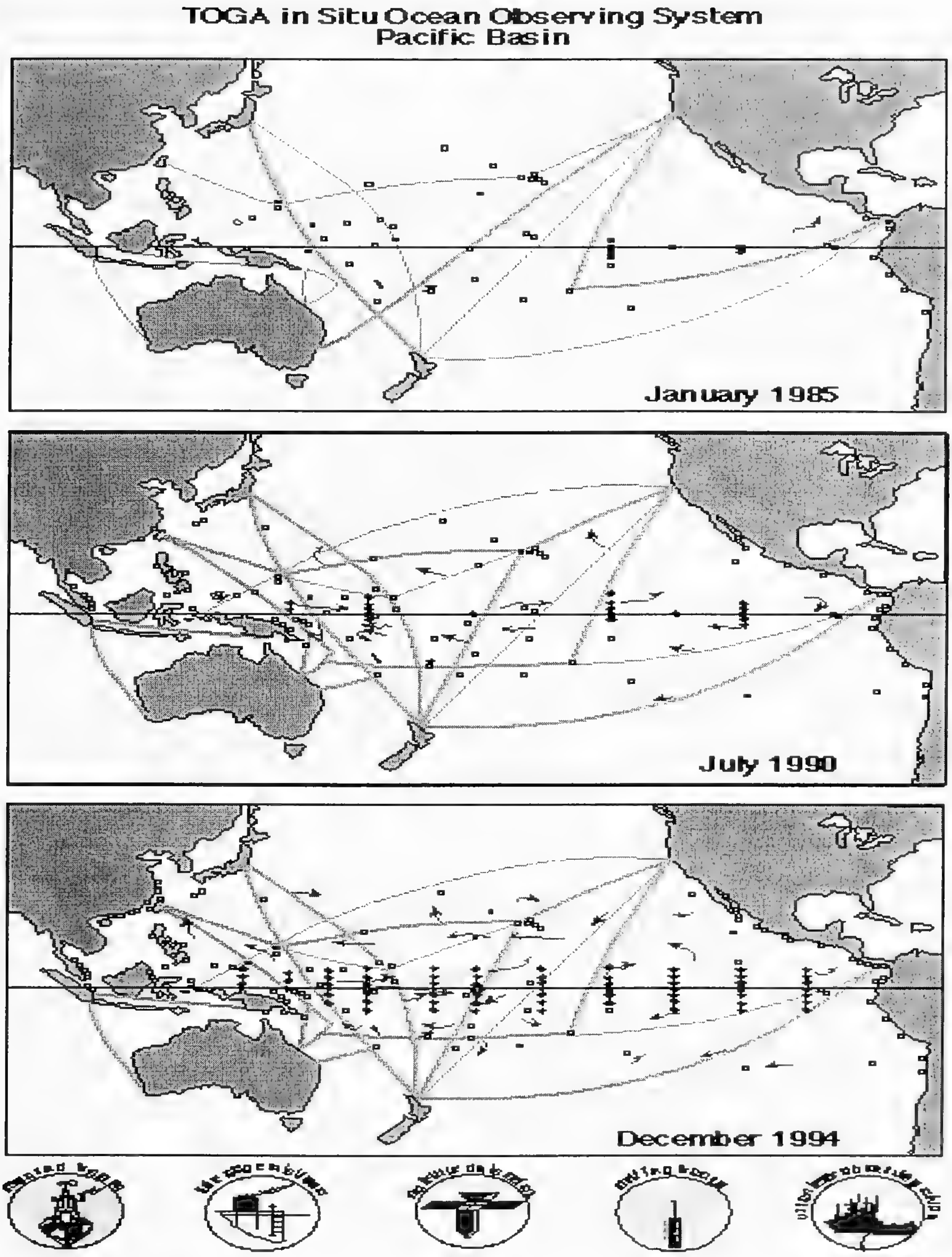



**Figure 5.** The improvement in the in situ observing system in the Pacific from 1985-1994: January 1985 (top), July 1990 (middle), December 1994 (bottom). The "pluses" show moored buoys, the "arrows" drifting buoys, the "lines" ships, and the "dots" tide stations.

systems, the predictive air-sea interactive signal in the Atlantic known as the North Atlantic Oscillation, and decadal and longer climate variability.

### Techniques and Arrangements for Managing Seasonal to Interannual Climate Impacts

NOAA, through the Climate Prediction Center of the National Centers for Environmental Prediction, currently provides operational seasonal forecasts based on a combination of dynamical model and statistical predictions for the U.S. for up to one year. NOAA actively coordinates its efforts with other federal agencies, principally NSF, NASA, and DOE. In addition to the federal agencies, the global nature of the climate signal requires involvement with universities and international agencies. These partnerships remain essential to develop the practical benefits of ENSO forecasts, and to move toward the understanding and prediction of other forms of climate variability.

Research programs are being developed to extend the predictability of ENSO and the accompanying oceanic and meteorological effects. These programs include the Global Ocean Atmosphere Land System Program which extends the original research effort begun by the Tropical Ocean Global Atmosphere Program, and the Global Energy and Water Cycle Experiment Program which improves the parameterization of water and energy fluxes in coupled air-ocean-land models.

A multinational Seasonal-to-Interannual Climate Prediction Program (SCPP) was designed to provide reliable forecasts and analyses of climate variations on seasonal to interannual time scales, and to develop the infrastructure by which this information can be used. The goal of SCPP is to take the next step toward reliable forecasts and analyses of climate variations on seasonal and interannual time scales, and to develop the infrastructure by which this can be used for social and economic benefit by all countries of the world. The program would initially focus on forecasting ENSO and the related climate impacts (atmospheric circulation, precipitation, and surface temperature), and will expand based on the results of continuing research.

A key component of the SCPP plan is the development of an end-to-end forecasting system to develop, improve, and transfer climate modeling technology from research centers to other centers which routinely produce and disseminate climate forecasts to affected local communities and local decision makers. This includes the establishment of an International Research Institute for Climate Prediction. This institute has the responsibility for generating and distributing experimental forecasts multinationally. The forecast information will be tailored to the specific area and take into account climate conditions, forecast needs, and interests as indicated by local decision makers and managers.

### Issues Pertaining to Education and Human Resources

A major focus of climate research is the development of an informed and responsible citizenry who are knowledgeable about climate variability. This includes assessing the impacts of climate variability on human activity and economic potential, and improving public education so climate forecasts are understood and used.

Societies from around the world could benefit by participating in a shared multinational mechanism to maintain and enhance predictability, and learn how to incorporate the information into decision making for broad based environmental and economic gain. Note that on a basic level, activities such as agriculture, fishing, water management, and fuel distribution must take into account the climatological mean annual cycle —crops are planted in anticipation of the optimal growing season, fishing vessels in Peru and Oregon are readied for the seasons when wind-driven upwelling provides nutrients for the food chain; reservoir levels are lowered in anticipation of spring flooding; fuel oil is distributed in anticipation of wintertime heating needs.

### Options for Consideration

The best understood and strongest interannual air-sea climate signal comes from ENSO which originates in the tropical Pacific and leads to changes in the atmospheric circulation well beyond the tropical Pacific. ENSO episodes can now be predicted to a level of skill and with enough lead time that hundreds of millions of dollars a year can be saved both in the U.S. economy and abroad.

NOAA currently provides operational seasonal forecasts based on a combination of dynamical model and statistical predictions for the U.S. An International Research Institute has been established to provide forecasts to other nations. For these efforts to succeed, it is necessary to continue to invest in process and modeling research and to enhance the global observing and data processing systems. It is also necessary to continue to study other interannual signals in the tropics and in higher latitudes. In addition, institutionalized systems, such as the International Research Institute, must continue to be supported so that national and international forecasts, as well as other climate services, can be continued and expanded as predictability of ENSO and other interannual signals improves. The development of new forecasting products that can be used for economic, disaster preparedness, and other planning purposes would also be very beneficial to the nation.

## DECADAL TO CENTENNIAL CLIMATE IMPACTS

### Introductory Considerations

Both the atmosphere and the ocean act together as a giant heat engine with the ocean also playing the role of a flywheel in the system. It takes approximately 4 years for the surface currents of the world's ocean bodies to circulate around the globe. As they do so, they give up their heat to their surroundings and cool. These relatively warm currents also tend to have a slightly higher salt content than the waters they circulate through. This is due to increased evaporation at low latitudes resulting in a small increase in the concentration of salt. In certain parts of the globe, these waters can cool sufficiently such that the colder temperatures combined with this higher salt content make them denser than the surrounding fresh waters. When this happens, this cold, dense water sinks and enters into the circulation of the deep ocean. The deep currents of the ocean eventually surface, primarily in the North Pacific, where they enter into the surface circulation again. It takes on the order of 700-1,000 years to complete a single circuit of the global ocean (see Figure 6, the "Conveyor Belt").

The ocean is not only an immense reservoir of heat and water but also of carbon dioxide ($CO_2$). On geological time scales, marine biological processes act through the uptake of dissolved $CO_2$ (photosynthesis) and its conversion to inorganic carbonate (which is precipitated as carbonate rock (limestone)) as the major control on $CO_2$ distributions in the Earth's biogeochemical system. On time scales of years, marine biological systems, as with faster growing terrestrial systems, equilibrate fairly rapidly with carbon dioxide in the atmosphere. On longer time scales, transfer of $CO_2$ to woody vegetation, soils, and transfer to the deep ocean removes $CO_2$ from the atmospheric system. The oceanic sink of $CO_2$ is considerably larger than the terrestrial sink. While 10-20 percent of the $CO_2$ emitted to the atmosphere by man's activities has been sequestered by terrestrial processes, some 40 percent of the total $CO_2$ emitted by man has been removed from the atmosphere relatively permanently by oceanic processes.

Increased confidence in understanding climate variability, and potential impacts by man on climate can only be obtained through improved representation of ocean climate processes in models, and systematic collection of long-term instrumental observations of climate system variables in the ocean. Key uncertainties limit our ability to detect and project future climate change. In particular, the IPCC 1995 report lists the following as priority topics:

- "Representation of climate processes in models, especially feedbacks associated with clouds, oceans, sea ice and vegetation, in order to improve projections of rates and regional patterns of climate change."

- "Systematic collection of long-term instrumental and proxy observations of climate system variables (e.g., solar output, atmospheric energy balance components, hydrological cycles, ocean characteristics, and ecosystem changes) for the purpose of model testing, assessment of temporal and regional variability, and for detection and attribution studies."

These priorities recognize that predicting climate change resulting from emissions of greenhouse species and formulating future decisions on the possible regulation of these emissions require more accurate models, models which have been adequately tested against a well-designed network of observations. Observations also serve other purposes. Of paramount importance, only observations can detect climate change. In addition, observations can provide increased understanding of climatically important ocean processes. Finally, chemical and physical oceanographic observations provide data needed to separate anthropogenic from natural variability.

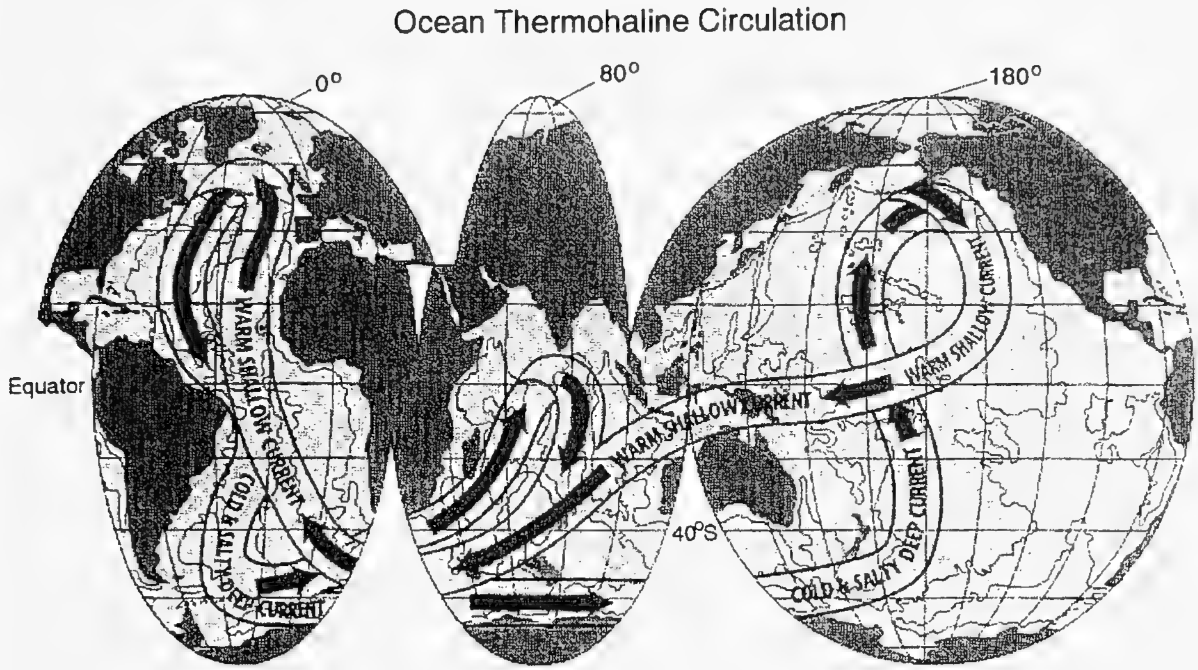



**Figure 6.** The two-layer thermohaline conveyor belt summary taken schematically from Broecker (1991), plotted on a different base map.

## Status of the Relevant Science and Technical Base

The ocean interior has a huge capacity to transport and sequester heat, fresh water, and $CO_2$ exchanged with the atmosphere at the sea surface. Ocean transports of these play a large role in the present climate and its variability. Coupled ocean-atmospheric models used to predict global temperature changes have shown that the ocean sequestration has the potential to delay the impact of greenhouse gas emissions and thus affect changes in atmospheric conditions. These latter changes occur both directly by the oceanic uptake of 30-60 percent of the anthropogenic $CO_2$ currently produced, thereby attenuating the atmospheric $CO_2$ increase, and indirectly by buffering the atmospheric temperature increase due to the ocean's large thermal mass.

The present state of models and sparse observations are factors that lead to uncertainties in estimates of oceanic transport, uptake and sequestration. For example, the current coupled General Circulation Models (GCMs) used to simulate climate change fail to produce long-term trends in Pacific sea-surface temperature. Observationally, three estimates of the transport of heat from south to north at 24°N in the Atlantic show a steady rise from 1957 through 1992. Available data can not resolve if these changes represent a natural or an anthropogenic induced trend and/or whether they are biased by an unresolved annual signal. Furthermore, the uncertainty in ocean dissolve inorganic carbon uptake is 40 percent of the total (2.0 billion metric tons of carbon per year). These uncertainties must be reduced if confidence in $CO_2$ warming scenarios is to increase.

Models complemented by observations provide the means to distinguish between natural variability on decadal to centennial time-scales and anthropogenic climate change. For example, a recent modeling study looked at a long term record of observed and simulated atmospheric temperature and found the rates of recent increases in temperature in both data sets to be similar. These rates are unprecedented in terms of the longer model record suggesting that the recent increases could be related to $CO_2$ effects.

An effective approach to improve the representation of climatically important ocean processes in models is to test hypotheses on the dynamics of naturally occurring, coupled air-sea interactions that are found in models and observations. Several candidate hypotheses exist. For example, a model forced only by seasonally varying solar radiation at the top of the atmosphere includes coupling on decadal time scales between two atmospheric patterns—a connection between the Pacific and North America known as the PNA pattern and a North Atlantic pattern known as the North Atlantic Oscillation (NAO)— and the upper layers of the northern hemisphere middle latitude ocean. The NAO is a seesaw pattern in sea-level pressure with nodes over the Bermuda High and Icelandic Low. Both atmospheric features have been shown to have significant impact on U.S. and European climate on many time scales. On decadal time scales this could mean multiple years of weather regimes, like drought in the Southwestern United States or floods in the South Atlantic states. Observational studies of coupled air-sea interactions using recently collected data find similarities between the measurements and the coupled model results on decadal time scales in both the North Atlantic and Pacific basins. However, the comparison studies are still at an early stage and validation of this coupled mode requires additional effort.

Results from another numerical model suggest that on multidecadal time scales, the NAO is coupled to the thermohaline circulation of the Atlantic. (Thermohaline circulation refers to circulation driven by density differences in the water with density being determined by temperature and salt content.) Recent observations also show that the decadal signal in upper layer temperature and NAO index are both superimposed on longer term trends. In addition, analysis of historical atmospheric data indicates that a strong decadal signal in NAO variability is limited to the past 30 to 40 years.

Recent model results from the Geophysical Fluid Dynamics Laboratory (GFDL) suggest the existence of a mode of climate variability on a multidecadal time series involving interactions between the Arctic and North Atlantic. This mode is characterized by variations in the export of fresh water and sea ice from the Arctic. It has substantial impacts on the atmospheric circulation and climate over parts of Europe, as well as on the intensity of the thermohaline circulation and associated meridional heat transport in the North Atlantic. Analyses of observations and various model runs with and without $CO_2$ increases provide data for: (1) increased understanding of the dynamics of the coupled ocean atmosphere system; (2) identification of climatically important oceanic features to monitor; (3) model validation; (4) predictability studies; and (5) separation of natural and anthropogenic climate change. For example, observations can be used to benchmark decadal and multidecadal variability from model simulations. If the models provide realistic results of recent variability, this will offer confidence to conduct long simulations and assess the role of $CO_2$ on the air-sea system.

Recent observations in the Atlantic argue for hypothesis driven climate studies in this basin. After decadal increases in the NAO index, a significant decrease in this pattern has just occurred (with expected changes in European weather). Concurrent with the increase in the NAO index, extrema in several properties of the thermohaline circulation in the Atlantic have been observed (e.g., convection in the Labrador Sea and lack of convection in the Greenland Sea, increased subsurface temperatures in the subtropical Atlantic, and recently ventilated waters observed in the deep currents along the western boundary of the North Atlantic Ocean).

Several data-sets have been collected and several observing networks are in place that provide a critical foundation for detection of climate change. The NOAA/DOE/NSF supported World Ocean Circulation Experiment hydrographic program and global carbon survey have provided an accurate benchmark for the ocean inventory of $CO_2$ and other properties. Comparisons of these data with historical records are revealing large-scale variability in ocean properties over decadal time scales. Synthesis of these data will greatly improve estimates of interior ocean fluxes. Analysis of the $CO_2$ survey data will yield robust estimates of the oceanic uptake of $CO_2$ to date thereby offering critical constraints on partitioning of anthropogenic $CO_2$ between the atmosphere, ocean, and terrestrial biosphere. Continued direct measurements are needed next to: (1) track the rate of change of oceanic $CO_2$ and estimate $CO_2$ fluxes (e.g., GCM's suggest that ocean sequestration of $CO_2$ decreases in response to climate warming); (2) track changes in the storage and fluxes of heat and freshwater; and (3) provide data for model validation studies.

Upper layer temperature data are collected, in part, by a global Volunteer Observing Ship network. This network provides over 100 years of surface data including SST and about 30 years of subsurface temperature data. Analysis of these data provided the characteristics of many of the decadal signals described above. There are, however, large areas, particularly in the central and eastern northern oceans and all of the southern oceans, where little or no data are available. Data sparsity in the northern hemisphere precludes validation of several of the theories described above. In the southern hemisphere, variability in water properties as large as those associated with the PNA pattern and NAO have been observed. Possible aliasing and other problems resulting from the sparse sampling in the region has made establishing dynamical mechanisms and air-sea feedback difficult. Trade-offs between in situ and remote sampling of upper layer characteristics in data poor regions must be evaluated to develop cost-effective network designs. Combinations of modeling and empirical network design efforts are an integral part of developing detection/attribution capabilities.

NOAA/OAR/ERL (Environmental Research Laboratories) are active in long term climate research ranging from data collection to data synthesis, and from model development to model validation. For example, the Atlantic Oceanographic and Meteorological Laboratory and the Pacific Marine Environmental Laboratory) are engaged in completing the global carbon survey directed at obtaining an accurate benchmark inventory of $CO_2$, anthropogenic $CO_2$ and other properties. In addition, the Atlantic Oceanographic and Meteorological Laboratory, the Climate Diagnostics Center, and the Pacific Marine Environmental Laboratory are involved in the Atlantic Climate Change Experiment, the last field phase of the World Ocean Circulation Experiment. This NSF/NOAA program is concerned with increased understanding of the role of the Atlantic Ocean in global atmospheric climate. ERL scientists are also involved in the synthesis of these data, bringing the diverse World Ocean Circulation Experiment and other data-sets into a comprehensive picture of the present state of the ocean. Attention is directed at air-sea and meridional ocean fluxes of carbon, heat, and freshwater, and the amount of anthropogenic $CO_2$ sequestered in the ocean.

GFDL scientists are constantly improving coupled GCMs to study natural decadal to centennial climate variability and the effects of different $CO_2$ scenarios. Recent activities have included: (1) The development of coupled models with higher computational resolution, leading to substantial improvements in the simulation of interannual to decadal climate variability; (2) fundamental improvements in the representation of sub-grid scale processes in ocean models; and (3) the simulation of the climate response to estimates of the time-varying radiative forcing of the Earth over the last 200 years. GFDL model results and results from other modeling centers are being compared to observations by all four ERL groups. The model-data comparisons are not only leading to GCM improvements but also to increased understanding of both the coupled air-sea system and the predictability of this system.

## Issues Pertaining to Education and Human Resources

The Earth's climate system is extremely intricate. Clouds, ocean currents, solar radiation and other elements interact in a complex way to determine our climate. Mathematical models allow us to study parts of the climate system and how those parts interact. Even though these models include many aspects of the climate system (air, oceans, land, biology) partitioned into many small grid boxes, and may require weeks of powerful computer time to run, they are relatively simple when compared to the natural system. The models indicate that temperature could rise considerably over some areas of the globe due to increased emissions of greenhouse species. The issue is one of how accurate are these predictions.

Despite their complexity, current models do not adequately represent the roles of the ocean and clouds in the climate system. These models do provide useful insights into the climate system. When attempting to make conclusions regarding long-term climate variability, these models require decades of precise observations to verify. Only now are we approaching possessing a long enough record of precise data to make some preliminary assessments regarding model predictions. Unfortunately, the long periods involved in the oceanic response and the large inertia of the ocean mean that any actions taken to reverse impacts of man on long-term climate will require decades to centuries before significant impacts could occur.

## Summary

Observations describe variations in the climate system, whereas models provide a mechanism for understanding why such variations occur and for predicting the future evolution of the climate system. A three-pronged program of integrated research has been used to improve representation of climate processes in models and to collect long-term instrumental and proxy observations in the oceans: (1) retrieval and analysis of instrumental and paleoclimate data to develop the long data-sets needed for detection studies and to test hypotheses and develop sampling strategies; (2) collection of new data for continued detection efforts based on analyses and weaknesses of the historical data; and (3) model studies using historical and new data to validate and initialize simulations and perform attribution studies. The benefits to society of this approach are: (1) improved detection of climate change signals in the ocean; (2) improved models of natural and anthropogenic climate variability; (3) quantification of the predictability of long-time scale climate variability; and (4) reduced uncertainties in $CO_2$ warming scenarios.

## Options for Consideration

In order to better understand the changes in the earth's climate and what types of impacts would occur, the following suggestions are offered:

- Conduct the research necessary to develop improved models of the coupled ocean-atmosphere system for long-term climate prediction purposes, including the use of proxy and paleo-indicators, continuation and enhancements of long-term observing programs, as well as conducting process research.

- Development of programs to more effectively utilize the data and observations we have available now through such mechanisms as improved data assimilation by models and more effective merging of in situ and remote sensing technologies.

- Conduct the research necessary to understand the global carbon cycle on a high temporal resolution (i.e., on the order of a decade) scale.

## GLOBAL CLIMATE CHANGE IMPACTS ON U.S. COASTAL AREAS

### Introductory Considerations

The United States has one of the longest and most diverse coastlines in the world—about 158,000 kilometers (95,439 miles) of tidal shoreline in coastal areas and the Great Lakes—and with characteristics as different as the locations of Alaska, Florida, California, and American Samoa. About 94,400 kilometers (59,000 miles) of this shoreline lie around the conterminous United States, bounding some of the most valuable and heavily used coastal areas in the world that could be affected by climate change. Within these coastal areas lie about 38,900 square kilometers (15,000 square miles) of coastal wetlands and 6,500 square kilometers (2,500 square miles) of developed barrier islands. The wetlands provide habitat for numerous species of birds, are a nursery ground for many commercial fish and shellfish; play a vital role in extracting nutrients and toxic chemicals from water; and provide a buffer against coastal storms. The developed barrier islands are primarily recreational communities.

U.S. coastal areas support a variety of important economic activities, including fisheries and aquaculture, tourism, recreation, industry, and transportation. Coastal fisheries, for example, produce about $3 billion in revenue to fishermen and generate $38 billion in economic activity nationally per annum. Seventeen million Americans who enjoy recreational fishing, generate an estimated $18 billion in economic activity. Over 85 percent of travel and tourism revenues are generated in coastal states. In Hawaii, seven million tourists generate $9.1 billion in revenue, and in Florida, 21.6 million tourists spend $7.9 billion and generate over 360,000 jobs mainly due to the attraction of Florida's coasts.

### Current Stresses on Coastal Resources

U.S. coastal areas are experiencing greatly increased pressures as a result of rapid population growth and accompanying development. Population growth in U.S. coastal areas is higher than anywhere else in the country. At present, more than 50 percent of the population lives within 130 kilometers (80 miles) of an ocean or Great Lake and population densities within U.S. coastal areas are five times the national average.

The effects of climate change would add to stresses that already affect coastal areas. An estimated 40 percent of estuarine and coastal waters is not "fishable or swimmable," primarily because of nutrients and bacteria from urban and agricultural runoff and municipal wastewater treatment discharges. About 40 percent of over 20 million acres of shellfish-growing waters in estuaries are "harvest-restricted," i.e., commercial harvest is either prohibited or limited, due primarily to bacterial contamination from urban and agricultural runoff and septic systems. In addition, the effects of pollution, as well as changes in salinity and hydrology have contributed to the loss of traditional shellfish acreage that can no longer support shellfish along U.S. coasts. These changes would be exacerbated by climate change. During 1996, at U.S. ocean, bay, and Great Lakes beaches, there were at least 2,596 individual closings and advisories, 16 extended (6-12 weeks) closings and advisories, and 20 permanent (over 12 weeks) closings and advisories. Including the days of extended closings, the total comes to over 3,685 closings and advisories (NRDC, 1997). U.S. shorelines are undergoing erosion from sea-level rise, natural retreat of headlands, coastal structures, and modifications to the natural flow of rivers.

Human activities from further inland can also have a deleterious impact on coastal resources. Effluent discharges from sewage and industrial plants, as well as agricultural run-off, have caused significant nutrient over-enrichment in many coastal waters. Sewage and siltation can be significant causes of coral reef and other coastal system degradation in Hawaii and Florida. Dams, irrigation projects, and other water control efforts have affected coastal environments by diverting or altering the supply of water, sediment, or nutrients to a naturally balanced ecosystem.

Intensive residential and commercial development of coastal areas, particularly dynamic, storm-prone areas such as barrier islands, puts life and property at risk and creates substantial financial liabilities. For example, there are currently an estimated 276,000 households located in high-hazard areas threatened by storm surge, and an additional 2.4 million households located in the flood plain adjacent to this high-risk zone. In addition, between 1970-89, almost half of all new residential, commercial, and industrial construction occurred in coastal counties and was not always built to standards to withstand major storms. Infrequent, yet high intensity storms that impact coastal areas, in conjunction with poor construction, can result in billions of dollars of damages, particularly where development occurs in low-lying areas. The cost of damage from Hurricane Andrew (in Florida and Louisiana) was $25 billion, and the combined costs for Hurricanes Hugo (South Carolina), Opal (Florida), and Fran (North Carolina) totaled $3 billion. While a majority of damage from these storms was due to poor construction of infrastructure and buildings, costs from coastal storms could be reduced or prevented by making better decisions about the location and type of development in coastal areas.

### Key Strategic Issues Concerning Coastal Areas and Climate Change

Throughout time, climate change has affected the coastal environment and will continue to do so in the future. However, human activities and alterations have rendered coastal resources more vulnerable to climate change-induced processes, such as accelerated sea-level rise, alterations of rainfall patterns and storm frequency or intensity, and increased siltation. Climate change and a rise in sea level or changes in storms or storm surges could result in the increased erosion of shores and associated habitat, increased salinity of estuaries and freshwater aquifers, altered tidal ranges in rivers and bays, changes in sediment and nutrient transport, a change in the pattern of chemical and microbiological contamination in coastal areas, and increased coastal flooding.

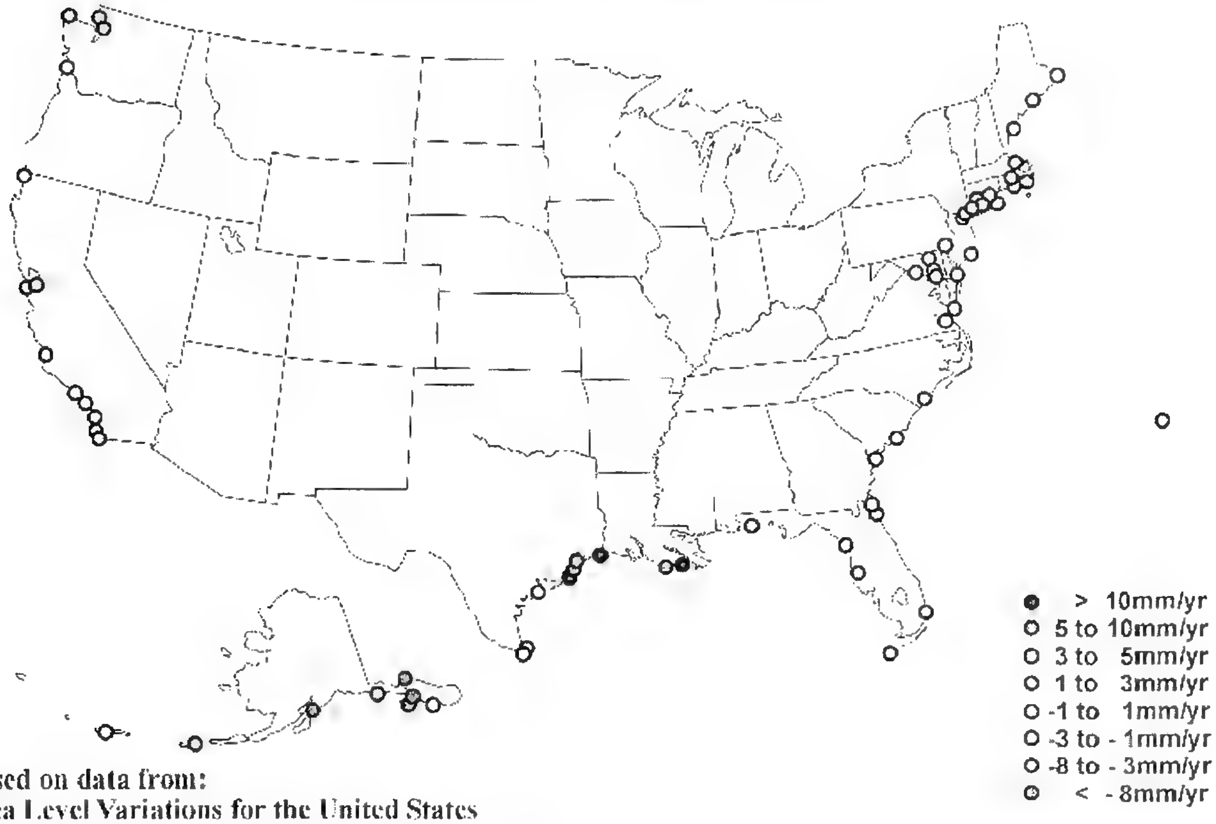
Some coastal ecosystems are particularly at risk, including saltwater marshes, coastal wetlands, coral reefs, coral atolls, and river deltas. Other critical coastal resources, such as mangroves and sea-grass beds, submerged systems including submerged aquatic vegetation , and mudflats, are at risk from climate change impacts, and exacerbated by anthropogenic factors. Changes in these ecosystems could have major negative effects on tourism, freshwater supplies, fisheries, and biodiversity that could make coastal impacts an important economic concern. These impacts would add to modifications in the functioning of coastal oceans and inland waters that already have resulted from pollution, physical modification, and material inputs due to human activities. Secondary impacts associated with climate change, such as inundation of waste disposal sites and landfills that in turn will reintroduce toxic materials and increased siltation into the environment, also pose threats to the health of coastal populations and ecosystems.

Global sea levels have been rising since the conclusion of the last Ice Age approximately 15,000 years ago. During the last 100 years, sea-level rise has occurred at approximately 1-2.5 mm/yr. This figure represents eustatic sea level (the absolute elevation of the Earth's ocean) that has been determined from tidal stations around the globe. However, there are large regional variations due to: subsidence, isostatic (glacial) rebound, tectonic uplift, etc., that contribute to a "relative" sea-level rise. For example, within the U.S., portions of the Gulf Coast are experiencing a relative sea-level rise of 10 mm/year. Concurrently, the coast of Alaska is experiencing a negative relative sea-level fall of up to 8 mm/year; i.e. sea level is receding. Figure 7 illustrates the change in sea level along U.S. coasts as determined from historical tidal data. If this historical rate of sea-level rise is projected to 2100, sea level would rise 10-27 cm globally. A recent EPA study assessed the probability of sea level rise along various U.S. coastal towns and estimated that there is a one percent change of a 120 cm rise and a 50 percent chance of a 55 cm rise in sea level by the year 2100 along the New York coast.

Rising global temperatures could further raise sea level by expanding ocean water, melting alpine and other small glaciers, and perhaps eventually causing the polar ice sheets of Greenland and Antarctica to melt into the oceans. The most recent IPCC assessment (1995) forecasts a rise in global sea level of 5 mm/year, within a range of uncertainty of 2–9 mm/year with almost all of the contribution resulting from thermal expansion and melting small glaciers. The IPCC predicts low, mid, and high estimates of 20, 49, and 86 cm. This current best forecast represents a rate of sea-level rise that is still about two to five times the rate experienced over the last 100 years. Furthermore, even if greenhouse-gas concentrations are stabilized, model projections show that sea level will continue to rise beyond the year 2100 due to lags in response to climate change. Figure 8 indicates the potential impact of a 50 cm sea-level rise, or approximately the mid-range IPCC estimate, in South Florida.

The IPCC estimates are based on the effects of thermal expansion of the ocean. They do not include the possible contribution that the melting of the Greenland and Antarctic ice sheets

LONG TERM SEA LEVEL TRENDS FOR THE UNITED STATES
(Accepted Global Sea Level Rise is 2mm/yr-o )




Based on data from:
"Sea Level Variations for the United States
1855-1986", National Ocean Service, NOAA, 1988

**Figure 7.** Long term sea level trends for the United States.


**Figure 8**. LANDSAT imagery and data from USGS topographical maps combine to illustrate the potential impacts of a half meter rise in sea level on South Florida (see Park and Lee, 1993). The maps demonstrate a substantial loss of mangroves and migration of wetlands inland.

would have on sea-level rise. While still debated and somewhat speculative, such melting would provide a much greater contribution to global sea-level rise.

Coastal land, including buildings, transportation infrastructure, and recreational and agricultural areas, is vulnerable to inundation and increased erosion as a result of climate change. All lowlands are threatened by a rise in sea level. Estuaries are also threatened by potential hydrologic changes that could increase the range of saltwater intrusion as well as alter the amount of freshwater reaching an estuary. If a one-meter rise in sea level occurs during the next century, the worst-case IPCC scenario, thousands of square miles could be lost, particularly in low-lying areas such as the Mississippi delta, where land is also subsiding at a rate of approximately one meter per century. Table 1 indicates the estimated land loss for seven regions of the United States. Storm damage is expected to also increase, particularly along the well-developed and low-lying Atlantic and Gulf of Mexico coasts.

Assessing total economic impacts from sea-level rise on coastal areas and on a national scale is still somewhat speculative. Nevertheless, a recent study has quantified the present value of the economic costs (protection plus abandonment) to coastal structures with a 1-meter sea-level rise as $6.4 billion between 1996 and the year 2100. However, this figure represents only market-valued estimates which are derived from property-value appreciation, market adaptation, and protection costs. Thus, it is a minimum cost estimate which does not include the lost service value of non-market resources, such as tidal wetlands. Estimates of impact on such resources are more difficult to quantify because they lie outside the traditional market and have not yet been thoroughly measured. Natural systems, like a tidal wetland, can provide flood control, storm protection, and waste recycling and have tremendous value when measured economically.

Coastal erosion is already a widespread problem in the United States. For example, in Oahu, Hawaii, over the past 50 years a quarter of the beaches have been lost or significantly degraded due to causes that are poorly understood. Heightened storm surge could increase the rate of erosion. The highest-risk areas are those with very low relief and currently experiencing rapid erosion rates, such as the southeastern United States and the Gulf Coast (see Figure 9). Coastal areas would also be more vulnerable to hurricanes, as well as to increased or decreased freshwater and sediment flux from river systems.

Rising sea-level will, in general, increase storm surge flooding by the level of sea-level rise, making every coastal storm appear more intense. However, some areas will experience dramatic changes—going from no flooding to extensive flooding. Many coastal features, such as levees, seawalls, and naturally occurring sand dunes and ridge lines effectively block storm surges for most storms. Whenever one of these features is overtopped by storm surge from either a hurricane or an extratropical storm, the areas inland will flood. Numerical modeling has shown that large amounts of water can move over such barriers, flooding over the marshland or bay behind the barrier, and sweeping over mainland areas.

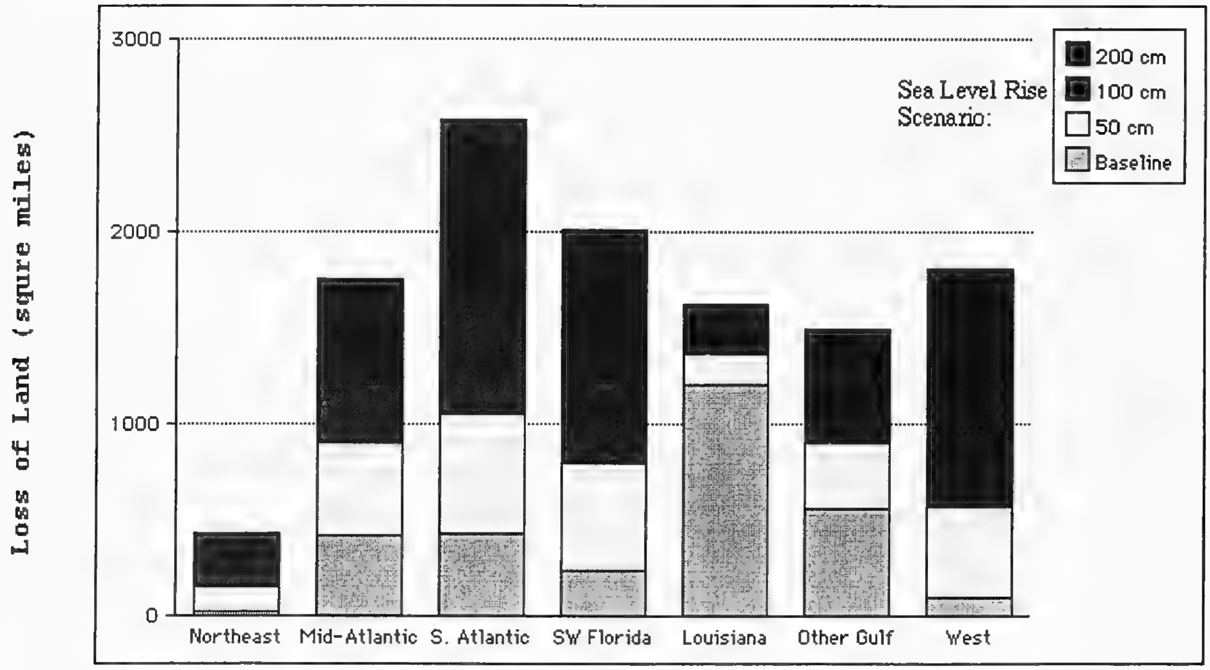



**Table 1.** Dry Land Loss by 2100 without shore protection (from Titus, et al., 1991).

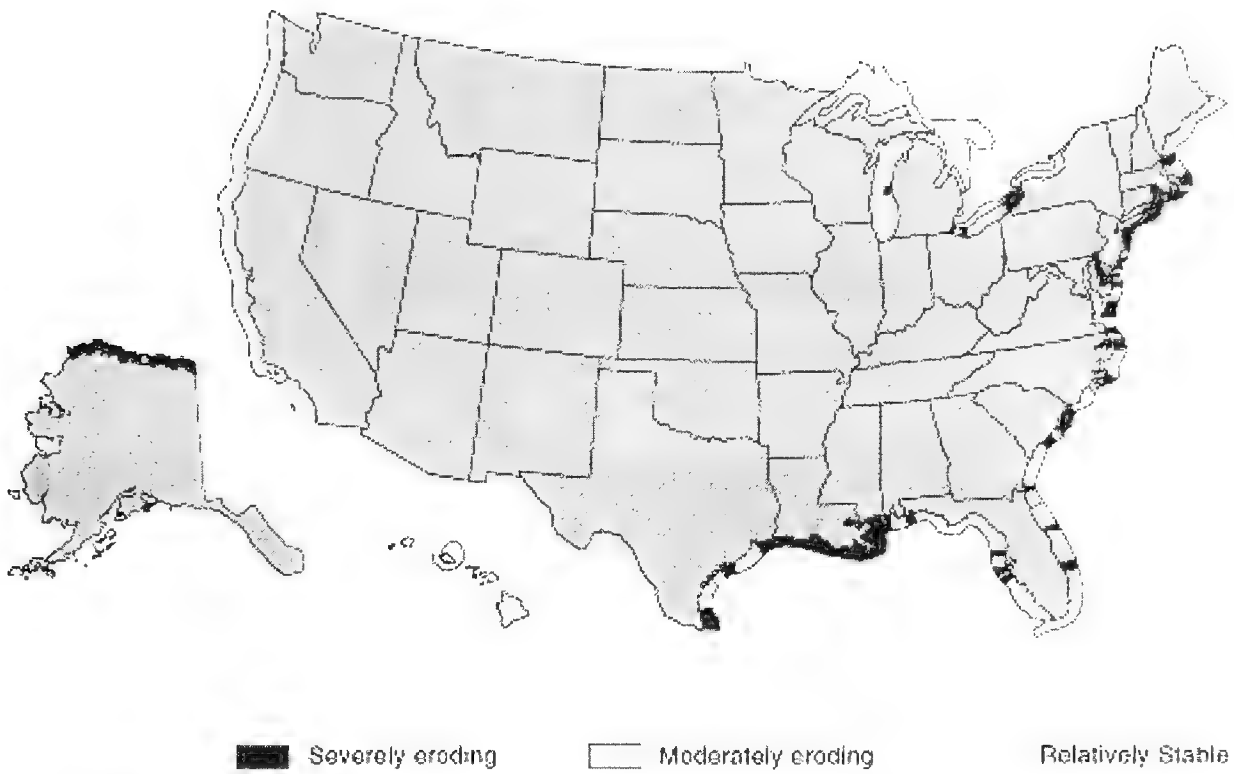



**Figure 9.** Classification of annual shoreline change around the United States. (Modified from Dolan, et al., 1985.)

Many coastal structures were designed with the 100-year flood as their basis. This flooding level determines the elevations to which the federal projects (such as U.S. Army's Corps of Engineers levees that protect New Orleans) are built. It is also the level to which coastal structures must be built to qualify for flood insurance through FEMA's Flood Insurance Program. If sea level rises, the statistics used to design these structures change. A 50-year flood may become as severe as (or even more severe than) a 100-year flood before sea-level rise. Coastal insurance rates would be adjusted to reflect such increased risk. Furthermore, FEMA estimates that with a sea-level rise of one meter, the number of households in the coastal floodplain would increase from 2.7 million to 6.6 million by 2100. This growth will be the result of sea-level rise as well as the increase of coastal population. In some areas however, structures will be upgraded as sea level rises so that flood risks will not increase.

Coastal wetlands are already eroding in most states (see Table 2), particularly Louisiana and Maryland. For example, Louisiana's coastal area lost an estimated 3,950 square kilometers of wetlands from 1930 to 1990. This loss of wetlands resulted, for the most part, from flood-protection levees along the Mississippi and artificial bank stabilization efforts to confine the flow of the river and prevent the flooding, sedimentation, and freshwater supplies that occurred naturally. Many wetland losses elsewhere result from draining or filling. In addition, large areas of brackish and freshwater wetlands have become progressively more saline as salt water has increasingly invaded the deteriorating coastal zone. Because 40 percent of U.S. coastal wetlands are found in Louisiana, this loss constitutes about 80 percent of the total national coastal wetland loss. Louisiana coastal wetlands are exceptionally valuable in terms of coastal fisheries and migratory waterfowl, protection of low-lying population centers from hurricanes and other storms, and oil and gas production. Furthermore, the greatly accelerated rates of coastal wetland loss appear to be the unintended result of massive human disturbances of these wetlands and intervention (for purposes of flood protection, water supply, maritime commerce, energy production, and wildlife management) in the processes that sustain coastal wetlands.

Wetlands require a delicate balance of sediment, fresh and salt water and are particularly vulnerable to inundation and erosion as a result of sea-level rise. Coastal wetlands are also vulnerable to changes in the source or decreased flux of fresh water and sediment, if upstream areas become more arid. Wetlands naturally migrate as land subsides and sediment supply changes, but migration has been limited in several areas by the encroachment of urban areas which utilize sea walls and other protective structures. In addition, the possible rate of sea-level rise predicted by some climate change models is more rapid than the natural rate of wetland migration, thus wetland losses will likely increase.

Estuarine beaches are also at particular risk to sea-level rise. They are much more vulnerable than ocean beaches because they tend to be narrower and policies against shoreline armoring generally apply to oceans but not to bays. Also, they are more vulnerable than vegetated wetlands because the wetland protection programs tend to focus on the total area of wetlands protected and because beaches are narrow, they do not represent much acreage. The loss of these beaches would effect species such as horseshoe crabs and the birds that feed on them, as well as terrapins, least terns, and tiger beetles.

**Table 2.** Regional and National Wetland Losses for the Trend and 1.0 Meter Sea Level Rise Scenarios (percent loss of current area) (from Titus, et al., 1991).

| Region | Current Wetland Area (sq mi) | Trend Standard(**a**) | Trend Total(**a**) | 1.0 Meter Standard(**a**) | 1.0 Meter None(**a**) |
|---|---|---|---|---|---|
| Mid-Atlantic | 746 | -5 | 70 | 46 | 38 |
| South-Atlantic | 3814 | -2 | 64 | 44 | 40 |
| South/Gulf Coast of Florida | 1869 | -8 | 44 | 8(**b**) | 7(**b**) |
| Louisiana (**c**) | 4835 | 52 | 85 | 85 | 85 |
| FL Panhandle, AL, MS, and TX | 1218 | 22 | 85 | 77 | 75 |
| West (**d**) | 64 | -111 | 56 | -688 | -809 |
| United States | 13,145 | 17 | 66 | 49 | 50 |
| Confidence Intervals: | | | | | |
| 95% Low | -- | 9 | 50 | 29 | 26 |
| 95% High | -- | 25 | 82 | 69 | 66 |

Note. A negative number indicates a gain in wetlands.

**a** Total protection refers to all shores being diked or bulkheaded; standard protection refers to only currently developed areas being protected.

**b** Results are not statistically significant; sampling error exceeds estimate of wetland lost.

**c** An evaluation of the management options currently contemplated for Louisiana (e.g. restoring natural deltaic processes) was outside the scope of this study.

**d** This anomalous result is from small sample size. The impact on the nationwide results is negligible.

Climate change also has the potential to significantly affect coastal biological diversity. It could cause changes in the population sizes and distributions of species, alter the species composition and geographical extent of habitats and ecosystems, and increase the rate of species extinction. Fragile systems such as coral reefs are highly susceptible to temperature increases. Short-term increases in water temperatures on the order of only 1-2°C, combined with other environmental stresses (such as pollution or siltation from human activities), can cause "bleaching," leading to significant reef destruction. Reefs in many parts of the world, including the United States, have undergone episodes of bleaching, particularly in the 1980s. Sustained increases of 3-4°C above long-term average seasonal maximums can cause significant coral mortality. Biologists suggest that full regeneration of these coral communities could require several centuries.

Fisheries in estuaries and the coastal ocean are also vulnerable to changes in water temperature and freshwater inflow. The loss of coastal wetlands has already been implicated in the decline of shrimp harvests in Louisiana, and would also likely reduce yields of crab and menhaden. Projections of general circulation models suggest that freshwater discharge from the Mississippi River to the coastal ocean will increase 20 percent if atmospheric carbon dioxide concentrations doubles. This is likely to affect water column stability, surface productivity, and global oxygen cycling in the northern Gulf of Mexico, which is already suffering from persistent hypoxia. In the open ocean, increased temperatures could result in a shifting of the geographical distribution of certain species. Decreasing freshwater flow, when combined with rising sea level could result in the encroachment of saltwater species into typically freshwater habitats. For example, in estuaries, decreased freshwater inflow could result in increased salinity and, in turn, a replacement of some freshwater species by saltwater species.

### Management Issues and Strategies

Management strategies in coastal areas can be divided into three categories:

(1) ***Accommodate.*** Vulnerable areas continue to be occupied, accepting the greater degree of effects, e.g., flooding, saltwater intrusion, and erosion; advanced coastal management used to avoid the worst impacts; improved early warning of catastrophic events; and building codes modified to strengthen structures

(2) *Protect.* Vulnerable areas, particularly population centers, high-value economic activities, and critical natural resources, are defended by sea walls, bulkheads, saltwater intrusion barriers; other infrastructure investments are made; and "soft" structural options such as periodic beach re-nourishment, landfill, dune maintenance or restoration, and wetlands creation are carried out

(3) *Retreat.* Existing structures and infrastructure in vulnerable areas are abandoned, inhabitants are resettled, government subsidies are withdrawn, and new development is required to be set back specific distances from the shore, as appropriate.

The cost-effectiveness of these adaptation strategies is enhanced to the extent that they are planned and implemented in the context of integrated coastal management programs carried out at various levels of government.

Integrated coastal management is a continuous, iterative, adaptive, and consensus-building process comprised of a set of related tasks, all of which must be carried out to achieve a set of goals for the sustainable use of coastal areas, including adapting to the effects of climate change (Bower, Ehler, and Basta, 1994). The dimensions of integrated coastal management include:

- Integration of policies and programs across and among sectors of the economy—e.g., economic development, transportation, recreation, and agriculture
- Integration among agencies involved in coastal management at all levels of government, including both vertical (national, subnational, and local) and horizontal (across the same level of government) integration
- Integration between public- and private-sector management activities
- Integration between management actions that affect the land and water environments of coastal areas, and areas upstream and upwind of coastal areas.
- Integration among the disciplines of coastal management, including ecology, economics, engineering, and political science.

At the federal level, agencies such as the U.S. Environmental Protection Agency have produced a number of studies which have begun to look at projected global climate change impacts on specific resources such as wetlands and to consider possible response options.

Individual states have used all three management strategies. Beach re-nourishment has been prominent in heavily developed areas (e.g., Miami, Florida and Ocean City, Maryland) where existing investments and the income generated by beach users is considered greater than the costs of the re-nourishment projects. Sea walls are often built to protect lives and property, but the trade-off is often the loss of usable beaches and other habitats. Most of these actions are taken to address current conditions and needs.

State and local government responses to future accelerated sea level rise scenarios include:

(1) taking accelerated sea-level rise into account when filling wetlands for water-dependent facilities (ports)—which requires an applicant to raise the fill level so facilities will not have to be abandoned during their 50-100 year life expectancy (San Francisco Bay Conservation and Development Commission);

(2) raising the elevation of new facilities such as sewage treatment plants to protect the integrity of the facility's use (Massachusetts Water Resources Authority);

(3) incorporating sea-level rise into setback laws for larger facilities which goes beyond the normal incorporation of only historical rates of erosion (Maine Coastal Zone Management Program);

(4) passing legislation in support of a retreat policy that normally prohibits sea wall construction to allow backward migration of a beach (North and South Carolina Coastal Zone Management Programs).

To support state coastal management efforts, the Coastal Zone Management Act was amended in 1990 to further encourage state efforts to incorporate the problems of climate change and sea-level rise into their programs under natural hazards.

In February 1997, the U.S. Country Studies Program and NOAA sponsored an international workshop in Chinese Taipei that developed guidelines for integrating coastal management and climate change adaptation strategies. These can serve as a guide for coastal nations to implement or strengthen an Integrated Coastal Management program, and simultaneously meet the obligations of international agreements.

**Status of the Relevant Science and Technical Base**

Continued investments in research and monitoring at the national and international levels are needed to improve the information base for adapting to climate change. For example, coastal wetlands naturally migrate in response to changes in sediment supply and relative sea level. However, it is unknown if the rate at which wetlands can naturally migrate is sufficient for the possible rates of sea-level rise that would be caused by climate change. Establishing locations for wetlands to migrate to by expanding reserves and protected areas adjacent to current coastal wetlands can facilitate adaptation. Creation or restoration of wetlands is another adaptive strategy that requires the development of effective methods for restoring coastal wetlands and for measuring the effectiveness of those restoration efforts.

The White House Committee on the Environment and Natural Resources (CENR) is currently coördinating several wetland activities— including studies of recent changes in wetland systems along the eastern Gulf of Mexico and southern Atlantic coasts, and studies of changes documented in the Mississippi Delta—which should establish credible limits on the ability of coastal wetlands to adapt to sea-level rise by vertical growth. Other Committee on the Environment and Natural Resources research related to the vulnerability and adaptation of coastal systems include space-based geodesy studies to distinguish the long-term trends in sea-level change due to glacial melting and ocean expansion from effects of post-glacial rebound and active tectonics; studies that test existing geological models of coastal erosion processes; and studies of the frequency, magnitude, and tracks of storms.

Internationally, the Intergovernmental Oceanographic Commission of UNESCO is coordinating the development of a Global Ocean Observing System (GOOS). This is an intergovernmental program for the collection, distribution, and exchange of marine and oceanographic data. One of its principal elements, the GOOS Coastal Module, is designed to integrate and facilitate access to in-situ and remotely sensed coastal observations for reliable assessment, prediction and management of coastal areas and resources.

The Global Coral Reef Monitoring Network is a major contribution to the GOOS Coastal Module. Co-sponsored by the IOC, United Nations Environment Programme and the World Conservation Union, the network's goal is to improve the conservation, management, and sustainable use of coral reefs and related coastal ecosystems by providing data and information on trends in their biophysical status and the social, cultural, and economic values that pertain to these ecosystems.

Two major international climate change assessments (1990 and 1995) have been conducted by the Intergovernmental Panel on Climate Change (IPCC), which was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988. These assessments examined the available science, the magnitude of human-induced climate change, and appropriate response options. Some areas that require further scientific research and data include scaling down of current general circulation models to obtain local climate change estimates, as the current GCM resolution is too low. In addition, sea-level rise alone is not an exclusive feature of climate change in coastal areas. Therefore, climate change studies need to be broader, combining the effects of sea-level rise, storminess, atmospheric circulation change, precipitation, etc.

The IPCC 1995 assessment indicates that more work is necessary for quantifying the social costs of climate change. Net climate change damages include both market and non-market impacts and, in some cases, adaptation costs. However, the non-market damages (e.g. human health, risk of human mortality and damage to ecosystems, etc.) are highly speculative and not comprehensive, and therefore are a source of major uncertainty in assessing the implications of global climate change for human welfare.

## Legal Framework

The United States is a Party to the Framework Convention on Climate Change that entered into force in 1994. Its major objective is to achieve the stabilization of greenhouse gas emissions and to identify national adaptation strategies. Article 4 of the Convention commits nations to, among other things, develop integrated plans for coastal zone management as part of their adaptation strategies. In response to potential commitments and obligations under the United Nations Framework Convention on Climate Change, many nations, including the U.S., are preparing national climate change action plans that identify management strategies to reduce greenhouse gas emissions. Although the United States is not currently developing a plan for adapting to the potential impacts of long-term climate change, such plans could be developed within the framework of existing laws.

Any plan for adapting to sea-level rise must consider federal, state, and local legislation. Under the common law of most states, tidal waters up to mean high water are owned by the public. As sea level rises, the boundaries of land ownership generally migrate inland, under state law. State laws vary considerably both on whether property owners must allow the shore to retreat or are allowed to erect protective measures. At one extreme, Texas and Maine prohibit structures that protect property at the expense of narrowing the beach; at the other extreme, Maryland's Tidal Wetlands Act guarantees the right to erect structures to hold back the sea.

Responses to sea level rise also depend on the type and density of development near the shore. In most states, local master plans and zoning laws govern land use, although state coastal zone management laws also play a role. Maryland's Critical Areas Act and New Jersey's Coastal Area Facilities Review Act severely restrict the density of development in portions of their coastal zones. Several states have setback laws requiring new structures to be a minimum distance from the shore. Although water pollution and existing erosion hazards were the primary impetus for these laws, they also provide a framework for a response to sea-level rise. Setbacks are consistent with a presumption that shores will retreat naturally. The Maryland and New Jersey statutes are consistent with a presumption that densely developed areas will be protected, while shorelines in undeveloped areas remain in their natural states.

State laws on access to the shore also influence a states ability to address rising sea level. Along ocean shores with ample public access, such as New Jersey and Florida, public support for beach re-nourishment and shoreline planning to maintain beaches tends to be great. Along shores with little public access, especially bay shores, the constituency for preserving natural shorelines tends to be less significant.

Several federal statutes address coastal problems related to rising sea level. Section 10 of The Rivers and Harbors Act and Section 404 of the Clean Water Act have created a federal program of wetland protection. Strictly speaking, federal jurisdiction only extends up to the upper boundary of the wetlands. Nevertheless, EPA and the Corps of Engineers have the discretion to consider sea level rise and other environmental issues in the administration of wetland mitigation programs in which, for example, a landowner is permitted to eliminate a strip of wetlands in return for protecting or creating wetlands elsewhere. The Federal Flood Insurance Act provides a comprehensive framework by which coastal communities attempt to limit the vulnerability of property to floods. Although the guidelines under which the program operates do not explicitly consider sea-level rise, they influence the vulnerability of coastal development to rising sea level. As with the wetland legislation, the executive branch has the administrative discretion to modify existing guidelines to prepare for rising sea level should it decide to do so.

Perhaps the most important federal statute for addressing sea-level rise is the Coastal Zone Management Act (as amended by Public Law 104-150). The Act provides a comprehensive framework within which all coastal problems can be addressed. In reauthorizing the Act in 1990, Congress recognized the importance of this potentially new threat to the nation's shoreline environments and encouraged coastal states and territories to begin to address rising sea level as noted in the following sections:

***Congressional Findings:*** SEC. 302. The Congress finds that...

(l) Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence.

***Congressional Declaration Of Policy:*** SEC. 303. The Congress finds and declares that it is the national policy

(2) to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development, which programs should at least provide for...

(B) the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands,...

(K) the study and development, in any case in which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of sea level rise; and...

(3) to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources,.. improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in governmental decision making...

Many state Coastal Zone Management programs have used federal funds to conduct studies and develop policies to this end.

In addition to its role as a regulator and financial and technical assistance provider, the federal government also has the legal authority to address sea-level rise in its role as a property owner. Numerous parks and wildlife refuges are found along the coast. Under both federal and state law, the federal government has the authority to purchase easements to enable ecosystems to migrate, and to construct coastal protections structures to protect government property from the effects of erosion and storms.

### Issues Pertaining to Education and Human Resources

Education, training, and outreach that target all sectors of society are essential components in the successful implementation of Integrated Coastal Management and climate change adaptation strategies. In July 1997, President Clinton launched a campaign to educate Americans about global warming and build support for the steps necessary to deal with it, including the United States agreement to binding reductions in greenhouse gases that were negotiated at the international conference on climate change during December 1997 in Kyoto, Japan. This led to a U.S. agreement for binding reductions in greenhouse gases that were negotiated at an international conference on climate change during December 1997 in Kyoto, Japan. However, as a July 21, 1997 article in the Washington Post pointed out, President Clinton faces an uphill battle in trying to "sell the public on the urgency that, in many minds, looms far in the future, if it exists at all." The article goes on to say that the message is being met skeptically, and in some instances, with outright hostility, particularly by certain U.S. industries and labor groups which maintain that the scientific evidence is unconvincing and the economic repercussions potentially disastrous.

Despite the scientific evidence that sea level is rising globally as a result of climate change, many individual homeowners continue to purchase beach-front property that is threatened even now by beach erosion resulting from human (obstruction of natural sand replenishment from construction of jetties, sea walls, sand mining, etc.) and natural (storms and hurricanes) causes. In some cases, people are unaware of the risk. In other cases, people who understand the risks are willing to develop property in hazardous areas because the value they place on inhabiting a shorefront home is larger than the expected damages from erosion and storms.

The willingness of some coastal residents to accept the risks of shorefront development are apparent in the attitudes of two people quoted in a September 13, 1997 Washington Post article about beach erosion in Holden Beach, North Carolina. One local resident whose home was knocked from its foundations by Hurricane Fran decided to move her 45-year-old family home just one lot back from property purchased by her father years ago. This lot is now beach front property due to erosion. Her response is, "It concerns me but does not threaten me. I just feel that it is fate—it's the same as getting in an airplane."

Even a town official of Holden Beach, who made mitigation of coastal erosion one of his top goals upon assuming his position, built his own home just 1,000 feet from the ocean, in an area where erosion has been the greatest. His attitude is "It'll be fine for me—but my great-grandchildren may have beach-front property." This attitude is not uncommon, the long-term nature of the problem does not incite much urgency to take different action now.

Well-designed public education programs should use target specific clientele—including elected officials, user groups, women's groups, school children, and the general public—to develop support for Integrated Coastal Management and climate change action plans. Public education ought to include informal education programs that will reach all segments of the community, including the illiterate, who may form a significant segment of the stakeholder population.

### Opportunities and Barriers (What Works Well and What Doesn't)

While climate change impacts such as accelerated sea level rise are a potentially major concern, state and local governments have hesitated to address the issues effectively because of the relatively long-term nature of the problem, scientific uncertainties and, in some cases, the large investments required. Because of scientific debate and uncertainties, few are willing to develop potentially costly management strategies for which the benefits will not be realized for years to come. Consequently, management responses to climate change impacts have been gradual since the early 1980s, but pioneering efforts have been important for U.S. policy makers.

In response to potential commitments and obligations under the United Nations Framework Convention on Climate Change, many nations, including the United States, are preparing national climate change action plans that identify management strategies to reduce greenhouse gas emissions and adapt to the potential impacts of long-term climate change. The successful implementation of these plans and their management strategies within individual countries, including the United States, will depend to a large measure on the extent of their integration into the implementation of other national and sectoral management plans, including coastal management plans.

Adapting to sea-level rise and other effects of climate change will involve important trade-offs that weigh environmental, economic, social, and cultural values. Effects will depend not only on the local patterns and intensity of climate change, but also on the nature of the local coastal environment; on the human, ecological, and physical responsiveness of the affected coastal system; and on actions in other sectors of the coastal and national economies. Given the long time frames involved in reducing the magnitude of global warming, it is vital that steps be taken now to manage the impacts that almost certainly will occur in islands and low-lying coastal areas.

### Options for Consideration

The following suggestions are offered based on the preceding discussion:

1. Continued investments in research, monitoring and economic methods for quantifying the social costs of climate change are needed to improve the information base for adapting to climate change and for coastal management. For example, the United States should take a leadership role in developing and advancing implementation of the Coastal Module of the Global Ocean Observing System, and particularly one of its key elements, the Global Coral Reef Monitoring Network.

2. As indicated in the IPCC 1995 Assessment Report, more work is necessary for quantifying the social costs of climate change. Net climate change damages include

both market and non-market impacts and, in some cases, adaptation costs. However, the non market damages (e.g., human health, risk of human mortality, and damage to ecosystems, etc.) are highly speculative and not comprehensive, and therefore are a source of major uncertainty in assessing the implications of global climate change for human welfare. In general, more work needs to be done on environmental evaluation techniques that accurately reflect the societal benefits of these so-called "non-market" coastal resources. It is important to accurately quantify their benefits and account for them properly in benefit-cost analysis in order to improve decision making. The U.S. should play a strong role in the IPCC third assessment that is just beginning, and particularly with regard to these quantification methods.

3. Areas that require further scientific research and data include higher resolution of current general circulation models to obtain local climate change estimates, because the current GCM resolution is too low. In addition, sea-level rise alone is not an exclusive feature of climate change in coastal areas. Therefore, climate change studies need to be broader, combining the effects of sea-level rise, storminess, atmospheric circulation change, precipitation, etc. The U.S. should support expanded studies of this nature.

4. A guidance document for local, state and regional offices of federal agencies should be developed, along with a handbook on no-cost and low-cost ways to prepare for sea level rise as part of ongoing coastal zone management activities, including wetland permits, infrastructure, shoreline management, land use planning, and flood insurance.

5. Public access to the coast should be expanded, especially in estuarine shore areas that may be eliminated by sea level rise, so that the public can appreciate the need to protect them and build support for management measures.

The scientific information generated from the first three above options for consideration are particularly important to substantiate the education initiatives necessary to galvanize the public support for management strategies. The coastal impacts of climate change need to be placed in the context of all the other pressures on coastal resources. U.S. coastal areas represent some of the most valuable assets that our nation possesses. Addressing sea level rise is but one facet of the major challenge that the U.S. and other nations face today which is restoring, maintaining, and enhancing the quality of coastal areas that are under the pressures of projected population growth, coastal development, and consumption patterns.

A major public education challenge is to convince individuals of the urgency of the problem, the long-range implications of current actions on coastal resources and their consequences for future generations. However, if people can be made to appreciate the importance of coastal resources, the many threats to them, and why management strategies are necessary, then the prospects for successfully implementing such strategies would be improved. Therefore, recommendations for U.S. education efforts include:

- Well-designed public education programs should target specific clientele—including elected officials, user groups, women's groups, school children, and the general public—to develop support for Integrated Coastal Management and climate change action plans. Public education ought to include informal education programs that will reach all segments of the community, including the illiterate, who may form a significant segment of the stakeholder population.

- Training and education for Integrated Coastal Management should be prepared on a multidisciplinary basis, so that trainees can become familiar with using all the scientific information related to it. Universities and training and research organizations should develop and strengthen programs of research, education, training, extension services, and technical assistance that will contribute to continuing ICM programs. These programs should combine theory and practice and should emphasize the application of research to address important coastal management issues.

- ICM programs require a team with skills in resource and socioeconomics, ecology, geomorphology, coastal engineering, analysis of industrial and agricultural processes, financing, and institutional (including legal) analyses. Climate change also requires skills in meteorology, physical oceanography, Earth science, geography, and predictive computer modeling. The most difficult skill to acquire is integrating the various aspects of analysis and defining priorities among them, and discerning the long-range implications of current actions.

## REFERENCES

Broecker, W. S., 1991. The great ocean conveyor. *Oceanography.*, 4, pp. 79-89.

Culliton, J. Thomas, et al. April 1990. "50 Years of Population Change Along the Nation's Coasts, 1960-2010." Washington, DC: NOAA, National Ocean Service.

Costanza, R., et al. May 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature*, vol. 387, pp. 253-260.

Dolan, R., F. Anders, and S. Kimball. 1985. "Coastal Erosion and Accretion in U.S. Geological Survey National Atlas." Reston, VA: Department of the Interior, U.S. Geological Survey.

EPA. 1995. Titus, James G. and V. Naranan. "The Probability of Sea Level Rise." Nov. 1995. EPA 230-R-95-008.

Federal Emergency Management Agency. 1991. "Projected Impact of Relative Sea Level Rise on the National Flood Insurance Program." pp. 4-7.

Hubbard, E.F., Sallenger, A. 1995. "A Whirlwind of Activity: The USGS Responds to Hurricanes. In: Under standing the Earth." Reston, VA: U.S. Geological Survey.

Hull, C.H.J. and J.G. Titus (eds). 1986. "Greenhouse Effect, Sea Level Rise, and Salinity in the Delaware Estuary." Washington, D.C.: Environmental Protection Agency and Delaware River Basin Commission.

Intergovernmental Panel on Climate Change (IPCC), 1994. *Radiative Forcing of Climate Change, the 1994 Report of the Scientific Assessment Working Group of IPCC Summary for Policymakers*, World Meteorological Organization, Geneva, Switzerland, 28 pp.

Intergovernmental Panel on Climate Change (IPCC), *Second Assessment Report, Climate Change 1995.* World Meteorological Organization, Geneva, Switzerland, 64 pp.

Lyle, S.D., L.E. Hickman, and H.A. Debaugh. 1988. *Sea Level Variations in the United States*. National Ocean Service, NOAA.

Mayer, Caroline E. "Life on the Beach is an Eroding Proposition," *The Washington Post*, Real Estate Section, September 13, 1997.

Natural Resources Defense Council. July 1996. "Testing the Waters VI, Who Knows What You're Getting Into." New York.

Natural Resources Defense Council. July 1997. "Testing the Waters VII, How Does Your Vacation Beach Rate." New York.
NOAA, Office of Oceanic and Atmospheric Research, Environmental Research Laboratories, Climate Diagnostics Center, http://www.cdc.noaa.gov, Boulder, CO.

NOAA, Office of Global Programs. 1994. "A Proposal to Launch a Season-to-Interannual Climate Prediction Program," Washington, DC, 19 pp.

NOAA, Office of Global Programs. 1995. "International Forum on Forecasting El Niño: Launching an International Research Institute," Washington, DC, 65 pp.

NOAA Office of Global Programs, 1994. *Reports to the Nation, No. 3, El Niño and Climate Prediction*, University Corporation for Atmospheric Research, Boulder, CO, 24 pp.

NOAA Office of Global Programs, 1997. *Reports to the Nation, No. 4, Our Changing Climate*, University Corporation for Atmospheric Research, Boulder, CO, 24 pp.

Park, R.A., Lee, J.K. 1993. "Potential Effects of Sea Level Rise on South Florida Wetlands," Climate Change Division. Environmental Protection Agency.

Peck, D.L., S.J. Williams, 1992. "Sea-Level Rise and Its Implications in Coastal Planning and Management: Ocean Management in Global Change." London: Elsevier *Applied Science*, pp. 57-73.

Titus, J.G., R. Park, S. Leatherman, R. Weggel, M. Greene, P. Mausel, M. Treehan, S. Brown, C. Gaunt, and G. Yohe. 1991. "Greenhouse Effect and Sea Level Rise: Loss of Land and the Cost of Holding Back the Sea." *Coastal Management* 19:171-204.

Titus, James G. and V. Narayanan. 1996. "The Risk of Sea Level Rise." *Climatic Change*. 33:151-212.

Titus, J.G. 1998. "Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners." *Maryland Law Review*.

United Nations Environment Programme, World Meteorological Organization, 1997. "Common Questions About Climate Change, United Nations Environment Programme," Nairobi, Kenya, 24 pp.

U.S. Country Studies Program: Support for Climate Change Studies. 1994. "Climate Change Implications and Adaptation Strategies for the Indo-Pacific Island Nations." Workshop Proceedings.

U.S. Department of Commerce. 1996. "Strategic Plan, A Vision for 2005," Washington, DC, NOAA, 16pp.

U.S. Department of Commerce. July 1991. *The National Shellfish Register of Classified Estuarine Waters.* Washington, DC: NOAA, National Ocean Service.

U.S. Department of Commerce. 1995. "Strategic Plan, A Vision of 2005", 16 pp.
U.S. Environmental Protection Agency. December 1995. *National Water Quality Inventory. 1994 Report to Congress.* Washington, DC: EPA, Office of Water.

The Washington Post, 1997. "A Greenhouse Tool Kit," *The Washington Post*, Washington, DC, 12 November 1997, pp. H4-H5.

Watson, R.T., M.C. Zinyowera, R.H. Moss. 1995. Climate Change 1995, Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, pp. 296, 315.

Warrick, Joby. "Clinton Outlines Global Warming Education Plan," *The Washington Post*, July 25, 1997

Yohe, G., J. Neumann, P. Marshall, H. Ameden. 1996. "The Economic Cost of Greenhouse-Induced Sea-Level Rise for Developed Property in the United States." *Climate Change* 32: 387-410.

## DOMESTIC LEGAL REGIME

### Contents



The legal regime covering the topic of weather, climate, and natural hazards is based on a collection of important federal statutory authorities. The following is a brief description of some of those authorities relating to weather, climate and natural hazards. The list is selective and is designed to illustrate some major weather, climate and natural hazards Acts. The list is not meant to be comprehensive.

**Global Change Research Act**, 15 U.S.C. §§ 2921 et seq.

Subchapter I - U.S. Global Change Research Program: The purpose of this subchapter is to provide for the development and coordination of a comprehensive and integrated U.S. research program which will promote, in both the domestic and international arenas, improved understanding, assessment, prediction and response to global change. Section 2938(a) directs the President, the Chairman of the Council, and the Secretary of Commerce to ensure that relevant research activities of the National Climate Program are considered in developing national global change research efforts.

Subchapter II - International Cooperation in Global Change Research: Section 2952(a) authorizes the President to direct the Secretary of State, in cooperation with the Committee on Earth and Environmental Sciences, of which the National Oceanic and Atmospheric Administration is a member, to initiate discussions with other nations leading toward international protocols and other agreements to coordinate global change research activities. As noted in the Climate Change Impact on U.S. Coastal Areas Year Of The Ocean theme paper, the U.S. is a signatory to the U.N. Framework Convention on Climate Change, which was adopted in 1992 and entered into force in 1994. Article 5 of the U.N. Framework Convention, "Research and Systematic Observation", provides for the development of international and intergovernmental programs and networks aimed at conducting research, data collection, and systematic observation. The U.N. Framework Convention recognizes that the measures required to address climate change will be most effective if they are based on relevant scientific considerations, as well as technical and economic factors, and must be continually re-evaluated in light of new findings and research. Continued Congressional support for funding NWS/NESDIS/OAR research is a necessary element in providing the necessary current data and information to support such international efforts.

__National Climate Program Act__, 15 U.S.C. §§ 2901-2908

The National Climate Program Act establishes the National Climate Program (Program) to assist in understanding and responding to natural and man-induced climate processes and their implications. The National Climate Program Office administers the Program under the general guidance of the interagency Climate Program Policy Board. The Program office oversees the implementation of a five-year plan which is prepared in cooperation with other Federal agencies, state offices, business groups and research and academic institutions. The Program office also prepares an annual report to the President and authorizing committees of the Congress; reviews participating agency budget requests and submits an analysis of the requests to OMB; coordinates interagency participation in international climate-related and experimental climate forecasting activities authorized by the Act; and provides financial assistance, primarily in the form of grants to public or private educational institutions, state agencies, and other persons or institutions qualified to conduct climate-related studies or to provide climate-related services.

__National Flood Insurance Reform Act of 1994 (NFIRA)__

The NFIRA established the Flood Mitigation Assistance (FMA) program. The purpose of FMA is to plan and carry out activities designed to reduce the risk of flood damage to structures covered under contracts for flood insurance under this title. Section 1366 of the NFIRA assigns the FEMA Director the authority and responsibility for carrying out the program. 42 U.S.C. § 4104c. Section 1367 establishes the National Flood Mitigation Funds to fund FMA grants. 42 U.S.C. § 4104d.

The Flood Mitigation Assistance program, unlike the Stafford Act programs, are pre-disaster programs. There are three types of FMA grants. *Planning grants* assist states and communities in developing flood mitigation plans. Under section 1366 of the NFIRA, a FEMA- approved Flood Mitigation Plan (FMP) is required in order for a state or community to receive a FMA project grant. *Project grants* fund eligible flood mitigation projects. FEMA encourages states to prioritize the mitigation activities outlined in their FMPs and fund projects that will greatly reduce or eliminate the risk of flood damage to buildings, manufactured homes, and other NFIP-insurable structures. Mitigation of repetitively or substantially damaged structures is a high priority. *Technical assistance grants* assist states in providing technical assistance to applicants in applying for the program or in implementing approved projects.

**National Sea Grant College Program Act**, 33 U.S.C. §§ 1121 et seq.

The Sea Grant Act authorizes the award of grants and contracts to initiate and support programs at Sea Grant colleges and other institutions for research, education, and advisory services in any field related to the conservation and development of marine resources. The Sea Grant Act also established graduate and post-graduate fellowship programs related to ocean, coastal and Great Lakes resources.

Through the mid-1980's, the Sea Grant Program received funding to strengthen the marine research and development capabilities of developing nations. Budget pressures eventually brought an end to the international program's appropriation. However, the current authorizing legislation at 33 U.S.C. §1124a provides for the conduct of an international program, although no funds are directly appropriated for this purpose. The current legislation is considerably broader in scope than the original program which was limited to providing technical assistance. The Sea Grant international program encourages and promotes international research, educational activities and technology transfers related to ocean and coastal issues; promotes the exchange of information and data with respect to conservation of these resources; and encourages international collaboration with respect to marine scientific research, including activities which improve understanding of global oceanic and atmospheric processes. Sea Grant colleges which include projects with international components should be encouraged, as they may serve as pilot projects for developing a new international initiative within the National Sea Grant College Program.

**National Weather Service Organic Act**, 15 U.S.C. §§ 313

The Organic Act provides the basic authority for all National Weather Service activities. The Secretary of Commerce (as delegated to the Assistant Administrator for Weather Services) is directed to forecast the weather, issue storm warnings, collect and transmit marine intelligence for the benefit of commerce and navigation, report temperature and rainfall conditions, and take such meteorological observations as may be necessary to establish and record the climatic conditions of the United States. The Organic Act also provides authority for the operation of weather satellites.

**NFIRA Section 577: Evaluation of Erosion Hazards**

The Upton/Jones amendment to the National Flood Insurance Act of 1968 (NFIP) was enacted into law in 1988, and then repealed a few years later. This amendment allowed payment of flood insurance claims to relocate or demolish buildings immediately threatened by erosion, prior to the actual damages. In order to administer the program, accurate erosion rate data was required. FEMA began in 1988 to acquire copies of existing erosion rate data and to a limited extent generate new erosion rate data.

Several proposals were made between 1990 and 1994 that would have established erosion management authority within NFIP, but none succeeded. Instead, replacing the Upton Jones amendment was section 577 of NFIRA, mandating an evaluation of erosion hazards. The study shall be designed to assist Congress in determining whether the NFIP needs to revise its treatment of structures at risk of erosion. Section 577 has these three key objectives:

1. Determine the amount of flood insurance claims that are attributable to erosion;

2. Examine the economic impact of proposals to change the NFIP by denying flood insurance, or making flood insurance available at actuarial rates in communities having erosion hazard areas; and

3. Examine whether the costs of mapping erosion hazard areas exceed the benefits to the National Flood Insurance Fund.

In addition, the study shall determine whether the expenditure of insurance premiums to map erosion hazard areas is the most cost-beneficial use of these funds to the NFIP.

**Robert T. Stafford Disaster Relief and Assistance Act,** 42 U.S.C. § 5121 et seq.

This Act governs almost all aspects of the federal response to natural disasters. Once a declaration of an emergency or a disaster has occurred, various actions by federal agencies as well as expenditures in the form of grants are authorized.

Important for mitigation are sections 404 (42 U.S.C. § 5170c) and 409 (42 U.S.C. §5176). Section 409 of the Stafford Act requires state and local governments to evaluate the hazards in a disaster area and take steps to mitigate those hazards, as a condition of receiving federal disaster assistance. The hazard mitigation plan, called a section 409 plan, is a vehicle for accomplishing this. It recommends policies, strategies and appropriate actions to reduce future losses. It must be submitted to FEMA for approval within 180 days of the disaster declaration. 44 C.F.R. § 206.405(d).

Section 404 authorizes Hazard Mitigation Grants to state, tribal and local governments and certain private, non-profit organizations to undertake measured identified following the evaluation of natural hazards under section 409.

FEMA has just recently determined that any county in a state in which a natural disaster has occurred is eligible for Section 404 funding, even if that county itself was not included in the disaster declaration. FEMA concluded that this would better fulfill the purpose of the Hazard Mitigation Grant Program, which is to reduce the risk of future damage and hardship. 62 Fed. Reg. 36289.

**Coastal Barrier Resources Act of 1982, as amended,(CBRA), 16 U.S.C. §§ 3501 et seq.**

See Ocean Living Resources 1998 Year of the Ocean Discussion Paper.

**Coastal Zone Management Act of 1972, as amended,(CZMA), 16 U.S.C. §§ 1451 et seq.**

See Marine Environmental Quality 1998 Year of the Ocean Discussion Paper.

Section 309 of the CZMA, the Coastal Zone Enhancement Program, allows states to compete for additional CZMA funds for development of enhancements to their CZM programs for, among other things, coastal hazard mitigation.

## LIST OF ACRONYMS

| | |
|---|---|
| AOML | Atlantic Oceanographic and Meteorological Laboratory |
| ASRL | accelerated sea-level rise |
| CDC | Climate Diagnostics Center |
| CENR | White House Committee on the Environment and Natural Resources |
| $CO_2$ | carbon dioxide |
| CPC | Climate Prediction Center |
| CZM | Coastal Zone Management |
| DOE | Department of Energy |
| ENSO | El Niño/Southern Oscillation (The term ENSO will be used to refer to both a warm and a cold episode; El Niño will be used to specify a warm episode, and La Niña will be used to specify a cold episode.) |
| ERL | Environmental Research Laboratories |
| FCCC | Framework Convention on Climate Change |
| FEMA | Federal Emergency Management Agency |
| GCM | General Circulation Model |
| GCRMN | Global Coral Reef Monitoring Network |
| GEWEX | Global Energy and Water Cycle Experiment |
| GFDL | Geophysical Fluid Dynamics Laboratory |
| GOALS | Global Ocean Atmosphere Land System |
| GOOS | Global Ocean Observing System |
| ICM | Integrated Coastal Management |
| IOC | Intergovernmental Oceanographic Commission |
| IPCC | Intergovernmental Panel on Climate Change |
| IRI | International Research Institute for Climate Prediction |
| NAO | North Atlantic Oscillation |
| NASA | National Aeronautics and Space Administration |
| NCEP | National Centers for Environmental Prediction |
| NOAA | National Oceanic and Atmospheric Administration |
| NSF | National Science Foundation |
| OAR | (Office of ) Oceanic and Atmospheric Research |
| PMEL | Pacific Marine Environmental Laboratory |
| PNA | Pacific-North American |
| SAV | submerged aquatic vegetation |
| SCPP | Seasonal-to-Interannual Climate Prediction Program |
| SST | sea surface temperature |
| TAO | Tropical Atmosphere Ocean |
| TOGA | Tropical Ocean Global Atmosphere |
| UNEP | United Nations Environmental Programme |
| UNESCO | United Nations Educational, Scientific, and Cultural Organization |
| VOS | Volunteer Observing Ship |
| WMO | World Meteorlogical Organization |
| WOCE | World Ocean Circulation Experiment |

# 1998 Year of the Ocean

## MITIGATING THE IMPACTS OF COASTAL HAZARDS

### Contents



This Year of the Ocean document was prepared as a background discussion paper and does not necessarily reflect the policies of the U.S. Government or the U.S. Government agencies that participated in its preparation.

## INTRODUCTION

### Coastal Hazards—Increasing Populations and Higher Costs

Destructive natural system events that impact coastal areas can be either episodic or chronic. Together, these types of events define what is meant by natural coastal hazards. The destructive potential of such events is often made much worse by the increasing amount of development along the nation's coastline.

A variety of natural hazards regularly threaten the nation's coastal inhabitants. Severe meteorological events such as hurricanes, tropical cyclones, and nor'easters are particularly harsh on coastal areas, often resulting in damages from high winds, storm surge, flooding, and shoreline erosion. Tsunamis, whose destructive force is characterized by potentially devastating flood inundation, are uniquely coastal events resulting from offshore earthquakes, landslides, or volcanic activity. Coastal locations are also subjected to the impacts of long-term hazards such as chronic coastal erosion, potential sea-level rise, and global climate change. Other hazards impacting coastal areas include biological events such as red tides and harmful algal blooms.

Coastal hazard events can significantly affect or even alter the natural environment, but their impacts are generally not considered to be "disastrous" unless they involve damages to human populations and infrastructure. Many of the coastal ecosystems that are particularly fragile and sensitive to the cumulative impacts of human development are also naturally fluid and generally capable of adapting to hazard impacts over time. When people and property are not present, hazards are merely natural processes that alter the environment as they have throughout the earth's history. When people and property are present, however, the impacts of hazards on the developed and natural environments are viewed quite differently. The primary focus no longer is on the natural processes associated with a major hazard event, but instead on the disastrous results that can be measured by lives lost, property damages, and economic and environmental impacts. Hazard impacts on the natural environment become more devastating because human development has altered the ability of natural systems to recover from such events. Natural hazard events can also spawn secondary hazards such as sewage releases or hazardous materials spills that are particularly damaging to coastal environments.

The impacts of natural hazards are becoming increasingly costly and devastating. Experts believe that the statistics on disaster losses continue to rise worldwide due to a combination of factors that include a rise in the number of hazard events due to global climate change or natural cyclical trends, and an increase in human exposure in hazardous locations. Some of the increase in disaster damages worldwide could also be the result of improvements in disaster monitoring and reporting capabilities, particularly in developing countries. Worldwide, all three factors may come into play, but disaster loss increases in the United States seem to be most closely tied to increased human exposure in high risk areas such as the nation's coasts.

Growth trends in coastal areas have the obvious consequences of increasing human exposure to natural hazards. The . United States has an expansive and diverse coastline that supports a disproportionate percentage of the nation's population. The nation's 451 coastal counties contain just over 50 percent of the U.S. population, yet only account for about 20 percent of the total U.S. land area. During the last decade, 17 of the 20 fastest growing counties were located along the coast. In addition, 19 of the 20 most densely populated counties in the nation are coastal counties, as are 16 of the 20 counties with the largest number of new housing units under construction.

Coastal locations were some of the first settled in this country, and have always accounted for a major percentage of the overall U.S. population. Their role as primary centers for transportation, tourism, recreation, commercial fishing, and other industry has ensured that coastal areas remain a crucial segment of the nation's overall economy. In the past, larger coastal populations were generally centered in the major port cities. Natural hazards affecting these cities were sometimes devastating, but there were fewer locations to potentially be affected. As coastal populations have increased, cities have become larger and more numerous. With the growth of coastal tourism, it is no longer necessary to rely exclusively on ports and industry to fuel economic growth in even the most remote coastal areas. There are now many more coastal locations with significant populations and property resources exposed to potentially devastating impacts from natural hazards.

Disaster losses in the United States are currently estimated conservatively at $50 billion annually. Losses in 1970 were estimated at approximately $4.5 billion annually. These figures only account for direct costs. They do not include indirect losses such as short and long-term economic and social impacts that many experts believe could more than double these cited figures. Of the estimated $500 billion in disaster losses between 1975 and 1994, 80 percent were imposed by meteorological events and 10 percent were the result of earthquakes and volcanoes. About 17 percent ($85 billion) of the estimated losses were insured. Since 1989, approximately $20 billion in losses have been paid by the federal government in presidentially declared disasters. It is interesting to note that while losses from major catastrophic events are rising, the majority of hazards-related damages result from smaller events that do not qualify for federal assistance and which are not insured, leaving victims primarily responsible for the costs.

The turning point in focusing national attention on disaster losses began with Hurricane Hugo and the Loma Prieta earthquake in 1989 and has been followed in rapid succession by major catastrophic events including Hurricanes Andrew and Iniki in 1992, the Midwest floods in 1993, and the Northridge earthquake in 1994. In recent years, several hurricanes including Hurricanes Opal, Marilyn, and Fran have significantly impacted the Southeast, Gulf, and Caribbean coasts, while the Pacific Islands and the West Coast have been pounded by Typhoons Omar and Paka and numerous El Nino-induced events. Destructive and costly ongoing flooding and erosion along the Great Lakes coast associated with higher than average lake levels and coastal storms has also occurred. The impacts from all of these large-scale events are having a profound effect on public policy and perceptions concerning hazards.

### Reducing Disaster Losses through Hazard Mitigation

Given the significant costs of the nation's catastrophic natural disasters, focus has shifted in recent years to expand beyond emergency preparedness and response to include a more long-term emphasis on disaster loss reduction. Hazard mitigation is the term used to describe activities that minimize either an individual's or a community's vulnerability to future disaster damages. Mitigation is often characterized as either structural (e.g., strengthening buildings or constructing protective devices) or non-structural (e.g., land use planning or incentive-based insurance rates). In a broader context, however, loss reduction or hazard mitigation can more accurately be described as a long-range goal or objective with many potential strategies for accomplishment.

Hazard mitigation is defined by the Federal Emergency Management Agency (FEMA) as "actions taken to reduce or eliminate long-term risk to people and property from hazards and their effects." The primary goals for mitigation include ensuring that fewer Americans become victims of disaster, reducing the costs associated with disaster, and shifting the burden of disaster costs from the public to those who choose to live in hazardous locations. In 1995, FEMA developed the National Mitigation Strategy to encourage partnerships between the public and private sectors with the specific goal of significantly reducing the impacts of natural hazards by the year 2010. In 1996, the President's National Science and Technology Council Committee on the Environment and Natural Resources developed the Natural Disaster Reduction Plan for the nation to complement FEMA's National Mitigation Strategy.

Concurrent with FEMA's aggressive stance on hazard mitigation, many federal agencies with hazards responsibilities, such as the National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), Department of Defense (DoD), and U.S. Coast Guard (USCG) also have programs and initiatives utilizing their own hazards information, scientific and technological capabilities, and resources to support a variety of hazards loss reduction activities.

Throughout the marine community and in coastal regions, the USCG works to spread the mitigation message for any impending coastal hazard. In many cases this includes direct personal contacts to ensure adequate actions are underway to secure port areas, or conducting harbor patrols to identify resources at risk and recommend specific mitigation measures as appropriate. The USCG, along with numerous federal agencies including the DoD and the Department of Housing and Urban Development, also participate in national response efforts for major disasters and contribute to national disaster planning activities.

The USGS, through the Coastal Marine Geology Program, conducts scientific research in the nation's coastal zone and in adjoining continental shelf regions. The broad goal is to collect information that will improve the understanding of geologic hazards, environmental conditions, biologic habitats, earth science processes, and energy and mineral resources. Such information in turn can help managers make informed decisions about wise use and protection of coastal and marine resources.

One of the most important details concerning hazard mitigation is that the vast majority of disaster reduction activities must be implemented at the local level. Most of the techniques that can reduce natural hazard vulnerability involve specific actions that can only be carried out by individuals or local communities. One of the key challenges facing national-level mitigation efforts is making the information useful at the local level while recognizing the vast differences in local conditions, both physical and political.

## KEY MANAGEMENT ISSUES AND STRATEGIES

Disaster management has been described in the past as a cycle, divided into four major categories, including preparedness, response, recovery, and mitigation. While these categories provide a good framework for discussing different aspects of emergency management, it is somewhat misleading to discuss hazard mitigation as a separate, distinct "phase" of disaster management.

Hazard mitigation has been described as a primary goal or objective to reduce future disaster vulnerability. This goal can be achieved through various strategies implemented throughout the preparedness, response, and recovery phases of disaster management. Common elements required to successfully integrate mitigation into all phases of emergency management include developing a better understanding of the various hazards and their potential impacts, and identifying options and opportunities within each phase to accomplish loss reduction objectives. Improvements in these areas will require a comprehensive multi-disciplinary approach to disaster management involving various degrees of research, science, technical resources, and education, as well as public policy development and implementation.

### Mitigation Through Better Predictions, Forecasts, and Warnings

Over the years, progress has been made in reducing hazard impacts through better predictions, forecasts, and warnings, particularly for meteorological hazards such as coastal storms and floods. General improvements in hurricane and tsunami prediction, and river and lake level forecasting, have been possible using the latest in computer modeling technology. NOAA's National Weather Service (NWS) is currently working with several new technological systems that are intended to significantly improve future flood forecasting capabilities. The NWS is pursuing improvements to flood warning systems that utilize two-way communication capabilities and provide real-time information to residents in flood prone areas. The USGS is also pursuing the use of new data collection and mapping technologies to provide near real-time information on storm events.

While research and technological advances have resulted in improvements in prediction and forecasting capabilities, there continues to be a need for advancements that could further mitigate disaster-related expenditures. Better and more accurate hurricane landfall predictions could save millions of dollars in evacuation costs, while longer range flood forecasting could result in longer lead times necessary to undertake adequate property protection and mitigation measures. There is also a need for a comprehensive and coordinated national strategy for hazard warnings. Current warning practices are highly fragmented among different agencies and are usually hazard specific, requiring the public to rely on multiple information sources in addressing different types of hazards. A more coordinated national strategy could help minimize public confusion and maximize the use of limited public resources.

### Broadened Emergency Preparedness And Response

Progress has also been made in reducing hazard impacts through better emergency preparedness and response activities. The vast majority of people dealing with disasters at the state and local level are emergency response personnel such as fire, police, and medical staff, along with disaster managers and planners who devote the bulk of their efforts to disaster preparedness and response activities. FEMA provides funding to help state and local governments maintain emergency preparedness programs and participate in activities such as developing disaster plans, conducting disaster drills, and implementing public education and awareness campaigns.

A key opportunity exists to incorporate hazard mitigation concepts into the disaster preparedness and response phases of emergency management. The primary focus of emergency management has previously been on how to prepare and respond to disaster events, not on how to manage the hazards that can sometimes cause disasters. A shift in emphasis from "disaster" or "emergency" management to "hazards" management could help to ensure that planning activities are broadened to address the hazards that *always* face communities rather than just the disasters that *sometimes* strike them. Many of the challenges that need to be overcome in implementing local hazard mitigation stem from the fact that hazards receive little attention until there is a disaster.

### Preplanning for Opportunities during Recovery and Reconstruction

In the past, the implementation of hazard mitigation activities has been closely linked to the post-disaster recovery and reconstruction phase of emergency management. Not only are hazard vulnerabilities in a post-disaster situation more obvious from the damages incurred, but the opportunity exists to rebuild in ways that should make them less vulnerable in the future. Another major factor in encouraging post-disaster hazard mitigation is the availability of money to help support such initiatives. FEMA's Hazard Mitigation Grant Program (HMGP) sets aside a percentage of disaster damage reimbursements to fund these types of projects.

Every major disaster brings new experiences and lessons about recovery and reconstruction processes. A major challenge in addressing these lessons from a national perspective is that most of the responsibility for setting and implementing reconstruction policies lies at the local level. While information gained from other experiences could help guide some local decisions, the recovery process is very localized—a function of specific local conditions including the nature and severity of the disaster, local political circumstances, and the degree to which reconstruction planning has already taken place.

One important aspect of using the recovery and reconstruction processes to accomplish hazard mitigation goals is how well prepared a community is to implement them at the time the disaster strikes. There are too many demands on a community to logically and systematically establish a hazard mitigation strategy and implement mitigation activities in the immediate aftermath of a disaster. It is critical that communities consider and plan these strategies and opportunities in their emergency planning processes.

There is currently no national policy on pre-event planning for post-disaster recovery and reconstruction. FEMA's guidelines on hazard mitigation planning encourage pre-event planning but are tied to HMGP requirements that become effective only in post-disaster situations. Most hazard mitigation plans, especially local plans, are developed after major disasters, usually many months or even years into the recovery and reconstruction processes. Many of the most important opportunities for reducing future hazard vulnerability are lost in the early recovery process when communities rush to return to normal activities.

There are difficult practical considerations associated with implementing hazard mitigation policies and initiatives in a post-disaster environment. These considerations need to be examined and weighed carefully in the planning process. Difficult political choices such as enforcing restrictions or prohibitions on rebuilding or requiring new (and possibly more expensive) construction standards for rebuilding, are often needed to implement post-event hazard mitigation policies. The pressures to return things to normal as quickly and inexpensively as possible are driven by the devastation to a community's disaster victims. Often, the adoption of new policies and restrictions on redevelopment is not advisable or even possible in a post-disaster environment. They often stand a better chance of adoption either in a pre-event hazards planning phase or far enough into the recovery process that they will only apply to victims of the *next* disaster. The implementation of these policies after a disaster is often politically difficult enough; trying to develop and adopt them in the chaos that follows a disaster is usually impractical.

A major impediment to accomplishing loss reduction goals in the recovery and reconstruction processes, is the lack of a coordinated federal policy concerning the use of various types of federal disaster assistance. Numerous federal agencies are involved in providing post-disaster recovery assistance to victims. Often this assistance is used to fund projects and activities that are inconsistent with local mitigation goals and objectives, and sometimes inconsistent with other federal programs.

### Coordinating Federal Policies on Hazard Mitigation

Some significant progress has been made toward encouraging mitigation efforts that are not exclusively associated with the "emergency" nature of hazards. These efforts are directed at ensuring a more long-term approach to dealing with risks and identifying strategies to minimize hazard exposure and potential losses. FEMA's National Mitigation Strategy sets the stage by establishing two primary goals for hazard mitigation by the year 2010:

(1) To substantially increase public awareness of natural hazard risk so that the public demands safer communities in which to live and work

(2) To significantly reduce the risk of loss of life, injuries, economic costs, and destruction of natural and cultural resources that result from natural hazards

The strategy involves strengthening public and private partnerships and creating partnerships where none exist for building safer communities. The strategy sets forth a series of objectives by which to measure the nation's success in achieving the hazard mitigation goals and identifies the following five major focus areas: (1) hazard identification and risk assessment; (2) applied research and technology transfer; (3) public awareness, training, and education; (4) incentives and resources; and (5) leadership and coordination.

To create a link between the concepts behind the National Mitigation Strategy and the implementation of hazard mitigation initiatives at the local level, FEMA has initiated a program called "Project Impact." This is intended to help communities protect their residents, organizations, businesses, infrastructure, and the stability and growth of the local economy as much as possible against the impacts of natural disasters before they happen.

There are a number of additional initiatives and activities at the federal, state, and local levels that support long term hazard mitigation. Many states have started state-wide campaigns to encourage hazards loss reduction activities ranging from land use planning and regulations to improved building codes and engineering standards. In addition, many coastal states participating in NOAA's Coastal Zone Management Program incorporate hazard mitigation activities into their state and local planning processes.

### Strengthening The Built Environment

One of the most cost effective measures for mitigating disaster damages is to design and construct hazard resistant structures. Most coastal states have adopted statewide building codes that incorporate some type of hazard resistant construction standards. A few coastal communities have even adopted more stringent standards than the state codes to ensure that new construction can withstand certain hazards. While it is impossible to construct facilities that will endure all intensities and types of natural hazards, it is possible to cost-effectively mitigate against a community's primary hazard threats.

The adoption and enforcement of building codes that address high risk hazard threats can ensure that structures are built to resist the impacts of natural disasters. Since most building codes only apply to new or substantially improved structures, the public and private sector can also encourage residents to retrofit existing structures for hazard resistance through other means. For example, the use of financial incentives such as reduced taxes or insurance premiums, by the public and private sectors can help to encourage hazard resistant retrofitting in existing structures.

The National Flood Insurance Program (NFIP), administered by FEMA, has played a critical role in mitigating damages due to coastal flooding. The NFIP provides federally backed flood insurance in communities that agree to adopt and enforce floodplain management measures to reduce future flood damages. FEMA has identified flood hazard areas, including coastal high hazard areas that are subject to wave forces. Buildings constructed to NFIP minimum standards on the average perform significantly better in coastal floods and have fewer insurance claims than buildings that pre-date those requirements. Even though NFIP standards and technical guidance have resulted in fundamental changes in how coastal buildings are designed and constructed, reducing the extent of damages to individual structures, overall damages may continue to rise due to the increased value and density of development in high hazard areas.

In addition to strengthening the structural integrity of facilities, there are also important mitigation tools for the non-structural elements of buildings, utility systems, and transportation systems. Simple retrofits such as securing light fixtures to ceilings, installing wind shutters, strapping or bolting mechanical systems to walls, and numerous other techniques can prevent injuries and minimize damages and business interruptions. On a larger scale, public infrastructure such as utility systems, roads and bridges, and drainage structures can be designed, built, or retrofitted for hazard resistance.

## The Role of Land Use Planning

The process of establishing and implementing state and community comprehensive development and land use plans provides significant opportunities to mitigate damages caused by natural hazards. Since location is a key factor in determining the risks associated with natural hazards, land use plans are a valuable tool in that they can designate low-risk uses for areas that are most vulnerable to natural hazards impacts.

Land use planning has long been recognized as an effective method for mitigating the impacts of natural hazards. As more information becomes available to local communities about the nature of the hazards they face, it is possible to integrate more detailed hazards data into ongoing planning and decision-making processes. Technology improvements such as the use of Geographic Information Systems in local planning allow numerous factors, including hazards, to be considered in making land use decisions. Even though more information is now available, numerous obstacles remain to implementing policies to prohibit, restrict, or even discourage development and redevelopment in high hazard areas. Many of these obstacles are political, relating to the ongoing debates about the rights of individual property owners versus the rights of government to restrict the use of private property. Even more basic, however, is the difficulty often faced in raising the priority of hazard considerations in the routine planning process.

## STATUS OF THE RELEVANT SCIENCE AND TECHNICAL BASE

### Scientific Understanding of Hazards

The previous discussion of key issues and strategies provides a general overview of the management topics associated with efforts to minimize the impacts of natural coastal hazards. To improve these management strategies and make additional progress in all phases of disaster and hazards management, it is necessary to acknowledge the scientific and technological information needs throughout the various hazards-related disciplines. Significant progress has been made in the research and science associated with natural hazards during the past 20 years, and improvements in technology and understanding about hazards and how to mitigate them continue to expand our opportunities to reduce their impacts.

Many improvements in coastal hazards management are rooted in a better scientific understanding of how the hazards affect the earth, both in natural and developed areas. Universities and research institutions (particularly the National Science Foundation), along with government agencies such as NOAA and USGS that maintain scientific hazards-related responsibilities, have contributed to advances in the scientific study of natural hazards. There is now more quantitative information available about the origins and behavior of hazard events that can be used for purposes of hazard mitigation.

### Hazards Risk and Vulnerability Assessment

A major area encompassing new research and technical needs is that of hazards risk and vulnerability assessment. Maps delineating hazard-prone areas at national, state, and local levels are needed to provide a more comprehensive hazards assessment using information on a variety of natural phenomena, including coastal storms, floods, earthquakes, tsunamis, landslides, wildfires, and drought. Much of this information already exists, but issues such as data integration, compatibility, scales, accuracy, and resolution need to be addressed to make the information useful at the local level. Better methodologies and models are also needed for conducting hazard vulnerability assessments that can incorporate highly variable local conditions and characteristics.

Hazard risk models in use today usually include data on many risk variables and can begin to provide estimates on projected disaster losses and other impacts using pre-determined scenarios. FEMA's Hazards U.S. (HAZUS) model, designed to estimate disaster losses from earthquakes, is a valuable tool for this type of analysis. HAZUS is currently being updated to model the effects of wind and flood damages.

Ideally, risk and vulnerability models of the future will provide interactive scenarios for determining hazard vulnerabilities based on estimated population growth and other "what if" criteria such as land use changes or building code changes. Other advances needed in risk and vulnerability assessment include the ability to identify potential social, economic, and environmental losses. Better hazard assessment tools should improve research capabilities for determining the effectiveness of existing and proposed hazard management and land use policies. In addition to meeting the needs of the research and scientific communities, hazard risk models and decision support tools should also be developed for use by local governments and decision makers..

On the national scale, the applicability of new technologies should be explored for cost-effective methods of assessing hazards vulnerability and measuring hazards impacts. National baseline data need to be established for use in collecting and quantifying disaster impacts. Computer-based geographic information systems should be used to analyze hazards information and provide national risk assessment data to state and local governments in a quick and easy manner. New high-resolution remote sensing capabilities should be examined for use in large-scale risk and vulnerability assessment projects.

## Hazards Prediction and Modeling

Technical capabilities to predict events have improved for some hazards, and made only modest gains for others. Improvements in monitoring, data collection, and data processing account for most of the advancements made in short-term weather-related forecasting. Better modeling capabilities, along with a more thorough understanding of variables, such as global climate change and sea-level rise, are needed to improve long-range forecasting and planning for coastal hazard impacts. More information is also needed about the interactions between hazard events such as rising water levels in the Great Lakes, and ongoing coastal processes, such as erosion, to predict future hazard impacts.

## Hazard Impacts and Losses

Significant progress has been made in understanding the various impacts that hazards produce on human and natural environments. Numerous research activities have been undertaken following the major hazard events of the past few years. These research activities focus on a wide range of impacts including those on developed and natural environments, as well as the effects of disasters on the social and economic systems of impacted communities. Unfortunately, much of this research is piecemeal and has not been incorporated into any type of comprehensive database on disaster losses.

Detailed information on disaster losses and their associated costs is needed to serve as a baseline for evaluating the effectiveness of mitigation measures. Other advancements needed for evaluating hazard mitigation options include better engineering information about the effectiveness of structural techniques such as flood or wind proofing, and better sociological information about the effectiveness of the various incentives available to encourage mitigation activities.

## EDUCATION, OUTREACH, AND PUBLIC INTEREST

### Links between Hazard Threats and Protective Behavior

Public interest and education are the most critical elements for succeeding in the overall goal to reduce the impacts of coastal hazards. Unfortunately, there are many complex issues involved in public perceptions about hazards, risks, and disasters. It is important to understand how the public perceives and responds to these topics. Research findings suggest that the links between perceived risk and behavior are particularly complicated. While it is the hazard itself that people respond to in an emergency situation, it is only the risk of the hazard that influences (or does not influence) behavior prior to an event. This is an important distinction in understanding public responses to hazards. While the impacts of actual hazard events or disasters leave the affected public reacting to nature's destructive forces, the threat of a hazard event causes the broader population to struggle with convoluted concepts of risk, probability, and possible consequences.

The issue can become even more complex depending on the "time horizon" for which people are expected to calculate risks. Even when faced with the threat of an actual storm event, people are often reluctant to heed warnings and protect themselves and their property. There have been many research projects dedicated specifically to studying influences on behavior in a pre-storm environment. These projects evaluate the factors influencing people's decisions to evacuate high risk areas, seek shelter, and take damage precautions for their property. Given the difficulty in convincing the general public of the risks associated with a near term threat, it is not surprising that long term hazard risks are often insignificant factors in individual decision making processes.

### Public Concern for Rising Costs

The public is genuinely concerned about the costs of major hazard events in terms of deaths and property damages. Disaster costs are skyrocketing, resulting in heightened public awareness. The public's concern about risk on an individual basis, however, is less certain. For example, studies have found that information about the potential for hazards such as earthquakes, coastal erosion, and flooding has little effect on the home selection of buyers. Other considerations such as price, location, size, and amenities are found to be overwhelmingly more important in their decision process. This evidence suggests that concerns about hazard risks at the individual level do not significantly influence the public's choices or behavior. As a result, demand for coastal growth and development is probably not the consequence of indifference to disaster costs, but more likely the outcome of the public's willingness to assume individual risks, even though the cumulative impacts can be catastrophic.

As population increases in coastal areas and more residents are subjected to the risks of coastal hazards, the link between information and awareness remains an important one. "It is not uncommon to hear people living in a hazardous place—especially if that place is a large urban area—declare that they are free of risk in their location. In urban areas, where there is a greater mobility of population and less direct contact with the environment, the occupant of hazardous terrain may be less informed." (Burton, et al., 1993) The uninformed public is certain to be at a disadvantage in preparing for and responding to hazard threats.

### Hazard Experience and Individual Behavior

Another misconception about public perception of hazard risks involves the link between hazard experience and behavior. A number of research studies indicate that prior hazards experience does not necessarily lead to subsequent preventative action. In fact, several studies have concluded that people without any hurricane experience tend to prepare and evacuate earlier than those who have experienced it before, suggesting that "threshold" levels are higher for experienced coastal residents. (Sims and Baumann, 1983). Education and outreach, therefore, must be continuous and ongoing efforts to convince a diverse public of their risks to the impacts of hazards.

### Multi-Faceted Public Education Process

The complexity of these issues suggests that a general "blanket approach" to hazards education and public policy will not be very effective. The reality is that people perceive hazard risks differently from one another and often perceive their own risks differently depending on the location and the situation. Different educational approaches need to be tailored to fit the appropriate audiences. Since hazard mitigation can include many different strategies such as improving emergency preparedness, strengthening the built environment, avoiding development in hazardous locations, and acquiring adequate insurance coverage, public education opportunities exist in many different disciplines. The challenge is for those disciplines to come together in promoting a clear and concise hazard mitigation message to the public.

Many organizations in the public and private sectors are involved in hazard mitigation education and outreach activities. FEMA, along with their state and local emergency management partners have ongoing public education campaigns directed at the general public. FEMA's National Flood Insurance Program also includes a major public information campaign. Other federal agencies such as NOAA and USGS also include hazards-related educational and outreach efforts that increasingly incorporate a hazard mitigation focus. Numerous state-level coastal zone management and Sea Grant organizations are developing statewide programs to promote hazard awareness and mitigation activities. Organizations like the American Red Cross and the Institute for Business and Home Safety are dynamic leaders in national hazard mitigation initiatives that promote public-private partnerships and education. The private sector is also becoming increasingly active in promoting hazard awareness and mitigation through programs such as the Disaster Recovery Business Alliance. Insurance companies and financial institutions are also playing a larger role in educating the public and encouraging disaster loss reduction through mitigation.

## OPPORTUNITIES AND BARRIERS FOR MANAGING THE IMPACTS OF COASTAL HAZARDS

A shift in focus from the traditional disaster planning and management approach to a more comprehensive hazards management strategy will require a long-range, coordinated effort involving numerous public and private sector partners. There is a great deal of attention focused on hazards due to several consecutive years of catastrophic events. El Nino has also played a major role in focusing the nation's attention on natural hazards. Now is an appropriate time to identify and evaluate the full range of opportunities for reducing future disaster impacts. Some of the highest priority hazards issues are identified below and described in terms of a few key barriers and opportunities for improvement:

**Scientific understanding of coastal environments.** A key element in reducing disaster impacts is to develop a more thorough scientific understanding of the natural and physical environments that are at risk. The opportunity exists to establish baseline information about the physical features and characteristics of the coast and identify the geologic factors that make certain coastal locations particularly vulnerable to hazard impacts. One of the primary obstacles to this effort is the lack of relevant data on a scale that can be useful in local hazards management.

**Risk assessment**. The increased emphasis on hazard mitigation at the local level led by FEMA's National Mitigation Strategy and its Project Impact initiative has expanded the interest and desire of many local governments to identify their hazards and conduct risk and vulnerability assessments. This interest presents an opportunity to develop sound risk assessment methodologies for use at the local level. The most significant obstacles to overcome in this area include the limitations of existing data and information, and the expense associated with developing high accuracy local hazards data. Some of the issues that need to be resolved include data availability, resolution, scale, accuracy, and cost. If risk assessments are too general, hazards data may not be incorporated into existing decision support systems at the local level.

**Prediction, forecasts, and warnings**. While varying degrees of progress have been reported in enhancing prediction and warning capabilities for the different natural hazards, certain research aspects of the field have flourished over the last several years. There is an abundance of social and behavioral research dedicated to studying individual responses to hazard predictions and warnings. This body of research provides opportunities for improving warning systems based on the human perceptions of disasters. There is a recognized need for a strategy that addresses the behavioral research findings, and strives to achieve some level of consistency and continuity concerning warnings for the various hazards that threaten communities. The most significant obstacle to implementing improvements in warning systems is the lack of a consistent national policy or strategy on warnings. Another challenge in the area of forecasts and warnings is expanding lead times enough to meet the increasing demands caused by growth in high risk locations.

**Disaster preparedness and response**. This is probably the most developed area of emergency management, complete with plans, exercises, training, and public education programs established at the various levels of government. In recent years, even the private sector has become active in disaster response planning. Based on the advanced level of program development and the presence of an established multi-disciplinary network, this field offers many potential opportunities to emphasize disaster reduction strategies and identify mitigation opportunities. The challenges to such efforts could include a general resistance to change in established programs, particularly at the local level where resources are scarce and personnel have little, if any, training to support such a focus.

**Education**. Opportunities to improve hazard mitigation through education are plentiful. Because numerous government and non-government organizations (such as the American Red Cross and Institute for Business and Home Safety) are focusing on disaster loss reduction initiatives, there are multiple networks and resources available for delivering hazard mitigation messages to school age children and the general public. One of the barriers, however, is the lack of a simple, clear, and meaningful message to relay. The concepts and terms associated with hazard mitigation need to be simplified and put into a concrete, recognizable frame of reference for a mass public audience. Many hazards practitioners describe a goal to influence public behavior through awareness campaigns as similar to those used for seat belts and recycling. To achieve such a goal will require well planned and thoroughly researched long range strategies.

**Disaster Losses**. There is now a recognizable need to improve the methods for collecting, reporting, and maintaining databases on the losses association with natural hazards. Several recent and ongoing studies are focusing on specific measures to improve these methods and more fully account for the short and long range impacts of natural hazards. One of the primary obstacles to implementing a more complete disaster loss database, is the government's fragmented approach to hazards information. Different agencies and organizations have responsibility for different types of hazards data. Often the data is anecdotal, collected for a specific case study or event, and not part of a larger, ongoing data collection effort. Categories of losses are generally not consistent from one agency to another, and when disaster loss totals for a single event are compared between agencies, they are rarely even close to the same figure. These inconsistencies create huge gaps in accountability and do not provide an adequate baseline for measuring progress for hazard mitigation.

**Post-Disaster Recovery and Reconstruction**. Many lessons have been learned from the recent catastrophic events concerning the use of hazard mitigation in the recovery and reconstruction process. Affected local communities can share these experiences concerning what works and what does not in a post-disaster environment. One of the things that has clearly been demonstrated in recent events is the need to prepare reconstruction plans *before* a disaster strikes. Most communities do not engage in recovery and reconstruction planning, leaving important hazard mitigation opportunities unrealized.

**Engineering and Structural Mitigation**. As increased attention has been focused on reducing disaster losses, significant research has focused on engineering and structural methods for strengthening the built environment. Much more information is available about construction and building techniques for withstanding the various forces of nature. While some progress has been made in the construction and retrofit of more disaster resistant structures, one of the main barriers to progress continues to be a lack of incentives to encourage such measures.

**Land Use Planning and Policies.** Land use planning has long been recognized as an effective method for mitigating the impacts of natural hazards. As more information becomes available to local communities about the nature of the hazards they face, it is possible to integrate more detailed hazards data into ongoing planning and decision-making processes. Technology improvements such as the use of Geographic Information Systems in local planning allow numerous factors, including hazards, to be considered in making land use decisions. Even though more information is available, there remains numerous obstacles in implementing policies to prohibit, restrict, or even discourage development and redevelopment in high hazard areas. Many of these obstacles are political, relating to the ongoing debates about the rights of individual property owners versus the rights of government to restrict the use of private property. Even more basic, however, is the difficulty often faced in raising the priority of hazard considerations in the routine planning process.

## REFERENCES

Burton, Ian, Kates, Robert W., White, Gilbert F. 1993. *The Environment as Hazard.* New York : Guilford Press.

Culliton, T.J., C.M. Blackwell, D.G. Remer, T.R. Goodspeed, M.A. Warren, and J. J. McDonough III. 1990. "50 Years of Population Change along the Nation's Coasts, 1960-2010" Coastal Trends Series, Report No. 2.

Federal Emergency Management Agency (FEMA), 1997. A Reference Library - Fact Sheet,@ FEMA web site. (http://www.fema.gov/fema/fact10.html) September 22, 1997.

Federal Emergency Management Agency (FEMA), 1995. "National Hazard Mitigation Strategy: Partnerships for Building Safer Communities."

Godschalk et al., 1989. *Catastrophic Coastal Storms: Hazard Mitigation and Development Management*. Durham: Duke University Press.

Katuna, Michael P., Robert B. Blythe, Michael E. Moeller, and Bryan P. Williams, 1995. "Final Report: Study of Shoreline Migration Rates and Sediment Budgets for Seabrook, Kiawah, and Folly Islands, South Carolina." Pages 2-3. University of Charleston. Submitted to the Minerals Management Service, Office of International Activities and Mineral Resources, Herndon, VA

National Research Council, 1990. *Managing Coastal Erosion*, National Academy Press, Washington, D.C.

Oregon Sea Grant, 1994. "Improving Natural Hazards Management on the Oregon Coast: Recommendations of the Coastal Natural Hazards Policy Working Group." Oregon State University, Corvallis, Oregon. ORESU-T-94-002. Page 11.

Pielke, 1997. Homepage for Roger Pielke, Jr. web site. National Center for Atmospheric Research, Boulder, Colorado (http://www.dir.ucar.edu/esig/HP_roger.html).

Sims, John H. ; Baumann, Duane D. "Educational Programs and Human Response to Natural Hazards," *Environment and Behavior*. 1983; 15, (2) 165-189

South Carolina Sea Grant Consortium, 1997. "Taking Steps to Protect Your Home," *Coastal Heritage*, Volume 12, Number 1. Charleston, SC.

U.S. Geological Survey (USGS), 1997. "Information Bank, U.S. Geological Survey, Coastal and Marine Geology, Western Region." web site. (url: http://walrus.wr.usgs.gov/docs/infobank/fielddata/infohome.html) September 18, 1997.

## LIST OF ACRONYMS

| | |
|---|---|
| DoD | Department of Defense |
| FEMA | Federal Emergency Management Agency |
| GIS | Geographic Information Systems |
| HMGP | Hazard Mitigation Grant Program |
| NOAA | National Oceanic and Atmospheric Administration |
| NFIP | National Flood Insurance Program |
| NWS | National Weather Service |
| USCG | U.S. Coast Guard |
| USGS | U.S. Geological Survey |

# 1998 Year of the Ocean

## OPPORTUNITIES AND CHALLENGES FOR MARINE SCIENCE, TECHNOLOGY, AND RESEARCH

### Contents



This Year of the Ocean document was prepared as a background discussion paper and does not necessarily reflect the policies of the U.S. Government or the U.S. Government agencies that participated in its preparation.

## PREFACE

Last year, a farmer in South Dakota lost his crop because of unpredictable, adverse weather. Consequently, he is very worried about weather patterns and their potential to adversely effect his soybean crop for the next season. Yet, he is unaware that the accuracy of long-term weather forecasts can improve dramatically via the implementation of models which look at how the ocean and atmosphere interact on a seasonal basis. The ocean sciences community is on the verge of giving this farmer a powerful set of new tools, and allowing him to plan more effectively.

An investment firm determines that coastal resort development is a sector for venture capital expenditure, but it needs a good risk assessment regarding the long-term prognosis for coastal environmental conditions. The firm seeks expertise to advise it on such issues as natural coastal hazards, and possibly anthropogenically induced processes including red tide blooms. The ocean sciences community knows how to better satisfy this firm's needs.

The U.S. Navy determines that rapid deployment of forces, in support of a policy of strong forward presence, requires improved understanding of certain oceanographic processes, especially in specific coastal regions. The skills required for acquiring the necessary data are held by scientists in the academic and industrial community. The Navy needs a way of getting these scientists to work intensively with the Naval oceanographers for several months at the Navy facility. The ocean sciences community can facilitate that collaboration through the National Oceanographic Partnership Program, a promising new coordinating mechanism that brings together scientists, educators, and research program managers from all sectors of the federal government., the states, academia, and industry.

Knowing how oceans can excite young people, a high school teacher in Washington State determines that her students could understand more about science and the interaction of physics, chemistry, biology, and geology by studying the nature of the ocean off their coast, but she is unsure how to get the materials and knowledge she needs to teach the course. The ocean sciences community can help her.

These illustrative situations involving quality of life, economic development, national security, and scientific literacy are real. Their solutions are of considerable consequence to the people of the world. For indeed, maintaining the food reserves, assuring economic viability of the globe's greatest natural resources, sustaining a peaceful international political environment, and providing exciting new opportunities to help achieve national science and mathematical educational objectives, are paramount goals. This report clarifies the role of ocean sciences in all of these objectives.

Whether from the perspective of national security or quality of life, one can argue that the advanced understanding of the ocean existent in the United States has been central to the nation's stature as a world leader throughout most of this century. With history as a guide, the ocean sciences community can comfortably extrapolate that a continuing position of leadership in understanding the ocean can facilitate a position of continuing global leadership in a much more competitive future world, provided that appropriate investment levels are maintained.

## INTRODUCTION-

The history of leadership by the United States in the world community is deeply entwined with the leadership role it has had in understanding the factors controlling the environment. The environment is where people live and work, and is the source from which resources come to create human habitats and economies. The environment is controlled by the world's ocean. This paper will discuss the oceanographic science community in terms of its accomplishments, its skills, and most particularly, the needs and investments that are required to maintain the role of the United States as an international leader in the science of the ocean.

Sixty percent of the states in this country have coastlines on the ocean or Great Lakes. Half of the population lives within the coastal zone. One out of every six jobs in the United States is marine-related. Yet less than 4 percent of the federal budget for basic research is spent on ocean sciences.

While the ocean sciences community in the United States is small[1])), the cadre of professionals in this field represent a wide spectrum of skills, ranging from molecular biology to fluid dynamics to cybernetics to organic chemistry. The strength of this community has been based on two factors: (1) its recognition of national research imperatives, and (2) its capability to work cooperatively on scientific problems. This Year of the Ocean observation provides an opportunity to review some examples of well-coordinated efforts to transcend disciplinary and institutional boundaries.

Notwithstanding its past accomplishments , however, the United States faces a new set of challenges in the next decade. These challenges will demand all of the existing resources and capabilities of the ocean sciences community, and then some! Demands on society are being made concerning economic development, quality of life, national security, and education. Driving these demands are changes in global geopolitics, military requirements, technological capabilities, economic competition, international demographics, and resource utilization. In defining general goals pertaining to these demands and changes, and responding to the opportunities presented by the International Year of the Ocean, the oceanographic community must seek to prepare to address new challenges, as well as meet current and continuing needs. That is to say, the community of ocean scientists is now poised to work toward meeting an even larger set of societal needs.

---

[1]Less than 2,500 American Ph.D. level oceanographers are employed in U.S. academia, government, and the private sector (NSF, 1991).

## BACKGROUND

In the 19th century, oceanography was placed in a position of high visibility by a Naval officer named Matthew Fontaine Maury. Maury, in service as the first Director of the Depot of Naval Charts and Instruments, recognized the value of standardizing the measurement of oceanographic properties, especially winds, currents and water depth. Maury knew that such measurements, while of obvious value to the Navy, were likewise useful in a diverse range of applications, including shipping, fishing, and transportation.

Similarly, the bold model of public support for basic research that was developed by Vannevar Bush subsequent to the end of World War II, ultimately demonstrated highly rewarding returns on federal investment dollars in science and technology. This vision became the foundation for today's highly efficient tools for directing public support toward academic research programs, notably two of which are the Office of Naval Research and the National Science Foundation.

In 1969, the Stratton Commission extended many of these same concepts into defining a national imperative for supporting research and development in the marine environment. The outcome of that exercise was the establishment in 1970 of a highly visible National Oceanic and Atmospheric Administration (NOAA). The foresight represented in this visionary effort has been fulfilled and strengthened by the research that has been conducted over the last two decades. The ocean sciences community now recognizes that a focused research program, including the interactive elements of oceanic and atmospheric dynamics, is critical to addressing a wide range of society's needs.

Clearly, the main need addressed by the federal investment in oceanography since World War II has been in the area of national defense. Basic research into the fundamental physical, chemical, biological, and geological properties of the sea was successfully exploited during the Cold War. For example, the United States became a leader in the development of operational systems which could detect Soviet submarines, while at the same time being capable of conducting its own missions in a manner of low detectability. Such successes would have been impossible without the investments made possible by the visions of Vannevar Bush and the Stratton Commission.

In the post-Vannevar Bush era of the late 1960s through the mid 1980s, the federal investment in basic research in the ocean sciences amounted to 7 percent of the federal budget in basic research. It was during this time that the ocean sciences community developed the "tool kit" of skills that now allow it to:

- Predict El Niño and its devastating effects on regional climates and fisheries—through understanding the "coupling", or connectivity, between the ocean and atmosphere in terms of heat transfer, winds, and currents

- Maintain superiority in undersea surveillance and antisubmarine warfare—by virtue of knowledge gained from experiments in sound transmission through the ocean, allowing detection at longer distances, and lower sound levels
- Provide fundamental concepts related to the beginnings of life forms on earth,—via the use of manned and unmanned submersibles to study undersea volcanoes and their concomitant life forms
- Save hundreds of thousands of lives through forecasts of coastal hazards (including tsunamis and hurricanes)—made possible through the exploitation of high performance computing, allowing implementation of increasingly sophisticated, and accurate, models for forecasting coastal dynamics
- Establish a whole industry based upon commercially viable fish farms and aquaculture facilities—through improvements in understanding of the physiology and ecology of important species, such as salmon and mussels
- Locate and build oil platforms to maximize production, and to survive the extremes of the ocean environment—as a consequence of new concepts in anti-fouling, ocean engineering, and seafloor mapping/characterization
- Build sustainable fisheries which in 1996 alone contributed $21 billion to the U.S. GDP —through science and research tools to manage the commercial and recreational fishing industries

But where does the ocean sciences community go from here? The 7 percent investment of the past led to outstanding products. Clearly, a stronger investment is needed for the broader set of challenges facing the United States in the next millennium.

In 1992, the Ocean Studies Board of the National Research Council (NRC), recognizing the need to revisit the status, roles, and plans of the oceanographic community, convened several meetings and prepared their assessment. Their report, entitled *Oceanography in the Next Decade: Building New Partnerships*, has been a landmark event in the direction of this community. The objectives of the study were to "document and discuss important trends in the human, physical, and fiscal resources available to oceanographers, ...to present the best assessment of scientific opportunities during the coming decade, ...and to provide a blueprint for more productive partnerships" (NRC, 1992).

The report of the National Research Council was particularly timely in that it dealt with the redefinition of the oceanographic community in the context of society's changing needs. In opening remarks launching the National Research Council's report its Chairman at the time, Dr. Frank Press, cited the marked changes taking place in the post-Cold War period. These changes seem to cry for new approaches to partnerships for the oceanographic scientific community. In fact, as he pointed out, "concerns about the ocean as a medium for warfare as a threat to national security are decreasing while environmental problems of the coastal zone and understanding how the ocean controls climate are of increasing importance." Further, he stated that while "major advances in understanding the ocean and in the development of technologies for observing it have set the stage for much greater research achievements," this comes at a time when "resources necessary to obtain this understanding are increasingly scarce."

Dr. Press continued, "As the context in which oceanography is conducted changes, how can federal agencies, private industry, local jurisdictions, and oceanographers in academic institutions, government, and the private sector strengthen and improve their cooperative efforts? In general, partnerships must be extended beyond financial relationships to include the sharing of intellect, experience, data, instrument development, facilities, and labor."

The proactive nature of such a proposal is founded upon the recognition of certain trends and "drivers" which point oceanographic researchers toward new areas of applicability. Some examples include:

**Global environmental concerns.** The debates concerning sustainable development, as well as renewed interest in "open ocean" resources (living and non-living), an ongoing crisis in world fisheries and the global loss of marine biological diversity, and the potential impacts of climate change on coastal ecosystems and ocean ecosystem processes, have put an emphasis on the careful use and understanding of the environment, including those ocean areas outside of the Exclusive Economic Zones of coastal nations.

**Explosions in technology and communications.** The ability to place highly sensitive instruments deep in the ocean, or far into space, with long-term monitoring and observation potential has only recently become a reality. Similarly, high-speed, wide bandwidth data transmission now allows information and documentation to be sent to and from the most remote sites on Earth, with relative ease. These data can be assimilated into a new generation of high fidelity models, run on supercomputers, and shared among researchers and educators via virtual oceanographic data systems currently under development.

**Restructuring of national security.** Our nation's security demands diligent consideration to a diverse set of threats. Vulnerability includes the economic infrastructure and the communications networks upon which society depends so critically. As delineated in the Potomac Declaration,[2] National Security now includes economic security, food security, and environmental security.

**National educational reform.** A recognition of the need for systemic reform in this country's educational systems, from kindergarten through graduate school has developed rapidly since 1990. All levels are being rethought, with respect to curriculum reform, teacher enhancement, career guidance, and integrated, constructivist, and cooperative learning, as well as use of educational materials. Contemporary thought, as embodied in the National Academy of Sciences *National Science Education Standards*, concludes that science education must be more than

2 Document produced by the Advisory Committee on the Protection of the Seas (ACOPS) Meeting in Washington, D.C., May, 1997. ACOPS is an independent non-governmental organization primarily made up of foreign individuals. The Potomac Declaration does not necessarily reflect United States Policy.

"science as process," with students learning observational, inferential, and experimental techniques. Rather, an increased emphasis is being placed upon a system that emphasizes inquiry as central to science education.

## A CALL TO ACTION

A broad thematic approach to the role of ocean science and technology should be undertaken, invoking themes of a nature highly relevant to society's needs. Four themes associated with national interests—identified in the CORE publication *Oceans 2000: Bridging the Millennia*, and echoed as themes and issues by the U.S. Year-of-the-Ocean Working Group—are listed below and broadly defined as indicated:

1. National Security. Ensuring that national interests are guaranteed at home and abroad and that basic and applied ocean science remains an essential element of this assurance. This category is meant to include issues associated with preservation of national interests, via military defense, and foreign policy support.

2. Sustainable Economic Development. Use of the basic and applied knowledge of the ocean and its resources for economic gain, including attention to marine resources, transportation, recreation, development, and related industries.

3. Quality of Life. Health and social well-being of people as derived from using basic and applied knowledge of the ocean. Subject material includes the topics of preservation/improvement/ stewardship of the environment (pollution prevention, marine protection, cleanup and remediation), shoreline protection, coastal hazard mitigation, and recreation.

4. Communication/Education. Conveying an understanding of the importance of the ocean to national decision making, to the public at large, and to decision makers and educators at every level using basic and applied knowledge of the ocean, to include the exploitation of state-of-the-art electronic networking and computer based simulations/ demonstrations.

In essence, the set of issues which the oceanographic community is bracing to address are enormous when considered by any dimension—the volume of data, the geographic breadth of impact, the range of disciplines, the variety of assets, and the physical challenges. A characteristic issue faced by this small but diverse community of scientists is that the expertise is distributed throughout the nation. The breadth of skills required in oceanography, coupled with the relatively small number of skilled practitioners translates to a thin, but wide distribution of capabilities. The situation might be compared to having a different medical specialist located at each hospital throughout the country, i.e., all of the necessary skills are at hand, but they are widely distributed. This condition is dramatically compounded by the high level of sophistication and multiple, costly platforms needed to make measurements or predictions in the ocean environment. Many of the major resources (people, equipment, platforms) are one-of-a-kind, resulting in a de facto establishment of many centers of excellence for the field. By fostering the development of new partnerships, the ocean sciences community can overcome many of these apparent obstacles. Through sharing of resources, data, and knowledge, the ocean sciences community will provide an impressive mechanism for working towards solutions.

## OPPORTUNITIES FOR THE YEAR OF THE OCEAN AND BEYOND

There is a very broad realm of research opportunities defined by the diversity of issues embedded in the subjects of quality of life, economic development, education/communication, and national security. The pervasive nature of the Year-of-the-Ocean themes lends strong credibility to the partnership approach; there is an implication that a partnership developed to address a problem in one area will provide collateral benefits to other applications.

What follows is a description of some opportunities for the development of ocean science. The intent is to identify where the key target areas exist and what the specific focus should be to address the most urgent needs of the ocean science community, during this Year-of-the-Ocean and for the decades to follow.

### Data Accessibility

The currency of oceanographic progress is data. The ocean environment is largely undersampled or unsampled. There exist data which might serve multiple needs and full and open access to these data by investigators is critical.

A national, virtual, and common oceanographic data system is needed to provide remote and transparent access to valuable unclassified data sets using state-of-the-networking-art on-line connectivity and linked to existing civilian databases—federal, state and academic institution based. Further development of a national, virtual oceanographic data system will provide on-line connectivity linking Naval oceanographic and civilian oceanographic government, industry, and academic organizations for the purpose of quality data transfer. In addition, the ocean sciences community must provide for the rescue, archiving, and quality assurance of historical and "shoe-box" data sets.

### Long Term Observations

For the same reasons that land-based weather forecasters depend on distributed networks of observational systems, the oceanographic community similarly needs such capabilities. In fact, one of the most dramatic demonstrations of the value of long-term observations is the payoff from the TOGA (Tropical Ocean–Global Atmosphere) buoys in the central Pacific ocean. This system has served as the primary early warning system for the El Niño onset in the last few years. The coincidental occurrence of what is shaping up as the century's strongest El Niño event, during this International Year-of-the-Ocean, highlights the opportunities and payoffs for ocean observational systems and strategies. As a result, the ocean sciences community will need vastly improved capabilities for long-term forecasts. The investments and commitment needed for such an effort, however, are serious and large. Also required will be long-term observations for biological systems, including fisheries and environmental observations.

The ocean (both deep ocean and coastal areas) is a highly dynamic environmental system whose variability is of the same magnitude as the atmosphere, in part due to the coupling of the two systems. In contrast to meteorology, there is no equivalent coherent synoptic monitoring and prediction technology for the ocean. Different agencies collect partial data sets or provide rudimentary predictions; but the effort is significantly below what is required. The data sets on waves, tides, circulation, temperature, salinity, and biological indicators are of potential use to governments and private industries concerned with hazard protection, transportation, recreational and environmental planning. The feedback of oceanographic information to atmospheric models should eventually improve weather forecasts as well.

Coastal regions worldwide are susceptible to heavy damage from earthquakes, hurricanes, storms and flooding. Recent hurricane damage on the east coast of the United States and recent earthquakes in California have resulted in a collective billion dollars worth of property damage and loss of commercial revenue. Several atmospheric and land-based observation programs that exist currently are dedicated towards sensing the formation of tropical storms and recording seismic events along the California coast. Additional information can be gained from ocean bottom and ocean surface deployed sensors, which when combined with the currently available data, would greatly enhance the understanding of these destructive events and provide new capabilities for disaster prediction throughout the globe. Bringing this all together and providing a mechanism for development and coordination is the task of inter-governmental programs under the sponsorship of several international agencies. The goal of ocean observations is to aid the public good, by making use of past research results, motivating new research, and maintaining operational observational programs.

The development of ocean observations systems requires overcoming four important hurdles:

1. The scientific determination of the proper parameters to measure, the correct instruments, and optimum locations for deployment;

2. The design and manufacture of precise, reliable components and data links;

3. The logistics of installation of the systems; and

4. The establishment of data recording, storage, analysis, and distribution facilities.

## Quality Control

One of the major advances to ocean science was made in the mid-1800s when Matthew Fontaine Maury standardized the methods for collecting data at sea. Today, because of the rapid advances being made in sensing technologies, and the capabilities to put data and information easily into the public access, the oceanographic community runs a risk of major problems with quality of data. Access to an information highway that contains raw, unverified, often sensationalized data can be a great danger to both the decision-making and scientific processes. The ocean sciences community needs to invoke standards, as Maury did, and establish protocols for introducing data into the public domain. Clearinghouses, industry standards, community stewardship, and training for data providers and researchers, are the tools that must be improved.

Future observational networks in the ocean are anticipated to consist of enhanced measurement, modeling, and delivery systems, for a host of critical ecosystem measures and standard physical parameters. Because the expected information management methods will rely heavily on Internet traffic, and because a large number of participants will not be performing as "contractors", measures to instill strict data quality assurance will necessarily rely on voluntary means. It is likely that a rigorous program of certification, based on community agreement to a range of qualification procedures (e.g. comparison with climatology), can be implemented successfully. Participation in certification efforts can become strong bonds within growing federal-academic-industry partnerships.

## Resources

*People*

Clearly the most valuable resource in oceanography is the cadre of trained professionals and capable students working in the field. The future body of researchers and educators in the ocean sciences may be distributed among a broader range of careers and job sectors than are currently represented. Efforts are already underway to develop mechanisms to train the next generation of ocean scientists in fields such as business, public policy, and communications, in order to expand the involvement of the oceanographic community. The current number of oceanographers suggests a need for partnership initiatives aimed at distributing capabilities, sharing personnel resources, and ensuring some quality control on the level of expertise. The community should establish formal mechanisms for facilitating the exchange of personnel between academic, government, and private organizations. Some mechanisms for these exchanges currently exist, but they are cumbersome and more prohibitive than conducive to cooperation. Additionally, a partnership approach might be invoked to assess the value and implementation of a professional certification program, as is done in many other technical fields.

The crosstalking and mutual understanding of goals among mission agencies, academia, industry, research agencies, and policy makers is disturbingly minimal. This comes at a time when downward budget pressures call for "downsizing" mission "purification" and "deregulation." The combination of these two trends proves to be very counterproductive, and is exacerbated by significant mission/interest shifts on the part of several agencies. Crosstalking and mutual understanding must be fostered at all levels from program execution to planning and setting of national policy.

In addition, certain private industries have operations that are synergistic with the education of students in the oceanographic community. Oceanographers from academia could benefit from opportunities to work in industry, to be exposed to the needs of industry, and to apply data being generated in the research environment. Programs could be set up to support such cooperative efforts.

Mechanisms, in addition to the traditional Intergovernmental Personnel Act, must be developed to encourage cross-fertilization as described above. Examples include:

- visiting senior scientists to operators and to policy making organizations,
- participation of industry and other user-community representatives across agency planning and policy lines,
- graduate education, research sabbatical and industry/laboratory appointments for military, government, and policy employees.

These mechanisms should span from short term exchanges to long term appointments. In view of the Information Highway/World Wide Web, it may be feasible to create "virtual appointments" that may also include "video conferencing and meetings."

Better understanding of both common and unique issues as well as a basis for improved communications between participants will result from such exchanges. For the oceanographic research community in government and academia, there will be opportunities for some to experience industry, its operations and the application of oceanographic data, thereby enhancing the value of the data being collected by applying it in new way. For industry, the resource of an experienced individual (an expert at times) in an application where such "short term" expertise is necessary would be a valuable asset to the operation at hand.

*Platforms*

The oceanographic community is a research-resource intensive group. Unlike many other scientific arenas, the oceanographic field critically depends on efficient community management of surface ships, manned submersibles, autonomous underwater vehicles (AUVs), scientific buoys, and research satellites. Plans for future field work will add capabilities to this list (e.g. ocean sampling networks, global observation systems) making the management of these research platforms an even more challenging endeavor. Partnerships are critical for successful application of these facilities.

Innovative materials which are becoming available now make new structures and vehicles possible. Carbon fiber and composite plastics could be utilized for strength, light weight, low manufacturing costs, and resistance to corrosion and biofouling. Other construction methods include re-use and re-combination of existing offshore structures from the oil industry, and recycling of dredged materials from the ocean and solid waste materials from the land (fly ash, sanitized sludge, etc.) to form artificial islands offshore.

The technology necessary to develop large offshore structures, innovative vessels, and undersea vehicles in a cost-effective manner is presently being developed. Partnerships are required between government, industry, and academia to conduct the necessary materials research and environmental impact studies. AUVs and robotic systems would be needed during the construction and maintenance of some structures, and for conducting autonomous research in harsh environments. Offshore structures provide platforms for mounting instrumentation for research, weather prediction, and aquaculture.

*Computing*

One of the major accomplishments of the oceanographic community in the last decade has been associated with advances in "data assimilation," the capability of upgrading a predictive model by incorporating data on a regular basis. Advanced development of state-of-the-art massively parallel computers continues to progress. Scientists will continue to recognize the advanced capabilities of these machines, and teachers will utilize their sophisticated programs for visualization and simulation. The costs of these computational systems are high and their access is limited. Careful partnering between the owners, operators, programmers and analysts is essential, and coupling these efforts with the data collection partnerships, described above, will be highly productive.

The Navy for national defense purposes, and civilian organizations for scientific purposes, require the capability to measure, analyze, and predict the state of the world's oceans on a continual basis. Such a continuum of function calls for fusion of data previously collected with that being collected (e.g., via ocean observational systems as described above), developing an analysis of current oceanic conditions using numerical models based on best physical principles understood, and finally, using the best predictive modeling techniques to develop forecasts of future oceanic conditions. An operational system that leaves out any part is less useful and does not effectively utilize the resources at hand.

Observational strategies and operations are improved by concomitant "end-to-end simulation" or "model-mediated approaches." This optimizes the data gathering methods against the underlying requirements, as well as the relevant physics and processes. Techniques that not only adapt to the incoming data stream, but also to alternative sources of information (e.g., remote sensing) offer a major capability enhancement.

The ability to assimilate significant amounts of disparate data in real-time and on scene together with very capable but relatively inexpensive numerical processing machines make a "model-mediated" approach very possible in the near to midterm (3-5 years). An opportunity exists to forge partnerships which bring together archival and near real-time collected data, large-scale computational facilities, predictive models and the methods to distribute results for operational purposes and correction of or improvements to the operational oceanography system.

*Labs/Infrastructure*

Laboratories and the collection of facilities that comprise the infrastructure of oceanography (e.g., large systems of instrumentation, such as ocean bottom seismometers) are as unique to the field as the research platforms. Again, the diversity of the field has been translated into specific technical strengths at individual laboratories. The U.S. Navy has particular capabilities for acoustic studies, for example, whereas the expertise for developing open ocean buoys resides at only a handful of academic and federal laboratories. The optimal exploitation of these facilities can only be attained through a program of sustained and active partnerships between the institutions.

Growing national security and other U.S. interests in littoral regions together with an emerging science and technology capability to adequately address this complex environment, offers an opportunity for interagency partnerships to establish a portfolio of coastal natural laboratories. These would be visited regularly to provide baseline data to understand processes, validate models and algorithms, and to test operational products across the various agencies and participating industry. In this way, positive feedback of engineering models to fundamental physics and process studies can be used to shorten product development time as well as fidelity/skill.

Carefully chosen locations for coastal natural laboratories can also serve as ground-truth for remote sensing (acoustic, space, and airborne techniques) and should be co-located with fiducial sites wherever possible. Notably, the world's marine laboratories are the repositories of collections and historical data of critical importance for coastal research. They have facilities to provide access to marine habitats, institutional stability , and a history of working together. An excellent example is provided by the National Association of Marine Laboratories' "LABNET," which will provide on-site access to data from the diverse mosaic of U.S. coastal zone habitats.

## EDUCATION AND COMMUNICATION

### Education and The Year-Of-The-Ocean

A major change in what the ocean sciences community knows about how people learn, especially how people learn science, has occurred in the last two decades. How, what, and why the ocean sciences community teaches science and mathematics, therefore, must be re-conceptualized. The purpose of education is to empower learners to make information meaningful, in contrast to memorizing a multitude of disconnected facts. What an individual knows about a topic influences the meaning he or she can extract from new information. Abstract concepts must be put in the context of experiences with which the learner is familiar. Furthermore, learners cannot be given concepts. They must construct concepts for themselves. Instructional strategies, subsequently, need to focus on learning, rather than on teaching, as a means for transmitting information. Moreover, the target audience for science education is all Americans, in contrast to science for the elite. Mathematics educators are calling for mathematical literacy for all, and technology educators are speaking of technology education for all—instead of it being limited to students bound for the workplace after grade 12. The revolution in science education requires the study of the interactions of science and technology, a transdisciplinary approach.

The oceans have an aesthetic appeal to humans and the study of oceanography is inherently interdisciplinary. The oceanographic community has an opportunity to make the oceans a major context in which to study the interactions of science, technology, and society, and from which to learn basic science and mathematical concepts.

Partnerships between oceanographers and educators with current perspectives on learning are necessary. There are reciprocal benefits between the two cultures, oceanography and education. The former focuses on generating new knowledge about the ocean. The latter focuses on tying pieces of information into a whole picture that can be made relevant to other scientists and to non-scientists. Together they can develop new courses.

Oceanography is an ideal platform for education, focusing on the interaction of forces and processes across a palette of disciplines, including biology, chemistry, physics and geology. The ocean is also a wonderful arena for applying concepts in mathematics (everything from the algebra of determining salinity, to the calculus of ocean currents). There are a handful of initiatives throughout the country attempting to build curricula along these lines. The formal educational community (including all components from kindergarten through graduate school) would realize immediate benefit from partnering through the establishment of oceanography-specific coalitions of educators.

There exist too few pre-college teachers, specifically elementary teachers who have the content, knowledge and confidence to teach science. This is one of the primary reasons that too many elementary students perform poorly in the sciences. It is well documented that a key to reversing the dangerous lack of scientific understanding being demonstrated by students is through teaching the teachers. Successful workshops, and undergraduate and graduate courses relative to marine sciences, should remain as an area of priority and be expanded at the local, state, regional, and national level. When new technologies and/or advances in scientific theory are developed, workshops and courses must be made available for teachers, thereby allowing them to infuse this "new" knowledge and complementary methodologies/activities into existing curricula, as advocated by the *National Science Education Standards* (NRC, 1996). New or revised curricular materials may also need to be developed. Teaching/learning experiences to assist with integrating these materials into classrooms would follow. The National Ocean Sciences Bowl, initiating a nationwide high school level competition during this Year of the Ocean, is precisely the kind of highly visible and exciting educational program that can re-energize pre-college education with an oceans-related emphasis.

New and/or extended partnerships need to be developed among the education community and marine scientists in government, academia, and the private sector. These partnerships must include, but should not be limited to, fiscal support, equipment, personnel, and/or resource materials (hard-copy, audio/video, diskette, laser discs, Internet, or other related types of materials). The ocean science community can collaborate with instructional material developers to produce correct and content-current materials, and can rapidly modify existing materials to add new content. Year-round academic years for precollege students are increasing in various school districts and parishes within the United States. This paradigm shift will provide the opportunity for increasing the competitiveness of this nation's youth in a global marketplace..

### Informal Education

The average American probably knows more about space than he or she does about the ocean. Given that so much of the quality of life and economic prosperity are dependent on oceanography, it is timely during this Year of the Ocean to address the need for increased public awareness of this field. The ocean research community is a treasure trove of fascinating findings. There are a very limited number of efforts to provide regular educational opportunities in oceanography for the public. Related to this need is the issue of providing information to policy makers at the federal, state, and local levels. Networks or coalitions are needed to foster this kind of dissemination of information, as well as to serve as focal points for ocean-related issues.

Ocean science data can be too fragmented or hidden in difficult to understand scientific papers with little relevance to "society" or legislators on all levels. The timely, accurate transfer of information (i.e., data, analytical products, synthesis documents) on marine environment issues to public leaders, educators and the general public is crucial if the ocean's role in human activities is to be properly understood. Many problems with stewardship of the marine ecosystem, response to natural and human-induced hazards, and the full appreciation of the ocean, arise either from the lack of information or the great difficulty in locating relevant data and products, or incompatibility between the few existing delivery systems. This situation concerning the informational flow to the public concerning marine issues requires initiatives to make the available information useful, to supply it in formats compatible with robust analysis packages, and to provision for an interested party to obtain more detailed answers dependent on the needs of the particular user.

Current technologies provide various models for making it relatively easy to transmit information. The challenge is to provide a "useful information flow" and a backup set of experts to handle questions. The useful information flow envisioned here would consist of a searchable catalog of data and products together with an efficient delivery system. Such a database must be accessible by multiple users such as media, legislators, public, or anyone looking for information. The opportunity is especially strong now with some on-line networks and Internet access tools.

## THE PARTNERSHIP PROGRAM AND U.S. OCEANS POLICY

The value of partnerships is defined in terms of the guiding principles outlined above. Additionally, the partnerships proposed by the National Oceanographic Partnership Program (NOPP) serve as particularly efficient mechanisms for overcoming hurdles, some of which are unique to the oceanographic community. Some of these singular hurdles are:

**Funding mechanisms.** Ocean science is primarily supported through grants and contracts from government agencies. The lack of a long term foundation of support (e.g., "hard money" for faculty positions at research universities) dictates that mechanisms (including leveraging the infrastructure investments in oceanographic research and development in the military and industrial sectors) are needed to maintain the long term continuity of the community. U.S. federal funding for basic research in ocean sciences effectively has been halved (by virtue of remaining flat) for nearly two decades, while the total federal support of basic research has nearly doubled. Given the broadening mission for the ocean sciences community, this situation is increasingly out of balance. The dollars are shrinking while the research requirements grow.

**Multiple Committee Jurisdiction in Congress.** Primary funding for the conduct of basic research in the ocean sciences emanates from the Congress of the United States. Nine federal agencies seek funding from Congress for ocean science and technology associated with their missions. But, to address funding needs of each of these nine agencies, over 40 committees and subcommittees of the House and Senate are involved in carrying out their relevant authorization and appropriation responsibilities. As a result, unless there is some clear integrating or cross-cutting process for Capitol Hill to deal with the broad national policy and programmatic issues surrounding ocean science and technology, any partnership arrangement limited solely to certain stakeholders would lack substance. Better horizontal integration of broad ocean science and technology policy and programs across the many federal agencies, is necessary if this nation is to maintain its lead in this critically important area and do so at minimum cost. This is particularly true during the post Cold War reappraisal of national priorities under more constrained budgets. This hurdle to the efforts in ocean science and technology needs to be addressed by the legislative and executive branches in cooperation.

**Security concerns and classified applications.** The oceans are the operating environment for national defense. In fact, it has been argued that the seas of the world are this country's moats. Any research in oceanography is immediately relevant to the operations of the U.S. Navy and may have implications for national security. As such, there will always be an awareness of the contribution of research and education in oceanography to national security concerns and vice versa.

**Management and ownership of resources.** The oceanographic researcher depends heavily on a major capital investment that has been made by industry and agencies within the federal government in terms of research platforms, equipment, laboratories, and general infrastructure. The management of these resources, and their ownership, is dispersed among public and private entities. Optimal use and upgrade of these facilities requires a delicate coordination of missions, plans, and funding. Furthermore, the human resources within the ocean sciences community are heavily concentrated in a limited set of job sectors. Management of the human resources will require a diversification of the job opportunities and new educational initiatives to help prepare students for more alternatives in employment.

**Communications.** The field of oceanography is represented by well over 50 different technical journals and no less than 15 professional organizations. While an isolationist approach to one's own research field may have sufficed 50 years ago, the inherently interdisciplinary nature of today's oceanographic issues dictates that marine researchers and educators have an extraordinarily broad network for communication.

**Public Awareness.** Some recent dramatic demonstrations of the lack of public scientific literacy have emphasized the need to bring oceanographic research results to the forefront of general visibility. The lack of attention paid to marine issues in the media is most likely attributable to a lack of coordinated publicity by the ocean research and education communities; it is not for lack of exciting showpieces from the science and technology being performed in the ocean.

## CONCLUSIONS

From such prestigious scientific bodies as the National Academy of Sciences and its many associated Boards, from well supported needs statements of the mission oriented federal agencies, and from a variety of highly respected scientific organizations, the question of "what to research" in the areas of ocean science and technology is outlined quite well. The International Year of the Ocean provides opportunities to highlight ways that new and enlightened partnerships can be established to provide the bonding agents needed to pull the currently disparate parts of the nation's oceanographic enterprise together.

## REFERENCES

Consortium for Oceanographic Research & Education, *Oceans 2000, Bridging the Millenia*, 1996, Washington, D.C.

National Academy of Sciences. 1995. *Allocating Federal Funds for Science and Technology.* ISBN 0-309-05347-1. National Academy Press. Washington, D.C.

National Oceanic and Atmospheric Administration. 1995. *NOAA Strategic Plan: A Vision for 2005*. Washington, D.C.

National Research Council Committee on Biological Diversity in Marine Systems, 1995. *Understanding Marine Biodiversity.* ISBN 0-309-05225-4. National Academy Press. Washington, D.C.

National Research Council Ocean Studies Board. 1992. *Oceanography in the Next Decade: Building New Partnerships*. ISBN 0-309-04794-3. National Academy Press. Washington, D.C.

National Science Foundation. 1991. *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*. NSF 91-317. Washington, D.C.
"State-Federal Technology Partnership Task Force Final Report." 1995. Gov. Richard Celeste and Gov. Dick Thornburgh, Co-chairs, Carnegie Commission on Science, Technology and Government.

National Research Council, Committee on Science Education Standards and Assessment, 1996, *National Science Education Standards*, ISBN 0-309-05326-9. National Academy Press, Washington, D.C.

## LIST OF ACRONYMS

| | |
|---|---|
| AUV | autonomous underwater vehicles |
| CORE | Consortium for Oceanographic Research and Education |
| MEDEA | Measurement of Earth Data for Environmental Analysis |
| NAS | National Academy of Sciences |
| NMEA | National Marine Educators Association |
| NOAA | National Oceanic and Atmospheric Administration |
| NORLC | National Oceanographic Research Leadership Council |
| NRC | National Research Council |
| NSF | National Science Foundation |
| ONR | Office of Naval Research |
| ROV | Remotely Operated Vehicle |
| TOGA | Tropical Ocean–Global Atmosphere |

# 1998 Year of the Ocean

## A SURVEY OF INTERNATIONAL AGREEMENTS

### Contents

## INTRODUCTION

The legal regime governing the use of the ocean is based on a network of important international agreements. The following is a compendium of some of those agreements and programs relating to the ocean with a brief description of each. The list is selective and is designed to illustrate the major ocean agreements relating to the environment, fisheries, transportation, and the polar regions. The United States is either a party to each agreement or in the process of ratification. The list is indicative, but not comprehensive.

## THE LAW OF THE SEA

### United Nations Convention on the Law of the Sea, 1982
### Senate Treaty Doc. 103-39, Oct. 6, 1994

The United Nations (UN) Convention on the Law of the Sea, with Annexes done at Montego Bay, December 10, 1982 (the Convention) and the Agreement Relating to the Implementation of Part XI of the 1982 United Nations Convention on the Law of the Sea, adopted and opened for signature at the United Nations in New York, July 28, 1994 (the Agreement) provide a comprehensive framework that sets forth the rights and obligations of States with respect to the uses of the ocean. Its provisions would guarantee United States' control of economic activities off its coasts, such as fishing and oil and gas development, and enhance the United States' ability to protect the marine environment. At the same time, it preserves and reinforces the freedoms of navigation and overflight essential to national strategic and commercial interests.

The Convention authorizes a territorial sea of up to 12 nautical miles and Coastal State sovereign rights over fisheries and other natural resources in an Exclusive Economic Zone that may extend to 200 nautical miles from the baseline. The Convention further accords Coastal States sovereign rights over the nonliving resources, including oil and gas, found in the seabed and subsoil of the continental shelf, which is defined to extend to 200 nautical miles from the baseline or, where the continental margin extends beyond that limit, to the outer edge of the geological continental margin. The Convention preserves the rights of navigation and overflight in areas under Coastal State jurisdiction and on the high seas beyond.

The 1994 Agreement fundamentally changed the provisions of Part XI of the Convention that establish a system for regulating the mining of mineral resources from the deep seabed beyond national jurisdiction. Part XI was renegotiated to remove the obstacles to the acceptance of the Convention that had prevented the United States and other industrialized countries from becoming parties. The United States signed the Agreement and has submitted the Law of the Sea Convention and the Agreement together as a package to the Senate for advice and consent. The entry into force of a widely accepted and comprehensive law of the sea convention has been a consistent objective of the United States since negotiations began on such a convention over two decades ago. The Convention entered into force in 1994 and over 120 States are parties including the United Kingdom, Germany, Italy, Japan, South Korea, Australia Russia, China, and France. The United States is not yet a party; the Convention was submitted for Senate advice and consent to ratification in 1994.

## THE MARINE ENVIRONMENT

### Conference on Environment and Development: Agenda 21 Chapter 17 (Oceans)

Chapter 17 on oceans in Agenda 21 sets forth an ambitious work program for the international community in pursuing the objective of sustainable development with respect to the ocean. To this end, it promotes new approaches to managing human uses of ocean resources, including the application of environmental impact assessment procedures and natural resource accounting techniques; economic incentives to encourage industrial and agricultural practices that avoid degradation of the marine environment; and protection of the ecosystems and habitats of marine species. Particular emphasis is given to coastal areas—the land/sea interface—which are critical to the life cycles of most marine species and in which human population is increasingly concentrated.

The specific program areas of Agenda 21 Chapter 17 (Oceans) may be summarized as follows:

(a) Integrated management of coastal areas, including representation of all affected interests in decision making, to ensure that human uses of these areas are compatible, sustainable, and environmentally sound;

(b) Development and implementation of strategies, particularly at the local and national level, to prevent degradation of the marine environment from land-based activities, including recognition of this effort as a central component of coastal area management;

(c) Strengthening and improving implementation of international measures to prevent marine pollution from vessels and from dumping at sea;

(d) Improved management of coastal fisheries, including use of selective gear and practices, to ensure healthy populations and to meet human nutritional needs;

(e) Implementation of obligations for international cooperation to conserve marine living resources found on the high seas (e.g., straddling stocks and highly migratory species);

(f) Protection and restoration of endangered marine species, as well as preservation of marine biological diversity, including protection of rare or fragile ecosystems and habitats critical for marine species;

(g) Coordinated programs of scientific research and systematic observations, as well as data exchange, to improve understanding and management of the marine environment, including implementation of a Global Ocean Observing System;

(h) Regular review and coordination of activities within the United Nations system relating to the protection and sustainable development of the marine environment and revitalization of the United Nations Environment Programme (UNEP) Regional Seas Program; and

(i) Elaboration of programs to address the particular problems of small island developing States, whose economies and very existence is integrally tied to the marine environment.

**Convention for the International Council for the Exploration of the Sea (ICES)**

The environment of the North Atlantic and adjacent seas has been the prime concern of ICES since its inception in 1902. As the oldest intergovernmental marine science organization in the world, its main focus has continued to be on international cooperative scientific studies. Article 1 of the 1964 ICES Convention formally identifies the Council's principal functions:

a. to promote and encourage research and investigations for the study of the sea particularly related to the living resources thereof;

b. to draw up programs required for this purpose and to organize, in agreement with the contracting parties, such research and investigations as may appear necessary;

c. to publish and otherwise disseminate the results of research and investigations carried out under its auspices.

Since the 1970s, a major responsibility for ICES has involved the provision of scientific information and advice for fisheries conservation and protection of the marine environment to intergovernmental regulatory commissions, the European Commission, and the governments of ICES member countries.

ICES works in the broad areas of fisheries, oceanography, and environmental sciences, including the study of marine pollution, and maintains extensive databases on the North Atlantic, in cooperation with other international organizations. The work is organized and carried out by scientists from the 19 contracting parties: Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, the United Kingdom and the United States. Scientific Observer status has been granted to Australia, South Africa and Greece. Lithuania applied in 1997 for membership.

More than 40 international organizations have Observer status and cooperative relations with ICES. Of the United Nations agencies, ICES works with the Fisheries Department of the Food and Agriculture Organization (FAO), the Intergovernmental Oceanographic Commission, the International Maritime Organization, the World Meteorological Organization, and the UNEP.

### Intergovernmental Oceanographic Commission, 1960

The Intergovernmental Oceanographic Commission (IOC) promotes marine scientific investigations to learn more about the nature and resources of the oceans and provides related ocean services and training. The IOC plans, coordinates, and supports global and regional programs, in cooperation with IOC member states and other international organizations. The IOC is designated in the UN Convention on the Law of the Sea as the competent international organization for marine scientific research. It also has specific responsibilities under the Framework Convention on Climate Change, the Convention on Biodiversity, Agenda 21 of the UN Conference on Environment and Development, and the International Decade for Natural Disaster Reduction.

Through memoranda of understanding, the IOC cooperates with ICES in the North Atlantic, and with the North Pacific Marine Science Organization (PICES) in the North Pacific region. UN agencies that work closely with the IOC on programs of mutual interest include the World Meteorological Organization, the UNEP, the International Maritime Organization, the FAO, and the International Atomic Energy Agency. Scientific advice is provided to the IOC by the Scientific Committee on Oceanic Research of the International Council of Scientific Unions. Major programs include study of global ocean circulation, ocean mapping, and global ecosystem dynamics. Under each of these program areas and in cooperation with national and international agencies, the IOC sponsors and organizes meetings and workshops to define scientific problems and service requirements, and to develop appropriate international programs. The programs are executed by the participating IOC member states.

### The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London, 1972

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, known as the London Convention of 1972, is the primary international agreement controlling the deliberate dumping of non-ship generated wastes at sea. Since entering into force in 1975, the London Convention has provided a structure by which its now 77 contracting parties have made consistent progress in combating marine pollution caused by dumping at sea. The London Convention has become more restrictive over the years. In 1993, bans on the ocean disposal of low-level radioactive wastes and industrial wastes were adopted.

In 1996, a Protocol to the London Convention was adopted, at a special meeting of the contracting parties, and signed by the United States, subject to ratification. The Protocol is a free-standing agreement to which both contracting and non-contracting parties to the London Convention may become party. The Protocol embodies a major structural revision of the Convention—the so-called "reverse list" approach. Parties are obligated to prohibit the dumping of any waste or other matter that is not listed in Annex 1 ("the reverse list") of the Protocol. Dumping of wastes or other matter on the reverse list requires a permit. Parties to the Protocol are further obliged to adopt measures to ensure that the issuance of permits and permit conditions for the dumping of reverse list substances comply with Annex 2 (the Waste Assessment Annex) of the Protocol. There are seven categories of substances on the reverse list. These include dredged material; sewage sludge; industrial fish processing or other fish waste; vessels and offshore platforms or other man-made structures at sea; inert, inorganic geological material; organic material of natural origin; and bulky items including iron, steel, concrete and similarly unharmful materials for which the concern is physical impact and is limited to those circumstances where such wastes are generated at locations with no practicable access to options other than dumping.

**Framework Convention on Climate Change, 1994**

Over 160 countries are now Parties to the United Nations Framework on Climate Change (the Convention) which was ratified by the United States in 1992. This Convention entered into force on March 21, 1994 and the Parties held their first meeting in April 1995 in Berlin. There, they launched a negotiating process designed to produce a new legal instrument to deal with the threat of climate change in the post 2000 period. In this regard, the Third Session of the Conference of the Parties [to the Convention] reached agreement December 11, 1997 on a protocol committing developed countries to reduce greenhouse gas emissions.

**Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention), 1983**

The Cartagena Convention, which entered into force in 1984, is a framework convention negotiated under the auspices of the United Nations Environment Programme, Regional Seas Program. It is aimed at the protection of the marine environment and the promotion of environmentally sound development in the wider Caribbean region, including the Gulf of Mexico. The Cartagena Convention is similar in form to nine other regional agreements negotiated under the auspices of the Regional Seas Program, including one for the South Pacific, to which the United States is a party.

The Cartagena Convention contains general obligations on parties to protect the marine environment of the region from a variety of pollution sources, including oil pollution from ships, dumping, and pollution from land-based activities. It is intended to be supplemented by protocols containing more specific obligations in these areas. A Protocol on Combating Oil Spills was negotiated and entered into force with the Cartagena Convention. A Protocol on Specially Protected Areas and Wildlife was negotiated in 1990 but has not entered into force. This Protocol has been transmitted to the U.S. Senate for advice and consent to ratification A protocol on pollution from land-based activities, which accounts for about 80 percent of the pollution entering the marine environment, is currently under negotiation.

**Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention)**

The Basel Convention is an international agreement which attempts to control the movement of hazardous waste across State boundaries. This Convention, which went into effect in 1992:

- requires environmentally sound management of transboundary movements and disposal of waste
- provides a list of covered wastes (including hazardous and other wastes)
- prohibits exports of covered wastes to the Antarctic Treaty Area
- generally requires notice to and consent, in certain circumstances, of transit and receiving countries before exports of covered wastes commence
- commits parties to prohibit a transboundary movement if there is reason to believe that the waste would not be managed in an environmentally sound manner in the importing country
- commits parties to assume responsibility for disposal of waste illegally exported and imported

One hundred twenty-two countries have ratified the Basel Convention. Although the U.S. Senate has given its advice and consent, the United States is not a party at this time.

**Global Program of Action for the Protection of the Marine Environment From Land-Based Activities, 1995**

The Global Program of Action was adopted November 3, 1995 at the conclusion of a two-week conference sponsored by the UNEP and hosted by the United States. The Global Program of Action seeks to prevent the degradation of the marine environment from land-based activities by helping States Parties realize the duty to preserve and protect the marine environment. It is designed to assist States in taking actions individually or jointly according to their respective policies, priorities, and resources. It constitutes a practical source of guidance for action which must take place at the national and regional level; identifies steps for making available knowledge and experience about effective measures to combat land-based sources of marine pollution; and offers instruction on how to involve the relevant United Nations institutions in the implementation effort.

### Convention for a North Pacific Marine Science Organization (PICES), 1992; U.S. Senate Treaty Document 102-9, 102nd Congress, 1st Session

PICES was established to promote and coordinate marine scientific research in the northern North Pacific and adjacent seas, particularly northward of 30 degrees north latitude. The organization's purpose is to advance scientific knowledge about the ocean environment, global climate change, living resources and their ecosystems, and the impacts of human activities, and to promote the collection and rapid exchange of scientific information on these issues. The six contracting parties are Canada, the People's Republic of China, Japan, the Republic of Korea, Russia, and the United States. Each party pays an equal contribution.

### South Pacific Regional Environment Program, 1995

The South Pacific Regional Environment Program (SPREP) is designed to promote cooperation in the South Pacific region, provide assistance to protect and improve the environment, and to ensure sustainable development. SPREP is comprised of twenty-two Pacific island countries and four developed countries with direct interests in the region. The SPREP Agreement came into force on August 31, 1995. The United States has signed the Agreement, which is before the Senate for its advice and consent for ratification.

### Convention on the International Hydrographic Organization

The International Hydrographic Organization is a technical organization established to coordinate and promote the adoption of reliable and efficient scientific practice in hydrography and navigation. It has the following objectives:

a. bring about close and permanent association between national hydrographic offices;

b. ensure the greatest possible uniformity in nautical charts and documents;

c. further the exchange of nautical charts and documents;

d. provide guidance and advice on request;

e. assist countries engaged in setting up or expanding their hydrographic service;

f. encourage coordination of hydrographic surveys with relevant oceanographic cruises or other activities;

g. facilitate the application of oceanographic knowledge for the benefit of navigators;

h. cooperate with other international organizations and scientific institutions with similar objectives.

The International Hydrographic Organization is organized in two parts. The Conference, composed of representatives of all member states, meets every five years. In the intersessional period, the scientific and technical business of the organization is conducted by the Bureau, composed of an elected Directing Committee and the Secretariat staff. Dues for the member states are assessed according to the tonnage of their fleets.

## LIVING MARINE RESOURCES

### International Convention for the Regulation of Whaling, 1948

The International Convention for the Regulation of Whaling, drafted in 1946 after a conference hosted by the United States, was subsequently ratified and entered into force in 1948. This Convention was the culmination of a series of agreements begun in the 1920s, the purpose of which was to establish a system of international regulation for whaling in order to ensure the conservation and development of whale stocks, and to make possible the orderly development of the whaling industry. The Convention created the International Whaling Commission, the organization that is internationally recognized as having authority over the conservation and management of whale stocks worldwide. In 1982, the International Whaling Commission adopted a commercial whaling moratorium, which took effect in 1986 and remains in place.

### Convention Between the United States of America and the Republic of Costa Rica for the Establishment of an Inter-American Tropical Tuna Commission, 1949; Tuna Conventions Act of 1950 (64 Stat. 777), as amended (16 U.S.C. 951-961)

The Agreement established the Inter-American Tropical Tuna Commission, to "(1) study the biology of the tunas and related species of the eastern Pacific Ocean with a view to determining the effects that fishing and natural factors have on their abundance and (2) to recommend appropriate conservation measures so that the stocks of fish can be maintained at levels which will afford maximum sustainable catches." The nations who are party to this agreement are: Costa Rica, Ecuador, France, Japan, Nicaragua, Panama, the United States, Vanuatu, and Venezuela.

The Commission's duties were broadened in 1976 to include work on the problems arising from the tuna-dolphin relationship in the eastern Pacific Ocean. The International Dolphin Conservation Program, which was developed by the Inter-American Tropical Tuna Commission, has drastically reduced the dolphin mortality in purse seine tuna fisheries, where the dolphin bycatch rate had been traditionally high. In 1992, ten nations with tuna vessels operating in the eastern Pacific Ocean entered into the La Jolla Agreement, which committed them to reduce dolphin mortality to insignificant levels, with a goal of eliminating it entirely through the application of ecologically sound fishing methods. This Agreement established an annually decreasing limit on the total allowable dolphin mortality in the fishery to a level of less than 5,000 in 1999. The International Dolphin Conservation Program has already achieved that mark, well ahead of schedule.

### Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea, 1953; Northern Pacific Halibut Act of 1982 (as amended: 50 Stat. 325; 67 Stat. 494; 79 Stat. 902; 97 Stat. 78).

The bilateral International Pacific Halibut Commission was created to conserve, manage, and rebuild the halibut stocks of the west coast of Canada and the United States to levels which would achieve and maintain the maximum sustainable yield from the fishery. The Commission is responsible for data collection and stock assessment, and addresses the issue of bycatch of halibut by the groundfish fisheries in the region. The halibut resource has been managed by this Commission since 1923.

### Convention on Great Lakes Fisheries between the United States and Canada, 1954; Great Lakes Fisheries Act of 1956 (16 U.S.C. 932)

The bilateral Great Lakes Fishery Commission was established to control and eradicate sea lamprey, which decimated important commercial and recreational fisheries in the Great Lakes. The lamprey entered the lakes through canals built in the nineteenth century to provide access to the lakes by ocean-going vessels. This Commission is also responsible for undertaking research programs to determine the maximum productivity of any stock of fish that is of interest to the parties, and making recommendations on appropriate measures for the conservation and management of those stocks.

### International Convention for the Conservation of Atlantic Tunas, 1966; Atlantic Tunas Convention Act of 1975 (16 U.S.C. 971)

The International Commission for the Conservation of Atlantic Tunas was established to provide an effective program of international cooperation in research and conservation in recognition of the unique problems of tunas and tuna-like species. The Convention area is defined as all waters of the Atlantic Ocean, including the adjacent seas. The Commission is responsible for providing internationally coordinated research on the condition of the Atlantic tunas, tuna-like species, and their environment, as well as for the developing harvest proposals for consideration by the convention parties. The objective of such regulatory proposals is to conserve and manage species of tuna throughout their range to achieve maximum sustainable catch. Parties include Angola, Benin, Brazil, Canada, Cape Verde, Cote d'Ivoire, Cuba, Equatorial Guinea, the European Union, France, Gabon, Ghana, Japan, the Republic of Korea, Morocco, Sao Tome and Principe, the Republic of South Africa, Spain, the Russian Federation, the United Kingdom, Uruguay, the United States, and Venezuela.

### Convention on Wetlands of International Importance Especially As Waterfowl Habitat, Ramsar, 1971

The Convention on Wetlands of International Importance, known as the Ramsar Convention from its place of adoption in 1971 in Ramsar, Iran, is the only international accord dedicated to the protection and conservation of wetlands. Over 100 contracting parties, including the United States, have committed themselves to the wise use of wetlands at over 700 sites that are specifically recognized as important under the Convention. Wetlands support many important plants and animals, migratory waterfowl, and provide water purification and flood control services. Wetlands also play an important role in protecting shorelines and coastal waters from pollutants. Under the Ramsar Convention, the definition of wetlands extends to a wide variety of habitats, including rivers, lakes, coastal lagoons, mangroves, peatlands, and coral reefs.

### Convention on International Trade In Endangered Species of Wild Fauna and Flora, Washington, 1973

The Convention on the International Trade in Endangered Species of Wild Fauna and Flora, which was signed in 1973, restricts international trade in the large number of endangered and threatened species. These species include all whales, dolphins and porpoises, sea turtles, some seals (including walrus), marine otters, polar bears, and some fish species. The United States is a party to this Convention.

### Follow-Up on Actions Taken at the 22nd Session of the FAO Committee on Fisheries, Rome, March 17-20, 1997

The United Nations Food and Agriculture Organization was founded in October 1945 with a mandate to raise levels of nutrition and standards of living, to improve agricultural productivity, and to better the condition of rural populations. Since its inception, FAO has worked to alleviate poverty and hunger by promoting agricultural development, improved nutrition, and the pursuit of food security—the access of all people at all times to the food they need for an active and healthy life. FAO is active in land and water development, plant and animal production, forestry, fisheries, economic and social policy, investment, nutrition, food standards, and commodities and trade. It also plays a major role in dealing with food and agricultural emergencies. As a long-term strategy for the conservation and management of natural resources, a specific priority of the FAO is encouraging sustainable agriculture and rural development. It aims to meet the needs of both present and future generations through programs that do not degrade the environment and are technically appropriate, economically viable, and socially acceptable.

The FAO Committee on Fisheries (COFI) will address fishing capacity issues, shark conservation and management, and seabird bycatch avoidance at three technical consultations early in 1998. Policy-makers from COFI member countries will meet in October 1998 to recommend plans of action in each of the three areas. The plans of action are to be adopted at the March 1999 COFI meeting.

**Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries, 1979; Northwest Atlantic Fisheries Convention Act of 1995 (Title II of P.L.104-43)**

The mission of the Northwest Atlantic Fisheries Organization is twofold:

(1) to provide for continued multilateral consultation and cooperation with respect to the study, appraisal, and exchange of scientific information and views relating to the fisheries of the Convention Area (which is off the Atlantic coasts of Canada and the United States, from the Virginia Capes to the southern tip of Greenland), and

(2) to conserve and manage fishery resources of the Regulatory Area, i.e., that part of the Convention Area that lies beyond the areas over which coastal states exercise fisheries jurisdiction.

The Convention applies to all fishery resources except salmon, tunas, swordfish, marlins, cetacean stocks managed by the International Whaling Commission, and sedentary species of the continental shelf. Parties include Bulgaria, Canada, Cuba, Denmark, Estonia, the European Union, Iceland, Japan, Latvia, Lithuania, Norway, Poland, Republic of Korea, Romania, the Russian Federation and the United States.

**Convention for the Conservation of Salmon in the North Atlantic Ocean, 1982; Atlantic Salmon Convention Act of 1982 (16 U.S.C. 3601)**

This Convention applies to the salmon stocks which migrate beyond areas of fisheries jurisdiction of coastal states of the Atlantic Ocean north of 36°N latitude throughout their migratory range. The purpose of the North Atlantic Salmon Conservation Organization is: (1) to promote the acquisition, analysis, and dissemination of scientific information pertaining to salmon stocks in the North Atlantic Ocean, and (2) to promote the conservation, restoration, enhancement, and rational management of salmon stocks in the North Atlantic Ocean through international cooperation. Members include Canada, Denmark, the European Union, Finland, Iceland, Norway, Sweden, the United States, and the Russian Federation.

**Agreement Between the Government of the United States of America and the Government of Canada Concerning Pacific Salmon, 1985; Pacific Salmon Treaty Act of 1985 (16 U.S.C. 3631)**

The mission of the Pacific Salmon Commission is to serve as a forum for cooperation between the United States and Canada in the establishment of general fishery management regimes for the international conservation and harvest sharing of intermingling North Pacific salmon stocks.

**Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America, 1988; South Pacific Tuna Act of 1988 (16 U.S.C 973-973r)**

This Treaty provides U.S. fishermen with the opportunity to fish within the exclusive economic zones of some countries in the South Pacific region under agreed terms and conditions. It prohibits U.S. fisheries of any kind (not only tuna) except in accordance with the agreement. Only purse seine fishing for tunas is allowed. A separate economic assistance agreement between the United States and the South Pacific Forum Fisheries Agency (FFA) is associated with the treaty. It calls upon the United States to pay 14 million dollars annually to the South Pacific nations through the FFA. The treaty requires the U.S. tuna industry to pay $4 million annually, in a lump sum, to the Pacific Island nations through the FFA. Nations party to the agreement include Australia, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu, Western Samoa, and the United States. The treaty and the economic assistance agreement entered into force on June 15, 1988. The treaty has no expiration date. The economic assistance agreement was initially agreed to extend for a five-year period. In 1988, the treaty was amended and the economic assistance agreement renegotiated and extended for an additional ten years.

**Convention on Biological Diversity, Rio De Janeiro, 1992**

The Convention on Biological Diversity is the main international forum for addressing biodiversity. Its three objectives are conservation of biological diversity, sustainable use of its components, and a fair and equitable sharing of the benefits of genetic resources. This Convention came into force in late 1993 and its Secretariat is located in Montreal. While the United States signed the Convention in June 1993, it is not a party at this time. The Senate Foreign Relations Committee favorably reported it to the full Senate in June 1994, but concerns related to domestic land use issues have stalled action on ratification.

The next Convention on Biological Diversity Conference of the Parties will be in Bratislava in May 1998. In November 1995, this body adopted the "Jakarta Mandate" on Marine and Coastal Biodiversity. Work has proceeded slowly on five issues: integrated marine and coastal area management, marine and coastal protected areas, sustainable use of coastal and marine living resources, mariculture, and alien species.

**Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean, 1992; North Pacific Anadromous Stocks Act of 1992 (Title VIII of P.L. 102-567)**

The North Pacific Anadromous Fish Commission serves as a forum for promoting the conservation of anadromous stocks and ecologically related species, including marine mammals, sea birds, and non-anadromous fish, in the high seas area of the North Pacific Ocean. In addition, this Commission serves as the venue for coordinating the collection, exchange, and analysis of scientific data regarding the above species within Convention waters. It also coordinates high seas fishery enforcement activities by member countries (the Convention prohibits directed fishing for salmonids and includes provisions to minimize the incidental take of salmonids in other fisheries in the Convention area). Members include Canada, Japan, the Russian Federation, and the United States.

### Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea ("Donut Hole Agreement"), 1994

This Convention establishes long-term measures for the conservation, management, and optimum utilization of the Aleutian Basin Pollock stock in the Central Bering Sea. The stock experienced a drastic decline prior to the negotiation of this agreement, and remains at a low level of abundance. There is currently a voluntary moratorium on fishing for pollock in the "Donut Hole," although fishing may resume under the Convention when stocks reach a sustainable abundance level. The Convention requires that vessels fishing for pollock in the "Donut Hole" use real-time satellite position-fixing transmitters and carry observers on board. It also requires that any vessels fishing in the area consent to boarding and inspection for compliance with the Convention by enforcement officials of the member states. The agreement will aid in ensuring the long-term health of pollock stocks in the Central Bering Sea on which the U.S. pollock industry in the Pacific Northwest in part depends. Parties include the People's Republic of China, Japan, the Republic of Korea, Poland, the Russian Federation, and the United States.

### Interim Agreement on Yukon River Salmon, 1995; Yukon River Salmon Act of 1995 (16 U.S.C. 1821)

The Yukon River Panel created by this agreement will make conservation and management recommendations to the management entities designated by each country, independent of the Pacific Salmon Commission. The Panel will also undertake research, management, and restoration activities within the Yukon River basin. The Yukon River is a major transboundary river, rising in Canada and flowing to the Bering Sea through Alaska. The Agreement institutionalizes cooperative conservation and management and contains a provision, unique in international fishery agreements, committing both the United States and Canada to protect salmon habitat in the Yukon River region. The Agreement is in place while negotiations continue on other difficult long-term issues and is currently being extended.

## LIVING MARINE RESOURCES—NEW AGREEMENTS NOT YET IN FORCE

### Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (Compliance Agreement)

The Compliance Agreement builds upon the legal framework established by the 1982 United Nations Convention on the Law of the Sea. The fishery provisions of that Convention contain basic obligations for States whose vessels fish on the high seas to cooperate in the conservation and management of living marine resources. Under the Convention, flag States must also ensure that there is a genuine link between themselves and the vessels that fly their flag.

The Compliance Agreement builds upon those obligations in order to address a growing threat to the integrity of multilateral fishery organizations and international fisheries conservation and management measures: Fishing vessels flying the flag of some States members of such organizations have in the past increasingly reflagged to nonmember states as a means to avoid fishing restrictions that would otherwise apply.

Reflagging is only part of a larger problem. A growing number of newly built high seas fishing vessels are registered directly, without reflagging, in states that are not members of the major multilateral fisheries organizations, precisely because these states are not bound by the restrictions adopted by those organizations. The Compliance Agreement is designed to address these situations and, more broadly, to bring all high seas fisheries under greater control. The Agreement has two primary objectives:

(1) to impose upon all states whose fishing vessels operate on the high seas an array of obligations designed to make the activities of those vessels consistent with conservation and management needs; and

(2) to increase the transparency of all high seas fishing operations through the collection and dissemination of data.

These provisions establish a sound basis for conducting high seas fishing while providing for the effective conservation and management of living marine resources.

The Compliance Agreement forms an integral part of the FAO Code of Conduct for Responsible Fishing which was adopted by the FAO Conference in November 1995, and the Conference passed a resolution which urged members and nonmembers of the FAO to accept the agreement and to bring it into force as soon as possible. The agreement will come into force upon its acceptance by 25 countries.

On November 3, 1995, President Clinton signed the Fisheries Act of 1995, which contains the implementing legislation necessary to allow the United States to accept the Compliance Agreement. The United States deposited its instrument of acceptance for the Agreement with the FAO on December 19, 1995. Thus far the European Union and nine countries have deposited instruments of acceptance with the FAO.

### Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995

The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and

Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (the Fish Stocks Agreement) was adopted on August 4, 1995.

The Agreement aims to reverse the global trend of declining fish stocks. It preserves current conservation and management concepts expressed in the United Nations Convention on the Law of the Sea. It also gives form and substance to this Convention's mandate for States to cooperate in conserving and managing straddling and highly migratory fish stocks. The Agreement complements the 1993 Agreement to Promote Compliance With International Conservation and Management Measures by Fishing Vessels on the High Seas, which itself is an integral component of the FAO Code of Conduct for Responsible Fisheries, and which was adopted in November 1995.

The Agreement lays out general principles to be followed by States to conserve and manage the stocks in question. It prescribes a precautionary approach to fishery management and advocates compatibility in the measures adopted for stocks within areas of coastal State jurisdiction and on the high seas. The Agreement specifies mechanisms for cooperation between coastal States and distant water fishing States, particularly the use of regional or subregional organizations or arrangements. It also requires strict fisheries enforcement and the collection and exchange of data on fishing operations, and requires parties to settle disputes using the procedures established in the 1982 United Nations Convention on the Law of the Sea.

Nations that have ratified (the Agreement will enter into force when 30 nations ratify) include: Bahamas, Fiji, Iceland, Mauritius, Micronesia, Nauru, Norway, Russia, St. Lucia, Samoa, Senegal, Solomon Islands, Sri Lanka, Tonga, and the United States.

**International Dolphin Conservation Program (currently being negotiated)**

This agreement, intended to formalize and strengthen the existing International Dolphin Conservation Program's provisions mandating dolphin conservation measures in the yellowfin tuna fishery in the eastern tropical Pacific Ocean, is currently under development. The most recent negotiating session, held the first week of February, 1998, resulted in the conclusion of an agreed conservation program. Nations involved include Colombia, Costa Rica, Ecuador, France, Japan, Mexico, Nicaragua, Panama, the United States, Vanuatu, and Venezuela.

**Multilateral Agreement on the Conservation and Management of Highly Migratory Species in the Western Pacific Ocean (currently being negotiated)**

This agreement, intended to establish a management regime for highly migratory species in the Western Pacific, is currently under negotiation. The next working group sessions are scheduled for March 1998; a plenary session is scheduled in June 1998.

Nations involved in negotiations include: Australia, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New

Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu, Western Samoa, Japan, Taiwan, China, Korea, the Philippines, and the United States.

## MARINE TRANSPORTATION

### Convention on the Intergovernmental Maritime Consultative Organization, 1948

The Convention establishing the Intergovernmental Maritime Consultative Organization, a specialized agency of the United Nations, entered into force in 1958. The name of the organization was changed to the International Maritime Organization (IMO) in 1982. The purpose of the IMO is to provide machinery for cooperation among governments in governmental regulation, policy, and practice relating to technical matters of all kinds that affect shipping engaged in international trade. It aims to encourage and facilitate the adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation, and prevention and control of marine pollution from ships. The IMO has 155 member states and two associate members. Many non-governmental organizations and observers also participate in IMO meetings. Since its inception, 30 Conventions and Protocols and over 700 codes and recommendations concerning maritime safety, prevention of marine pollution, and related matters have been adopted under the auspices of the IMO, some of which are discussed below. The IMO also focuses on the effective enforcement and implementation of these conventions, codes, and other instruments.

### International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969; International Convention Establishing a Fund for Compensation of Oil Pollution Damage (Fund Convention), 1971

The CLC and Fund Convention were negotiated in 1969 and 1971 respectively, to establish an international regime of liability and compensation for pollution damage from oil tanker spills. The CLC established a regime of strict liability on tanker owners to pay for damage up to $20 million. Above this amount, the international fund created by the Fund Convention provides additional compensation up to a total per incident of about $86 million. The United States never ratified these conventions, due in large part to the limits which were considered insufficient to cover damages and cleanup costs from major oil spills. In 1984, Protocols were negotiated to both conventions which increased ship owner liability to a maximum of nearly $86 million, and increased the total per incident compensation to about $194 million (the total compensation would rise to about $260 million if the United States were a party). After further technical amendments, these Protocols were adopted in 1992 and entered into force internationally in 1996. The United States is not a party to either Protocol and has adopted a unilateral domestic liability and compensation regime.

### International Convention for the Prevention of Pollution From Ships, as amended (MARPOL Convention), 1973/1978

The MARPOL Convention, which entered in force in 1983, is the primary international agreement aimed at preventing or reducing intentional and accidental discharges from ships into the marine environment. The MARPOL Convention and mandatory Annexes I and II deal with discharges of oil and noxious liquid substances in bulk, respectively. Optional Annexes III, IV and V deal with packaged harmful substances, sewage, and garbage, respectively. MARPOL and Annexes I, II, III, and V are in force both internationally and for the United States. Annex VI, dealing with air pollution from ships, was negotiated in 1997 but is not yet in force. Another Annex, currently under negotiation, will be aimed at preventing the introduction of aquatic nuisance species, such as the zebra mussel, through ships ballast water.

The MARPOL Convention greatly reduces the amount of oil and ship generated waste which can be discharged into the sea by ships and bans such discharges completely in certain special areas. For example, the Caribbean and Gulf of Mexico have been designated as special areas where the dumping of ship generated waste, including plastic, is prohibited. This designation will become effective as soon as adequate reception facilities for such waste are available in the region.

### International Convention on Oil Pollution Preparedness, Response, and Cooperation (OPRC Convention), 1990

The OPRC Convention, which entered into force in 1995, was negotiated to provide an international framework for cooperation in combating and responding to major oil pollution incidents, and to enhance existing national, regional, and global capabilities concerning oil pollution, preparedness, response, and cooperation. The OPRC Convention encourages all parties to enter into bilateral and regional response agreements to prepare for and respond to oil spills, and establishes a voluntary mechanism for parties to provide technical assistance in the form of equipment and training to other parties that request it. It also requires parties to establish national systems for preparedness and response which would include shipboard oil pollution emergency plans, and reporting requirements for oil pollution incidents. Even before the OPRC Convention entered into force, its provisions on cooperation were effectively utilized on a provisional basis to respond to the massive oil pollution of the Persian Gulf during the 1991 Gulf War.

### International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS Convention), 1996

The HNS Convention establishes an international regime of liability and compensation for damages resulting from maritime accidents involving the carriage of hazardous and noxious substances, similar to the international liability and compensation regime for oil which is described above. Maximum ship owner liability is set at approximately $133 million and the international fund will increase the total per incident compensation to approximately $334 million. At present, only one State is a party to the Convention but several European States and

Canada are well along in the ratification process. The Clinton Administration is in the process of deciding whether to submit the HNS Convention to the Senate for advice and consent. Several difficult issues are under consideration, including preemption of U.S. liability statutes, which were particularly troublesome in the context of the international liability and compensation regime for oil.

### International Convention on supplemental Compensation for Nuclear Damage (Supplemental Convention on Nuclear Damage) 1997

The Supplemental Convention on Nuclear Damage, was negotiated under the auspices of the International Atomic Energy Agency to provide supplemental compensation for civil damages resulting from a nuclear accident, including an accident involving the transport of nuclear materials by sea. It establishes an international fund that would provide compensation of approximately $400 million, over the first $400 million of the liability limits provided by a party's domestic legislation. In order to become a party to the Supplemental Convention a State's liability legislation or international obligations must meet certain minimum criteria, including strict liability, channeling of liability to the operator, and a single forum for jurisdiction among parties. It also creates a mechanism that facilitates States entering into global international agreements on civil nuclear liability that does not currently exist.

## THE ANTARCTIC AND ARCTIC

### The Antarctic Treaty, Washington, 1959

The Antarctic Treaty, which entered into force in 1961, applies to the area south of 60°S including all ice shelves. The Treaty guarantees freedom of scientific research in Antarctica; establishes Antarctica as a zone reserved exclusively for peaceful purposes; bans military activities, including weapons testing; and prohibits nuclear explosions and the disposal of radioactive waste. It also provides the right of onsite inspection of all stations and installations in Antarctica to promote the objectives of the Treaty and to ensure compliance with its provisions. The Treaty freezes the question of previously asserted rights and claims to territorial sovereignty in Antarctica, and provides that no acts or activities carried out while the Treaty is in force will constitute a basis for a claim. The Antarctic Treaty provided for consultative meetings to exchange information, consult on matters of common interest, and recommend measures in furtherance of the principles and objectives of the Treaty.

As a result of these consultative meetings, approximately two hundred recommendations have been agreed to by the consultative parties. The recommendations incorporate measures to give effect to the principles and purposes of the Antarctic Treaty. Recommendations adopted at consultative meetings include initiatives which have led to the conclusion of separate agreements which address resource issues. Two such agreements are in force: the Convention for the Conservation of Antarctic Seals (concluded 1972, entered into force 1978) and the Convention on the Conservation of Antarctic Marine Living Resources (concluded 1980, entered into force 1982).

The consultative parties adopted a Protocol on Environmental Protection in Madrid on October 4, 1991, which entered into force on January 14, 1998. The Protocol designates Antarctica as a natural reserve, devoted to peace and science, and sets forth basic principles and detailed mandatory rules applicable to human activities in Antarctica, including obligations to accord priority to scientific research. The Protocol also establishes a Committee on Environmental Protection as an expert advisory body to provide advice and formulate recommendations for consideration at the consultative meetings.

The Treaty is open to any member of the United Nations. Thirty-one additional countries have joined since it came into force in 1961: Austria, Brazil, Bulgaria, Canada, China, Colombia, Cuba, the Czech Republic, Denmark, Ecuador, Finland, Germany, Greece, Guatemala, Hungary, India, Italy, the Republic of Korea, the Netherlands, Papua New Guinea, Peru, Poland, Romania, the Slovak Republic, Spain, Sweden, and Uruguay. Of these, Brazil, China, Ecuador, Finland, Germany, India, Italy, Republic of Korea, the Netherlands, Peru, Poland, Spain, Sweden, and Uruguay have since become consultative parties entitled to attend and vote at consultative meetings provided for under Article IX of the Antarctic Treaty. Consultative status is open to representatives of any acceding party during such time as that party demonstrates its interest in Antarctica by the conduct of substantial scientific research there. Representatives of all other Antarctic Treaty parties may participate in consultative meetings as observers if they wish to do so. These meetings are held annually to consult on matters of common interest to Antarctica and to recommend to the Consultative party governments measures which will further the objectives of the treaty.

**The Convention for the Conservation of Antarctic Marine Living Resources, 1980**

The Convention for the Conservation of Antarctic Marine Living Resources establishes the legal obligations and mechanism for dealing with fishing activities in the waters around Antarctica. This Convention requires that management action take into account the impact of activities on all living organisms in the Antarctic ecosystem. More specifically, the objectives of the Convention are to ensure that:

(a) exploited populations not be allowed to fall below a level close to that which ensures their greatest net annual increase;

(b) depleted populations be restored to such levels;

(c) ecological relationships between harvested, dependent, and related species be maintained; and

(d) risks of changes to the marine ecosystem that are not potentially reversible over two or three decades be minimized.

The original signatories to the Convention were Argentina, Australia, Belgium, Chile, France, the Federal Republic of Germany, the German Democratic Republic, Japan, New Zealand, Norway, Poland, South Africa, the United Kingdom, the United States, and the U.S.S.R. It entered into force on April 7, 1982.

**Declaration on the Arctic Council, 1996**

The eight Arctic governments[1] met in Ottawa on September 19, 1996, and signed the Declaration on the Arctic Council, which established the Arctic Council as a high-level forum to promote cooperation among the Arctic states on issues of mutual concern that require circumpolar cooperation. The Council incorporates the structure of the Arctic Environmental Protection Strategy, which was created in 1991 to foster cooperation in solving Arctic environmental problems. In establishing the Council, the Arctic governments took particular note of the important role Arctic science and research play in adding to the collective understanding of the circumpolar Arctic. The Arctic Council currently comprises four subsidiary groups: Arctic Monitoring and Assessment Program, Conservation of Arctic Flora and Fauna, Protection of the Arctic Marine Environment, and Emergency Prevention, Preparedness and Response. Two of the most notable results of the Arctic Environmental Protection Strategy and the Arctic Council in the area of protecting northern waters have been the publication of *Arctic Offshore Oil and Gas Guidelines* in English and Russian, as well as ongoing activities within the Protection of the Arctic Marine Environment working group to develop a "Regional Program of Action for the Protection of the Arctic Marine Environment from Land-Based Activities." The Arctic Council is a forum for consultation but does not have an independent organizational structure with a secretariat.

**Agreement on the Conservation of Polar Bears**

In 1973, the United States, Norway, Denmark, Canada, and the former Soviet Union signed the international Agreement on the Conservation of Polar Bears. The United States ratified the Agreement in 1976. Under the terms of the Agreement, it became the responsibility of each nation to develop conservation programs to promote compliance with the Agreement. The Marine Mammal Protection Act of 1972, as amended, served that purpose, vesting authority in the U.S. Fish and Wildlife Service for the management and conservation of polar bears. Both the Agreement and the Marine Mammal Protection Act prohibit the take of polar bears in United States territory except in specified circumstances (by Alaskan Natives for subsistence purposes).

[1] The United States, Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, and Sweden.

## LIST OF ACRONYMS

| | |
|---|---|
| FAO | Food and Agriculture Organization (United Nations) |
| FFA | South Pacific Forum Fisheries Agency |
| ICES | International Council for the Exploration of the Sea |
| IMO | International Maritime Organization |
| UN | United Nations |
| UNEP | United Nations Environment Programme |

# 1998 Year of the Ocean

## MARINE EDUCATION, U.S.A.: AN OVERVIEW

### Contents

## INTRODUCTION

This document provides an overview of marine education in the United States in 1997. For the purposes of this report, marine education refers to the education related to the ocean, coastal waters, and the Great Lakes. Aquatic education is a broader term that includes all inland waters (rivers, lakes, and wetlands). Environmental education is another term broader than marine education. These are not directly covered by this report. Formal marine education is carried out at schools, colleges and universities. Informal marine education occurs in the media, at public aquaria, and by various public and private agencies and organizations.

The Advisory Committee on Protection of the Sea's May 1997 report of the Oceans and Security Conference, includes the "Potomac Declaration: Towards Enhanced Ocean Security into the Third Millennium." :

Recognizing that:

> Continuing intensification of human activity in coastal and marine areas will adversely affect marine and coastal ecosystems world-wide and threatens the well-being of the human population. The natural resource base of world fisheries is threatened by overexploitation, habitat degradation, introduction of alien species and loss of biological diversity. Human security is threatened by unsustainable food production, increased public health hazard and unemployment, which may contribute to escalating human conflicts. Humans themselves have entered into conflict with the very environment that supports them. It is vital to take immediate action to strengthen environmental security if global human security is to be sustained;
>
> Climate change threatens to affect ocean levels and temperature, the land and peoples living in low elevation coastal regions, and species dependent on ocean and land touched by oceans. The oceans play an essential role in the planet's climate, though the mechanisms are poorly understood; and
>
> Sustainable development, including conservation of the marine environment, can actually increase environmental, food and economic security and therefore provide a foundation for political security.

Recommendation 10 from the Oceans and Security Conference states:

> "Concerted national and international efforts should be undertaken to introduce environmental studies into all levels of formal school curricula at a global level, in order to eliminate environmental illiteracy, increase environmental awareness, and promote deeper environmental ethics. Up-to-date scientific knowledge about the oceans should be popularized and disseminated to the public through both formal education and creative communication channels such as arts, music, and multi-media. In support of this effort, the year 2000 should be declared as the "Year of Environmental Awareness" by the UN General Assembly at its forthcoming Special Session."

## HISTORICAL BACKGROUND

It is only fitting that any discussion of marine education in the United States begin with a recognition of the contribution that Benjamin Franklin made as the publisher of the first chart of the Gulf Stream in 1770. In order to speed up the delivery of mail and goods from America to Europe, he urged that ships stay in the Gulf Stream to take advantage of the current. Based on measurements of temperature he took in his Atlantic crossings in 1775, 1776 and 1785, he advocated using regular temperature readings to ensure that the ship remained in the relatively warmer waters of the Gulf Stream. Franklin's cousin, Captain Timothy Folger of Nantucket, Massachusetts, provided essential information about the Gulf Stream and assisted in making the first chart. Folger was an experienced whaling ship captain who was familiar with the North Atlantic Ocean.

In 1838, the first American scientific voyage of discovery was launched. The United States Exploring Expedition, under the leadership of U.S. Navy Lieutenant Charles Wilkes, was a four-year expedition which resulted in a final report of 19 volumes of maps, text, and illustrations, including 241 new maps and charts.

Earlier, on August 13, 1825, Midshipman Matthew Fontaine Maury had been assigned to the USN Frigate, Brandywine, whose first duty assignment was to return General Lafayette to France following the mourning of the simultaneous deaths of Thomas Jefferson and John Adams on July 4, 1825. Maury kept a diary of his observations at sea, and his recordkeeping expanded in 1831 when he became sailing master of the Falmouth. On October 17, 1839, Maury was thrown from a stagecoach in an accident and sustained multiple injuries that precluded his return to sea. Fortuitously, Maury was reassigned as Superintendent of the U.S. Navy Depot of Charts and Instruments, later to become Superintendent of the U.S. Naval Observatory. In these new positions, he assiduously collected information from ships' logs. His first oceanography book, *The Physical Geography of the Sea*, was published in 1854 and was followed by seven revisions. The book was both popular and influential and is an important milestone in the history of marine education in America.

Two other popular books written in the 19th century by Americans also contributed to the public's knowledge about the sea. *Two Years Before the Mast*, by Richard Henry Dana, documented his voyage around Cape Horn from New England to California. It provided the public with a true, first hand account of shipboard life and waves and weather across more than 100 degrees of latitude in two oceans. The other book, Herman Melville's *Moby Dick*, while a novel, described many aspects of the life of a whaler and much information about whales and other sea life. Both books were important early sources of information for the public about the sea.

Science teachers in New England began receiving the first summer training in marine biology in the late 1870s under the leadership of Harvard University's famous naturalist, Alexander Agassiz. In addition to having founded the Museum of Comparative Zoology at Harvard, he was also the founder of the first U.S. marine station, the Anderson School of Natural

History on Penikase Island, Buzzard's Bay, Massachusetts. There, the teachers, who were all women, stayed in a dormitory at Woods Hole, Massachusetts, and studied local marine life while learning new techniques using microscopes and dissection instruments. This represented a new, hands-on approach for pre-college education. Indeed, the study of science was just being introduced in schools at this time.

Scripps Institution of Oceanography was founded in 1903 and became a part of the University of California, Los Angeles in 1912. During the first half of the 20th century, virtually all the U.S. oceanographers were trained at this institute . It remains a cornerstone of leadership and research in the oceanographic community and in higher education. Woods Hole Oceanographic Institution was originally a marine biological laboratory and did not offer graduate degrees until the post-World War II era. In fact, the other leading institutions of higher education in oceanography did not play a significant role until after World War II.

World War II was a major milestone in marine science and education. Of course, many people went to sea for the first time. Sea warfare, especially submarines and aircraft carriers, created new strategic ocean-related needs. In 1942, the last single volume (1,087 pages) was published containing everything known about oceanography, *The Oceans*, by H.U. Sverdrup, Martin W. Johnson, and Richard H. Fleming. The field of oceanography has grown geometrically since then.

The deep dives by Andreas Rechnitzer, Don Walsh (both U.S. Navy) and Jacques Piccard in the bathyscaph, Trieste, captured the American pride in 1959 and 1960 after the cultural shock of Sputnik in 1958. These dives, the first television shows by Jacques Cousteau, and the emerging theory of plate tectonics raised the awareness level of the American public. A new exploratory submarine, Alvin, was launched. Amidst the excitement, many new ideas emerged. Three had special significance for marine science and education. One was the theory of plate tectonics, which forced a rewriting of textbooks at all levels, and a new general understanding of why earthquakes occur and why they occur where they do. A second idea came from Dr. Carl Hubbs at Scripps Institution of Oceanography. He thought a facility that would bring people in proximity to whales could prove educational. Thus, the idea for Sea World came to fruition with private sector support. Third, Dr. Athelstan Spilhaus, an eminent scientist, thought that the United States should enact a Sea Grant Act patterned after the Land Grant Act but focused on the sea. With support from the new Dean of the School of Oceanography at the University of Rhode Island, John Knauss, Senator Claiborne Pell, and many others, the Sea Grant Act was enacted in 1966.

The period of 1969-1974 was a time for a call to action in the environmental arena.. It was during this time that the Environmental Science and Services Administration, later to become the National Oceanic and Atmospheric Administration (NOAA), was established. Notable legislation enacted included: the Endangered Species Act, the Marine Mammal Protection Act; the National Coastal Zone Management Act; the Marine Protection, Research and Sanctuaries Act; the Federal Water Pollution Control Act; and the Clean Air Act. It was also during this period that the U.S. Environmental Protection Administration (EPA) was created.

President Richard M. Nixon supported the initiation of the UN Law of the Sea deliberations and set the agenda for them. He also supported the UN Resolution on Prevention and Control of Marine Pollution. From this brief summary of events during his administration, it is possible that history may come to view President Nixon as one of the greatest "environmental presidents." .

For marine education in the 1970s, the resonant call to action produced multiple responses. New aquaria were built and Sea World expanded. Ocean-related television programs proliferated, with those featuring the prominent oceanographic explorer, Jacques Cousteau, being among the most notable. The National Marine Educators Association was established in 1976. The National Sea Grant College Program funded many initiatives in K-12 curriculum development. Interest and excitement peaked in 1977 with the discovery of the Galapagos deep sea hot springs and their associated chemosynthesis-based food web.

The stage is now set for a look at the current state of marine education.

## INFORMAL MARINE EDUCATION

### SeaWeb

"SeaWeb" was established in 1996 by the Pew Charitable Trusts to provide information about the ocean and ocean-related issues to the public. It is a multi-media educational organization designed to make the public more aware of the ocean and ocean life. It does no lobbying. One of SeaWeb's first endeavors was to contract with The Mellman Group to carry out a national survey of public attitudes towards, and knowledge about, the ocean, ocean life, and ocean-related issues.

The results of the SeaWeb survey provide a promising picture on the level of awareness and importance of marine issues to the public. The most startling finding was that people (72 percent) believe that ocean exploration is a higher priority than space exploration. Many people (87 percent) consider the ocean to be important to them. Most people (67 percent) believe the ocean is in trouble. A majority (58 percent) believe the condition of the oceans has deteriorated in the past few years, and many (87 percent) see the destruction of the ocean as a threat to their quality of life. A large majority of the people in this survey (82 percent) attributed the deterioration and threats to the ocean to human activity. Although Americans generally want less government in their lives, 85 percent would like the federal government to do more to help protect the ocean. Finally, when asked the question, "Which messenger of information about the environment do you trust a great deal?", people chose *National Geographic Magazine* (68 percent), Jacques Cousteau (63 percent), zoos and aquaria (51 percent), and NOAA (49 percent). Prominent elected officials, regardless of party, were very low on this list.

The SeaWeb survey establishes the importance of the ocean to the American public and the readiness of the public to take action to remedy ocean-related issues. As one of its educational activities, SeaWeb has begun publishing a monthly, "Ocean Update," focusing on current issues and providing contacts for further information (website address: www.seaweb.org). SeaWeb also sponsors a 90- second "Ocean Report" on National Public Radio and Voice of America with Sylvia Earle.

## Aquaria

Aquaria, maritime science centers, and museums are currently a major source of informal marine education for the public. At this time, there are twenty-seven aquaria around the country, some for-profit, some for nonprofit. Education is a fundamental goal for all of them. Most aquaria have extensive educational outreach programs for school children and children in other groups (Scouts, Boy/Girls Clubs, etc). The outreach programs include escorted tours at the aquarium, classroom visits by aquarium staff, books, tapes, and curriculum materials.

Some of the best known of these facilities are Sea World, Monterey Aquarium, Waikiki Aquarium, the National Aquarium at Baltimore, the New England Aquarium, the Miami Sea Aquarium, and the Chicago Aquarium. In 1998, a new Maritime Discovery Center will open in Seattle. In 1999, a new aquarium will open in Charleston, South Carolina, and another in Long Beach, California, in 2000. New facilities are in the planning stage in Erie, Pennsylvania, and Denver, Colorado. These facilities are extremely popular and annually host millions of people to whom they provide high quality marine education opportunities. This approach to providing marine education is highly successful. It could possibly be improved by cooperative input from federal agencies as is now being initiated through Coastal America, a federal, multi-agency consortium.

## Media

As indicated by the SeaWeb survey, the national media have an excellent reputation with respect to informing the public about the ocean. Most notable is the National Geographic Society . This organization's magazine has a large public circulation, is relatively inexpensive, and is in most school libraries. A notable example is the *National Geographic* issue of November, 1995, whose theme is "Exploring the Ocean's Bounty: Diminishing Returns." Other efforts by the Society in partnership with IBM have produced state-of-the-art CD-ROMs on marine life. It is widely recognized that the Society's television specials are high quality and popular, which explains why they are often shown on PBS-TV pledge nights. The National Geographic Society plans a one hour special for the Year of the Ocean to be shown on NBC-TV in 1998.

Everyone will miss Jacques Cousteau and he can never be replaced. His role in providing marine education for the world public is unmatched and unique. He has left a legacy of books and television programs for the continued benefit of the public. Some other individuals have made important contributions to informal marine education. In the 1950s, Thor Heyerdahl captured the attention of the world with his ocean voyages, books, and films. Currently, Robert Ballard, through his JASON project, has reached many people—especially young people. He has collaborated with the National Geographic Society in producing television specials. Another prominent spokesperson is Sylvia Earle, who serves on the Board of Directors for SeaWeb and has served as Chief Scientist for NOAA.

A recent spokesperson for the ocean, Jane Lubchenko, has gained prominence as President of American Association for the Advancement of Science. As a marine biologist studying coastal, rocky-shore ecology, she has raised the knowledge and awareness of many about the vulnerability of the coastal zone to human impacts.

There have been many modern books that have made major contributions to the understanding of the sea by the public. Rachel Carson's books, *The Sea Around Us* and *Under the Sea Wind*, were both best sellers and have served to educate and heighten the awareness of the public about the sea since their publication thirty years ago. A recent best seller, *The Perfect Storm*, by Sebastian Junger, gives a riveting account of men and women at sea struggling against the sea and weather. This nonfiction account of three storms coalescing off New England in October, 1991, is an excellent source of information about the sea.

Newspapers and national magazines are increasing their coverage of environmental issues, including the ocean. Global warming is a high-profile international issue which now has frequent and comprehensive coverage. The predicted El Nino, 1997-98, has received similar coverage. Many scientists have been quoted and the media has made a significant effort to educate the public about the science involved. Many elements of the national media have increased their coverage of such ocean-related issues as global climate change, El Nino, and fisheries. Occasional disasters, such as Hurricane Andrew and the Exxon Valdez oil spill, have also led to expanded media coverage of the ocean and subsequent education of the public.

## Federal Agencies

Identifying the federal agencies involved in informal marine education is not entirely straightforward. Determining how much these agencies spend on informal education is an impossible task. The problem is that many agencies have a general responsibility for education with no specific staff educators or budget. To a large extent, responsibility lies in a public affairs office, as in the case of the U.S. Coast Guard. Then too, it also depends on the definition of informal marine education. For example, if one includes boater education, The U.S. Coast Guard plays a large role. For this report, agencies with a budget and legislative mandate for informal marine education will be highlighted.

In the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, programs in three offices have specific informal marine education responsibilities. Obviously, the National Weather Service is a major provider. With more than 50 percent of the nation's population living within 100 miles of the coast, information about weather, tides, and waves along the coast is of continuing interest to the public. The National Weather Service maintains local forecast offices, provides information on the Weather Channel and other broadcast outlets for television and radio, and has special severe storm watch centers. The

National Weather Service does an outstanding job of meeting its informal marine education responsibilities.

The National Sea Grant College Program in NOAA's Oceanic and Atmospheric Research Division supports informal education through its local programs in 30 coastal and Great Lake states and Puerto Rico. In Fiscal Year 1997, Sea Grant funds six special informal education projects for $486,000. Most of its activities in this area are carried out by marine educators and marine advisors through local marine extension programs. The activities are diverse and range from teacher workshops to boater education and safe handling of seafood. Some of the activities are community-based efforts such as beach clean-ups. Others are national in scope such as MarinaNet, which provides information and education to marina owners and operators, and the Hazard Analysis and Critical Control Point system, which provides Food and Drug Administration-approved safe handling techniques to people in the seafood industry. Testimony in Congress at the recent Sea Grant reauthorization hearings and a recent study by the National Research Council endorse the success and high quality of these efforts.

The National Marine Sanctuaries Program and the National Estuarine Research Reserves System in NOAA's National Ocean Service also have informal marine education responsibilities. One of their mandates is "resource protection through enhanced public awareness, understanding, appreciation, and wise use of the coastal and marine environments." There are presently 12 sanctuaries and 22 estuarine reserves. Sanctuaries has been granted special authority to organize "friends" groups to help support local sanctuaries. Sanctuaries and Reserves both have education visitor centers for the public and school children. They provide supplemental school curricular activities, sponsor nature walks, and publish informative newsletters. These activities are limited in scope but highly successful and effective at their local sites.

Coastal America is a partnership of representatives of eleven federal agencies including NOAA, the Environmental Protection Agency, the U.S. Navy, the U.S. Army Corps of Engineers, and the Department of the Interior. Their activity in informal marine education is to designate Coastal Ecosystem Learning Centers at various aquaria and to provide appropriate enrichment materials from each participating agency at the Centers. This is a new effort and only five learning centers, such as at the New England Aquarium, are functioning. It shows great potential for disseminating materials from diverse agencies. Also, Coastal America offers an opportunity to coordinate informal marine education activities among the partnering agencies.

The Smithsonian Institution has a long record of high quality informal education. Each of the Smithsonian museums has its own education program. None of the museums is specifically marine oriented, although the Museum of Natural History has many marine exhibits including special displays, and a traveling exhibit and documentary movie for "1997, International Year of the Coral Reef." Their outreach effort on coral reefs has reached millions of Americans during the past year. Their magazine, *The Smithsonian*, sometimes carries marine-related articles and has substantial public circulation. The Smithsonian also has another traveling exhibit called "Project Ocean Planet Awareness."

The U.S. Coast Guard, as previously mentioned, has a significant and important role in informal marine education. The principal responsibility rests in the Office of Navigation, Safety and Waterway Services. The specific responsibilities include enforcement of federal laws and regulations (and dissemination of knowledge about them), supervision of local Coast Guard Auxiliary operations, establishment of pleasure craft safety standards, administration of public education and training programs (especially regarding handling of all vessels and pollution control), and liaison with other organizations and state and local agencies concerned with boating safety and water pollution. The Boating Education Branch administers an extensive public information program which includes distributing literature, offering courses, and making announcements for the media. Recreational boating represents a $20 billion dollar industry in the United States with a 10 percent annual growth rate. The main problem for the USCG is its multiple responsibilities. It does an outstanding job with limited resources.

The Department of the Interior's National Park Service, through some of its parks, monuments, and national seashores, maintains site specific programs in informal marine education. There are visitor centers at each of these sites with educational exhibits, special programs, nature hikes, and book stores. The National Park Service has a World Wide Web site called The Learning Place (http://www.nps.gov/interp/learn.htm) with many educational materials, especially for teachers.

The U.S. Environmental Protection Agency (EPA) provides and supports a wide array of marine education mechanisms that reach targeted technical audiences, children, the general public, and industry groups. EPA's Marine Debris Curriculum, available in both English and Spanish, provides lesson plans and activities to help teach grade school students about marine debris, where it comes from, how it can harm the environment, and what they can do to help reduce the amount of debris entering marine waters. The National Estuary Program contains a public outreach and education component, and all 28 estuary programs around the country include a Citizens Advisory Committee to educate citizens about threats to their estuaries and involve them in devising solutions to those threats. Numerous training courses are offered to EPA constituent groups on topics such as coastal resource protection at the local level, consensus-building for watershed planning, and volunteer monitoring in estuarine waters. Technology transfer is also emphasized in many of EPA's ocean and coastal programs such as an effort underway in the wider Caribbean to share low-cost methods for managing land-based sources of marine pollution, and EPA's support of the *Coastlines* newsletter to provide local communities with a source of applied coastal management techniques and contacts to protect their coastal watersheds.

# K-12 MARINE EDUCATION

## National Standards

The *National Science Education Standards* by the National Research Council (National Academy Press, Washington, DC, 1996) contain almost no mention of the ocean.[1] There is no mention of the oceans or life in the sea in the major sections on Physical Science, Life Science, Science and Technology, Science in Personal and Social Perspectives, or History and Nature of Science. The citations above are in Earth and Space Science. Inferred references can be found in the citations regarding water, although a knowledgeable person would need to point these out. In the references to fossils, evolution and biological diversity, the ocean connection is never explicit. The words "ocean," "sea," "marine," or even "water," do not appear in the index. This omission is appalling. Of course, no oceanographers were on the consulting advisory panel. There is a crucial need for an addendum to the *National Science Education Standards* detailing how the ocean fits in with the cited standards.

Admiral (ret.) James Watkins, President of the Consortium for Ocean Research and Education (CORE), recognized this omission and pointed out that, in fact, the ocean sciences comprise "one perfect implementation mechanism to meet national standards." In his address to the National Marine Educators Association conference in Chicago, August 1997, he said, "The so-called content standards of the *National Science Education Standards* include categories, each of which I will discuss in conjunction with utilizing ocean sciences as the ideal implementing tool." To this end , Admiral Watkins remarked on the following categories:

> **Unifying Concepts and Processes in Science.** "The science of biochemistry, which is one of the most interdisciplinary fields ever developed, was invented by marine scientists in order to understand the global carbon budget and its role in controlling climate."
>
> **Science as Inquiry.** "Ocean science is still a science of untold discoveries. Each research cruise raises as many new questions as it answers old ones. Some refer to oceans as the last frontier here on earth."
>
> **Physical Science.** "Study of the sea covers every aspect of physics, from the classical dynamics of wave theory, to the most fundamental aspects of high energy physics related to how sea water interacts with deep undersea muons and neutrinos. It is these studies which will feed into our understanding of such seemingly unrelated subjects as nuclear fusion as an energy source."
>
> **Life Science.** "The ocean holds the key to the origins of life, as shown in the chemosynthetic behavior of deep-sea vent biota. How can life exist in the absence of

[1] Here are the only citations: (1) page 159, "ocean floors are the tops of thin oceanic plates," "...to change continuously earth's crust, oceans, atmosphere..."; (2) page 160, "Water evaporates...collects in lakes, oceans, soil...", "Oceans have a major effect on climate, because water in the oceans holds a large amount of heat." (3) page 189, "This energy transfer is influenced by...static conditions such as the position of mountain ranges and oceans."

sunlight, and often in hostile environments prohibitive to their counterparts with which we are familiar in shallower waters?"

**Earth and Space Science.** "Even a subject as seemingly remote as the study of asteroids is now being addressed through analysis of deep-sea cores where sediments have revealed the clues to the extinction of dinosaurs 65 million years ago."

**Science and Technology.** "Every aspect of technology, including communications, advanced materials, information technology, and sensor design, is critical to ocean sciences, and made even more difficult by the forces of the operating environment. Arguably, in many aspects, deep ocean research is more technologically challenging than studying rocks on Mars."

**History and Nature of Science.** "The history of oceanography is one of basic research feeding immediately into societal needs -- defense and fisheries are the classic examples, but new issues such as coastal hazard mitigation and sustainable development of mineral resources will demand even stronger ties between the social sciences and ocean sciences."

## Textbooks

None of the major publishers of public school textbooks publishes one on oceanography, marine science, or marine biology for the K-12 portion of formal education. Many publishers have sections of Earth Science textbooks that relate to the oceans. Most are compendia of facts or concepts about the ocean such as tides and plate tectonics, which tend to be complicated. The coverage of other topics in the ocean sciences is sparse. The authors and editors of these volumes appear to have little knowledge about the oceans except what they may have read in a college textbook. They also seem unaware that many children in the United States have been to the ocean often; after all, 50 percent live within 100 miles of the shore. Many children thus have an experiential base to build on. There is a major need for a national conference/workshop to educate the authors and editors of the major textbook publishing companies about the ocean and how this knowledge can be infused into the K-12 science and social science curriculum.

## Curricula

While textbooks in marine education are scarce and inadequate for K-12 education, the same cannot be said for available curricula. The Consortium for Ocean Research and Education (CORE) is compiling an inventory of K-12 marine education programs. This is due to be published in 1998 and will provide much needed information on a national basis.

Federal agencies, especially Sea Grant and the National Science Foundation (NSF), have funded the development of marine science curricula for K-12 use. Some of these have been in use for several years by many teachers, and have been cited for excellence by various organizations such as the National Science Teachers Association (NSTA) and the U.S. Department of Education.

The Hawaii Marine Science Studies program was developed by the Curriculum Research and Development Group at the University of Hawaii. It is designed as a one or two year integrated science program for grades 9-14. It is a hands-on, multidisciplinary program with a marine theme that integrates science, technology, and environmental studies. The Fluid Earth portion has units on waves and beaches, physical oceanography, chemical oceanography, and transportation. The Living Ocean portion deals with fish, invertebrates, plants, and ecology. This is not a Hawaiian-only program. The program has been reviewed by at least 50 marine scientists and tested in the classroom by over 400 teachers to date. Clearly, this is a high quality program that fits a new niche in grades 9-12, namely, a two-year "integrated science" course for all students. This type of course is especially applicable in California where the State Science Framework calls for some physical, life, and earth sciences in each science course.

At the Lawrence Hall of Science, University of California, Berkeley, the Marine Activities Resources and Education program is a comprehensive ocean exploration program developed for K-8 (elementary and middle schools) . This program devotes the attention of an entire student body of a school to the ocean for a week. Students read books and stories about the ocean, create ocean-related art, listen to music about the sea, and study ocean-related topics in mathematics, science, and social science. There are special programs for teachers, parents, and even the community. This program provides a short but intense and comprehensive approach to marine education, not just to marine science education.

A new international environmental curriculum is underway that has the endorsement of the Clinton/Gore Administration. Called "Global Learning and Observations to Benefit the Environment (GLOBE),". its focus was on making measurements and observations related to lakes, rivers, and weather. Recently, GLOBE is expanding to include coastal waters. Students make measurements and observations based on a GLOBE protocol and share data via the Internet. To date, more than 3,000 schools in 50 countries are participating.

Under an NSF grant, three curriculum projects spanning K-12 have been refined and enhanced. They will become available soon on two multimedia compact discs. The discs will contain all the text and graphics from the three projects. The three are the Marine Activities Resources and Education program, FOR SEA (developed by the Marine Science Center at Poulsbo, WA), and "Living in Water," an aquatic science curriculum for grades 5-7 developed at the National Aquarium, Baltimore.

"Oceanic Education Activities for Great Lake Schools " was developed at Ohio State University under the leadership of Dr. Rosanne Fortner. These are activities that are designed to take a concept or idea from the existing school curriculum and develop it into an oceanic and Great Lakes context using teaching approaches and materials appropriate for grades 5-9. Dr. Fortner has also developed "Great Lakes Instructional Materials for the Changing Earth System."

The topics include fisheries, shipping, pollution, biodiversity, climate, and estuaries (wetlands). These were developed mainly with Sea Grant funding.

In 1998, CORE is sponsoring a national "Ocean Sciences Bowl" along with CORE member institutions and the National Marine Educators Association (NMEA). This will be the first time a national high school competition on the ocean is held. Awards will include scholarships, research cruise participation, visits to ocean research laboratories, computer hardware and software, and laboratory supplies and equipment. The grand prize will be a trip to the International Year of the Ocean celebration at EXPO '98 in Lisbon, Portugal. This bowl will be modeled after the National Science Bowl, now in its seventh year. There will be regional competitions (16) followed by a final competition in Washington, D.C., during Earth Week in April, 1998. It is expected that teams from up to 500 high schools will compete. Funding is provided by NSF, NASA, NOAA, U.S. Navy, and other agencies, and private sources. This competition should provide national visibility for the ocean sciences and be highly motivational for students. It is great to see such cooperation between ocean science-related agencies.

A "new kid on the block," the National Ocean Partnership Program (NOPP) has recently appeared on the marine science education scene. Following a very short notice and limited Internet announcement, this program has nonetheless already funded five K-12 ocean-related projects that may prove to have major national impact potential. These are as follows:

- "The Bridge: A Marine Education Clearinghouse" is a project to provide teachers access to the multiplicity of marine-related educational and curriculum materials or, at least, annotated reviews of commercial materials. This is an update and extension of a Sea Grant-funded project begun over 15 years ago at the Virginia Institute of Marine Sciences. "The Bridge" will be developed in consultation with the National Marine Educators Association and will be linked to NMEA on the Internet.
- "JASON IX" will continue under the leadership of Dr. Robert Ballard. This is an ocean exploration project which links Dr. Ballard in a submersible, usually Alvin, to students at remote, scattered sights via telecommunication/satellite. This is a real-time, live, exciting experience for students and teachers (and sometimes Dr. Ballard!).
- "COAST: Consortium for Oceanographic Activities for Students and Teachers" builds on the past five years experiences of "Operation Pathfinder," the Sea Grant initiated teacher training workshops. It also will extend Operation Pathfinder to high school teachers and pre-service teachers in training at the college level. As with Operation Pathfinder, a shipboard, at-sea experience for teachers is included.

- "Bringing the Ocean into the Pre-college Classroom Through Field Investigations at a National Underwater Laboratory" will be carried out through Rutgers University and NOAA. There is presently a shallow water laboratory located offshore of New Jersey doing comprehensive ocean data monitoring. The experimental project will be linked to classrooms enabling students not only to learn about the nearshore marine environment, but also to appreciate the technical problems inherent in real-time ocean monitoring in the environment.

- The University of South Florida will extend its "Project Oceanography" live via educational television to middle school science students. In Fall, 1997, seven weeks are devoted to coral reefs and seven weeks to plankton. NOPP is joined in supporting this project by National Geographic Society and five private sector corporations (Honeywell, K-Mart, Northern Trust Bank, TASA Graphic Arts, and Time-Warner Communications).

Sea Grant has funded fifteen K-12 education projects for 1996-97 at fifteen different educational institutions from Hawaii to Maine to Puerto Rico. These projects are for teacher training, curriculum development, and student field experiences. They include Operation Pathfinder, which will be publishing 50 activities of its "best of the best" designed for middle school students by the teacher participants.

The Environmental Protection Agency is funding a compilation of 50 coral reef education activities for middle school teachers. This effort will employ both English and Spanish editors. The activities are compiled by Dr. Sharon Walker, Gulf Coast Research Laboratory, Biloxi, Mississippi. Teacher workshops will be held in Humacao, Puerto Rico, in summer, 1998, in conjunction with the annual conference of the National Marine Educators Association.

In an innovative new program being developed currently with funding from NOAA's Oceanic and Atmospheric Research Division, real-time oceanographic data will be accompanied by lesson plans and instructions for using the data through OAR's home page on the WWW.

### Teacher Training

The National Science Foundation has funded summer institutes and other programs to train teachers in marine education. In fact, the author directed the first summer institute in oceanography for teachers in 1972-73. NSF has recently been funding the "Maury Project" at the U.S. Naval Academy. This teacher training project was originally a partnership between the Naval Academy. and the American Meteorological Society. With its early success, sponsorship has grown and now includes the U.S. Naval Meteorology and Oceanography Command, the Office of Naval Research, and NOAA's National Environmental Satellite, Data, and Information Service, and NOAA's National Ocean Service. This project concentrates on physical oceanography in a two-week summer workshop including laboratory and ship-board experiences. To date, 76 teachers have been trained and each summer 25 more are expected to be trained. After attending, teachers are expected to become "peer trainers" to conduct local workshops for teachers in physical oceanography. This has been a highly successful program that deals with a topic rarely or poorly covered in K-12 curricula.

Sea Grant initiated a teacher- training program called "Operation Pathfinder," now in its fifth year under the leadership of Dr. Sharon Walker at the Scott Marine Education Center and Aquarium in Biloxi, MS. The project name derives from the USN survey ship Pathfinder. Two week summer workshops are held regionally for elementary and middle school teachers. In 1997, six were held in Connecticut, North Carolina, Mississippi, California, Minnesota, and Ponape Island (Mariannas). The following agencies were co-sponsors with Sea Grant: NOAA's National Environmental Satellite, Data and Information Service, Office of Naval Research, U.S. Naval Meteorology and Oceanography Command, and the Department of the Interior. Teachers were trained in oceanography and coastal processes. They also had a shipboard at-sea experience. About 300 teachers have been trained to date. "Operation Pathfinder" was the basis for an expanded teacher training program called "COAST," which has been funded by the previously mentioned NOPP.

NOAA maintains a "Teacher-At-Sea" program. Teachers are invited to participate in fishery cruises under the research program of the National Marine Fisheries Service. As many as 40 teachers participate annually. The National Undersea Research Program in NOAA funds an "Aquanaut Program" which allows some teachers and students to go to sea to use remotely operated vehicles in research projects. The U.S. Navy and the National Geographic Society run Project Marco Polo which enables middle school teachers and students to go to sea on a Navy oceanographic ship.

Nationally, pre-service teaching and teacher credential programs rarely provide any special instruction in oceanography. Some universities offer oceanography or ocean-related courses as electives for those planning to teach. Teaching methods courses frequently provide information about water, but rarely about the ocean specifically. Some colleges that train teachers in dissection techniques do use fish as a vertebrate example; more generally however, teacher training at universities ignores areas that pertain to the ocean. One noteworthy exception is Oregon State University, which offers an MS degree in science education with marine emphasis for teachers. The teachers go to Newport, Oregon, and take courses every summer for three years at the Mark Hatfield Marine Science Center. This is the only degree program in marine education in the United States and it graduates about five students per year while maintaining enrollment at fifteen students.

CORE led an education workshop on ocean sciences and K-12 education in 1996 sponsored by NSF. The participants included ocean scientists, classroom and informal science education experts, and leaders in science education. The participants agreed on the following general conclusion:

> "...the workshop participants strongly support the theme that the ocean agencies present outstanding opportunities and untapped resources for K-12 education, and that oceanographic processes and features are ideally suited for constructing and demonstrating knowledge and science-based skills in the fundamental principles of science across all disciplines, including the social sciences, and over a wide range of levels of sophistication. The challenge is for the ocean sciences research community and

K-12 educators to reach out and develop partnerships (both formal and informal) to, over the long term, mutually develop new ways to infuse the ocean sciences into K-12 education at all levels and throughout the curriculum."

The CORE report recommended urgent action in these priority areas:

1. Develop a formal umbrella partnership directed at ocean sciences and K-12 education reform with professional societies and associations which share similar goals and concerns. These include, but are not limited to: the American Association for the Advancement of Science (including Project 2061), the National Science Teachers Association, the National Marine Educators Association, the Association of Science-Technology Centers, the Association of Zoos and Aquariums, The American Geophysical Union, and The Oceanography Society. The basic purposes of these partnerships should be to:

    a. facilitate implementation of the recommendations in this report;
    b. ensure the highest standards of quality are met throughout this process;
    c. foster the development of standards for ocean science literacy;
    d. enhance visibility of ocean sciences in educational reform;
    e. explore new linkages between ocean sciences and education communities.

2. Develop, publish and disseminate "Standards for Oceans/Ocean Science Literacy." In other words, what are the basic knowledge components (by discipline, such as physics and by topic, such as ocean currents) that should be understood by students at different grade levels (K-4, 5-8, 9-12) and which can be explored and tested through grade appropriate inquiry-base study? At the adult level, what should a science literate person know about the oceans and their influence on global environment and impact (both now and likely in the future) on the global economy?

3. Issue a policy statement strongly endorsing the need for pre-college outreach on the part of ocean science researchers. Federal agencies concerned with the support of ocean sciences should advocate pre-college outreach by ocean science researchers and include outreach as an evaluation criterion in the review of research proposals by these agencies. Strong endorsement by funding agencies of the need and value of pre-college outreach is particularly necessary in order to change the reward system (tenure) for younger faculty at academic institutions.

4. Prepare a thorough inventory of existing K-12 ocean sciences programs and curricula. Initial focus should be placed on gathering information on pre-college outreach programs conducted by universities. The inventory should then be expanded to include other sites and locations through the assistance of the education societies including the AAAS, the National Marine Educators Association and the National Science Teachers Association. This inventory should be made available in readily

usable format to classroom teachers and informal science educators. In addition, working with scientists and K-12 educators, standards or guidelines which could be used by teachers and educators to judge the quality, currency, and utility of existing K-12 ocean science education programs should be developed.

Another recommendation called for CORE to expand and enhance its current home page on the World Wide Web (http://core.cast.msstate.edu) to include information on K-12 programs and opportunities. This home page should also "point" to those other home pages in the ocean sciences research community which include K-12 information. The CORE Home Page will also be the site for the maintenance and display of an inventory of current K-12 programs, particularly those involving and impacting teachers.

Consistent with these urgent needs for action, the universities should encourage and provide incentives for faculty members to engage in K-12 outreach to teachers and students. These activities could include, but are certainly not limited to: working with teachers in nearby schools to help incorporate ocean sciences research into classrooms; designing and delivering outreach skills-training to faculty and scientists; providing opportunities for field trips and research internships for teachers and their students; mentoring and counseling both teachers and students, etc.

The CORE/NSF workshop participants also made general recommendations for the improvement of K-12 marine education:

1. Creation of a national program of summer research internships for K-12 teachers at oceanographic institution research sites.

2. Development of a model pre-service ocean sciences course for use in pre-service K-12 math/science teacher education.

3. Continued support for K-12 curriculum development.

4. Increased teacher and student participation through technology in ocean sciences data collection and analysis.

The National Marine Educators Association has provided leadership for some 20 years, and has kept marine education "alive and kicking" through a network of educators and a professional journal. The organization has a membership of just over 1,000 teachers and informal educators. It is not a grant receiving institution, nor does it have political clout in Washington, DC. CORE could provide the clout and grant attracting ability to expand and improve K-12 marine education.

Federal granting agencies such as Sea Grant, NSF, and the Department of Education need to maintain and expand where feasible their support for K-12 marine education.

## HIGHER EDUCATION

Thirty- six universities or consortia offer a graduate degree (MS/Ph.D.) in a marine related field in the United States. Some of the consortia (e.g., Dauphin Island) consist of several universities. About 650 Ph.D. degrees are granted annually. These figures come from the Marine Technology Society (MTS) publication, “Education and Training Programs in Oceanography and Related Fields” (1995). NSF annually supports about 500 graduate students in ocean sciences research. Sea Grant supports another 250 graduate students (personal communications).

Again, based on figures from the MTS directory, about 200 BA/BS degrees are earned annually in marine-related areas and about 1,100 MA/MS degrees are earned. The purpose of the MTS directory was not to collect this data; however, there was a line for respondees to report “Number of Degrees Granted.” Not all universities reported, so the numbers are less than the actual number of degrees granted. On the other hand, the reported degrees are in “Oceanography Related Fields,” which would indicate that the numbers probably exceed the marine science or oceanography degrees earned at reporting universities. In any case, this provides a general sense of university output in the field. Some figures are startling: Coastal Carolina University has an undergraduate Marine Science major with 400 students! The University of Miami and the University of Rhode Island do not report degrees granted.

According to a survey by CORE of alumni of U.S. marine science and policy graduate institutions, there were only 157 MS degrees and 309 Ph.D. degrees granted in 1994. This represents a much narrower survey of marine science than the MTS Directory uses and is based on graduates of the major ocean research institutions.

The California Sea Grant College Program publishes a “Directory of Academic Marine Programs” (1993, 3rd edition). There are ten programs at two-year colleges. There are 38 four-year colleges with oceanography or marine-related programs. Most are, for example, biology (with marine emphasis). The University of Southern California offers both an MS and Ph.D. in ocean sciences. The University of San Diego and Humboldt State University offer a BS in marine science and oceanography, respectively. The U.S. Naval Postgraduate School offers a Ph.D. in oceanography. The University of California, Berkeley offers a Ph.D. in ocean engineering. The University of California at Santa Barbara offers both the MS and Ph.D. in ocean engineering. Scripps Institution of Oceanography offers both an MS and a Ph.D. in applied ocean sciences, biological oceanography, geological, sciences, geophysics, marine biology, geochemistry, marine chemistry, and physical oceanography.

In discussions with experts in these fields, a need exists for trained graduates in maritime law, marine affairs, seafood technology, recreation, and naval architecture that are not being met. Marine recreation, for example, is now a $17 billion industry in California. Based on the MTS Directory and additional personal communications, national needs are similar to those in California. In recognition of these needs, new graduate programs in marine affairs are emerging.

The strength of marine higher education in California and the nation lies in the research training area for the basic sciences. There is no question that the United States has the best marine research and training in the sciences available in the world. The number of graduating trained researchers certainly meets or exceeds the needs of the nation at this time. The main support comes from NSF, Sea Grant and the U.S. Navy.

In addition to grant support of graduate students in research, there are Fellows and Internship programs supported by NSF, Sea Grant, AAAS and the U.S. Navy. The Knauss Sea Grant Fellows program provides Washington, D.C.-based experience in both the executive and legislative branches of government for about 24 graduate students per year. This kind of practical training enhances the university experience. Sea Grant is beginning an Industrial Fellows program which will place graduate students in private industry. This program should be expanded.

One of findings made by Dr. Andreas Rechnitzer's in California in 1969 persists. That is, graduate students are mainly prepared to be research professors at graduate research institutions. The reality is that the majority of MS and Ph.D. graduates in ocean sciences will find employment in government agencies and private industry. University faculty and placement offices need to be more aware of this reality and help students prepare better for this eventuality.

There are eight maritime academies or institutes in the United States. The U.S. Merchant Marine Academy at King's Point, New York, is the only federal academy. Six are state-run (New York, California, Massachusetts, Maine, Texas, and Michigan). The Maritime Institute of Technology and Graduate Studies (MITGS) is the training arm of the International Organization of Masters, Mates and Pilots at Linthicum, Maryland. These are all high quality institutions that maintain a tradition of training U.S. merchant mariners. Most have from three to six hundred students. The MITGS trains about 1,400 working professionals annually in specialized courses for upgrading and modernization. With a relatively small fleet of non-military U.S. flag ships, these institutions meet the current U.S. need.

The U.S. government also supports the U.S. Naval Academy and the U.S. Coast Guard Academy, both of which maintain high quality undergraduate level programs in ocean-related studies. These institutions meet the current U.S. needs.

## ETHNIC MINORITIES

The ocean sciences community continues to have extremely low numbers of people from ethnic minorities. This means that all universities, government agencies, and private industries dependent on graduating students are affected.

At NOAA, each line office (National Weather Service, Oceanic and Atmospheric Research, etc.) has a program to encourage participation and professional training of ethnic minorities. The Sea Grant program, for example, has granted $50,000 per year for three years to five "historically black colleges and universities" to develop and encourage undergraduate participation and studies in ocean sciences. NOAA's total annual investment is about $1.5 million. Unfortunately, there is no coordination of the program in NOAA.

The U.S. Navy probably has the best record for recruiting ethnic minorities into the ocean sciences by virtue of its overall record in this area.

NSF has funded projects to encourage ocean science study by ethnic minorities as well. An example is a summer program between Harbor Branch Oceanographic Institution and Savannah State University. This provides research and ship-board opportunities for both faculty and students from Savannah State.

NOAA is also supporting an Earth Systems Science curriculum at Clark Atlanta University which includes an agreement with Oklahoma University leading to a BS in Earth Systems Science and an MS in Meteorology. Students spend three years at Clark Atlanta and two years at Oklahoma.

There is no clear answer to the glaring problem of low numbers of people from ethnic minorities in the ocean sciences community. Surely more intra- and inter-agency coordination would help matters. Universities and K-12 educators also need to direct more attention to this matter and must shoulder some of the blame for the present condition. New ideas in this regard are urgently needed.

## CAREER OPPORTUNITIES

Too often, ocean scientists advise students only about careers in research. High school students receive little information about ocean related careers. The best job opportunities today are in marine recreation and tourism. In California alone, it has already been noted that this is a $17 billion per year industry. There are a few good publications that provide information about marine careers. Sea Grant has a recent publication, *Marine Science Careers: A Sea Grant Guide to Ocean Opportunities*. This can be obtained from Woods Hole Oceanographic Institution Sea Grant Program, 193 Oyster Pond Road, Woods Hole, MA 02543-1525. A good source for information about ocean-related careers other than the sciences is *Opportunities in Marine and Maritime Careers* by William Ray Heitzmann (VGM Career Horizons, 4255 West Tonky Avenue, Lincolnwood, IL 60645). Additional resources include the organizations and publications listed below:

**Publications:**

*Careers in Oceanography and Marine-Related Fields.* The Oceanography Society, 4052 Timber Ridge Drive, Virginia Beach, VA 23455, (804)464-0131, fax: (804)464-1759, e-mail: jrhodes@ccpo.odu.edu.

*Education and Training Programs in Oceanography and Related Fields.* Available from the Marine Technology Society, 1828 L Street, NW, Suite 906, Washington, D.C. 20036-5104, (202)775-5966, fax: (202)429-9417.

*Strategies for Pursuing a Career in Marine Mammal Science.* Allen Press, P.O. Box 1897, Lawrence, KS 66044-8897, 800/627-0629.

*Taking the Initiative: Report on a Leadership Conference for Women in Science and Technology.* Available from the Association for Women in Science, 1522 K Street, NW, Suite 820, Washington, D.C., 20005, (202)408-0742, fax:(202)408-8321, e-mail:awis@digex.net.

*Careers in Oceanography.* Neritic Enterprises, PO Box 5485, Santa Barbara, CA 93108.

There is a need to communicate information about marine careers to high school guidance counselors. California Sea Grant sends its Directory of Marine Programs to every counselor in the state. NOAA, the U.S. Navy, and/or CORE should consider buying a booth at the national conference of career and guidance counselors.

## CONCLUSIONS

Informal marine education is extensive and growing in the United States. The media has improved its coverage in both extent and quality over the past 25 years. There are many aquaria and similar institutions available for public viewing and education. These institutions have extensive and usually high quality education programs. SeaWeb has begun a worthy program of raising the awareness of the public about ocean issues. The U.S. Congress has also shown new interest about ocean issues and policy after a 25-year hiatus. Government agencies are extensively involved in a wide range of informal marine education endeavors and maintain a high level of quality.

K-12 marine education appears to lag other aspects of marine education. There are a few curricular programs and materials that are available from aquaria and government agencies. Science textbooks have little coverage of the ocean. Teacher training in marine education is almost non-existent in universities. Several government agencies have in-service teacher training programs. The new NRC *National Science Education Standards* ignore the ocean.

Higher education is a bright spot in marine education. Graduate programs are high quality and produce adequate members of scientists to meet national needs with the exception of marine affairs (social sciences). Marine affairs is of growing importance to the nation and there is a need to develop new graduate degree programs. Maritime academies meet the national needs at this time considering the low availability of jobs in the merchant sector. NSF and Sea Grant are the main supporters of ocean science graduate students.

Ethnic minorities while under-represented in science are even more under-represented in the ocean sciences. Women are generally represented in oceanography similar to their representation in other sciences.

There are some publications available for career opportunities in the ocean sciences. Students at all levels are poorly informed about the range of careers available in the ocean sciences. The best job opportunities lie in the area of marine recreation and tourism.

## OPTIONS FOR CONSIDERATION

- Provide leadership and visibility for marine education;
- Seek new international/national advocates for marine education;
- Coordinate efforts and new ideas to promote diversity of people in marine education;
- Increase public awareness of ocean issues;
- Educate the public regarding the role of the ocean in global climate;
- Coordinate marine education support by federal agencies;
- Revise/amend the *National Science Education Standards* (National Research Council) to infuse ocean sciences;
- Fund and organize a national conference/workshop to educate K-12 textbook authors and editors about the oceans;
- Support CORE and National Ocean Partnership Program;
- Make real-time oceanography accessible and useful for teachers and students;
- Encourage more university programs in marine affairs, law, coastal engineering, and ports and harbor management and planning;
- Improve career education information about ocean-related employment at all levels of education;
- Provide marine career information to career and guidance counselors.

## REFERENCES

1. Advisory Committee on Protection of the Sea. *Report of the Conference: Oceans and Security*. U.S. House of Representatives, Washington, DC, 1997.

2. Benson, Keith. *History of Marine Education*. Proceedings of the IV Congress on the History of Oceanography, La Jolla CA, 1993 (in press).

3. California Sea Grant, *Directory of Academic Marine Programs in California*. 3rd edition, University of California, La Jolla, CA, 1993.

4. CORE. "Report from Education Workshop on Ocean Sciences and K-12 Education." Washington, DC, 15 October 1996 (unpublished: cast.msstate.edu).

5. CORE. "National Ocean Sciences Bowl." (unpublished: cast.msstate.edu).

6. Eisenhower National Clearinghouse. *The Guidebook of Federal Resources for K-12 Mathematics and Science.* U.S. Department of Education, Washington, DC. 1996.

7. Fabry, C.M. (Editor). *Education Training Programs in Oceanography and Related Fields.* Marine Technology Society, Washington, DC, 1995.

8. Fortner, R.W. and Mayer, V.J. "Marine and Aquatic Education - A Challenge for Science Education." *Science Education*, vol. 73, no. 2, pp. 135-154, 1989.

9. Goodwin, H.L. and Schaadt, J.G. "The Need for Marine and Aquatic Education." Delaware Sea Grant, University of Delaware, 1978.

10. Lanier, James. "The National Marine Educators Association: Historical Notes." *Current*, vol. 8, no. 2, pp. 5-20.

11. Mellman Group. "Presentation of Findings From a Nationwide Survey and Focus Groups." SeaWeb, Washington, DC, 1996.

12. Rechnitzer, A.B. *Marine Sciences in California Institutions of Higher Education.* A Report Prepared for the Coordinating Council for Higher Education of the State of California, Council Report Number 1037; 1969.

13. Smith, D.R. et al. "The Maury Project: An Educational Partnership for Oceanography. *Bulletin of the American Meteorological Society*, vol. 78, no. 7, July 1997, pp. 1497- 1502.

14. Spinrad, R.W. and Nowell, A.R.M. "Ocean Science Educators Retreat." AGU Conference, Fall, 1996 (unpublished: cast.msstate.edu).

15. Watkins, Adm (ret.) James D. "A New Agenda for Science in Education." National Marine Educators Association Conference, Chicago, 1997 (unpublished: cast.msstate,edu).

16. Wildman, R.D. and Ross, D.A. "Sea Grant's Role in Marine Education." *Oceanus*, vol. 33, no. 3, Fall, 1990, pp. 39-45.

## LIST OF ACRONYMS

| | |
|---|---|
| COAST | Consortium for Oceanographic Activities for Students and Teachers |
| CORE | Consortium for Ocean Research and Education |
| GLOBE | Global Learning and Observations to Benefit the Environment |
| MTS | Marine Technology Society |
| NASA | National Aeronautics and Space Administration |
| NMEA | National Marine Educators Association |
| NOAA | National Oceanic and Atmospheric Administration |
| NOPP | National Ocean Partnership Program |
| NRC | National Research Council |
| NSF | National Science Foundation |
| UN | United Nations |
| USCG | United States Coast Guard |
| USN | United States Navy |

# 1998 Year of the Ocean

## THE LEGENDARY OCEAN—THE UNEXPLORED FRONTIER

### Contents

## EXECUTIVE SUMMARY

The ocean remains as one of Earth's last unexplored frontiers. It has stirred our imaginations over the millennia and has lead to the discovery of new lands, immense deposits and reservoirs of resources, and startling scientific findings. The presence of the human eye and the human ability to sample and to conduct experiments from the coastal regions to the deep ocean abyss has provided answers to questions on such critical issues as global change, waste disposal, mineral deposits, and the creation of life itself. In spite of the development of new technologies, comparatively little of the ocean has been studied. The leadership role of the United States has been eroded by a gradual decrease in funding support in spite of public opinion polls that indicate that ocean exploration is more important than space studies. As exciting and enlightening as ocean discoveries have been, they will likely pale in comparison to future discoveries.

## SEAS OF LEGENDS, LIFE AND DISCOVERY

The ocean stirs the imagination. Covering more than 70 percent of the surface of the earth, the ocean's beauty and power has long been a source of awe as well as suspicion for many cultures. Legends were developed to help explain both the ocean and our own existence. The Greeks named Poseidon the god of the sea to help protect their seafarers and fishermen. The Eskimos told the story of a sea goddess Sedna, whose lost fingers filled the oceans with marine fish and mammals. In pursuit of meaning—both material and spiritual—many cultures have turned to the sea for inspiration as well as survival. Although few explorers discovered the riches they initially sought, they found not only new lands, but also unexpected, bizarre, and dazzling deep-sea creatures inhabiting an alien world.

Within the past few decades, ocean explorers have uncovered evidence of plate tectonics. These are global geological processes fundamental to the basic understanding of the Earth upon which we live. As exciting and promising as discoveries such as these have been, however, they may pale in comparison to what future exploration may uncover. It must again be noted that these discoveries, some of which shake the very foundations of centuries old beliefs about the basic nature of the Earth, are very recent. As a result of the tools now becoming available, the pace of discovery is escalating rapidly. In the past 25 years, mankind has learned more about the ocean and what lies beneath its surface than had been learned throughout all of previous human history.

## A LONG HISTORY OF OCEANIC EXPLORATION

### Early Explorations

The ocean was a highway for early explorers. As early as 2000 B.C., Phoenicians sailed the waters of the Mediterranean, the Red Sea, and the Indian Ocean. There is some evidence Phoenicians even ventured beyond the Strait of Gibraltar. Scandinavian sailors apparently reached North America around 1000 A.D. During the period 1492-1522, known in the culture of the Western world as the Age of Discovery, mankind began to fully realize the vastness of the earth's water- covered surface. During this period, the world was first circumnavigated, North and South America were discovered, and human cultures began to develop a modern view of geography.

Following this period, exploration became a tool of empire-building for European nations, and was often associated with the pursuit of scientific interests . Between 1772 and 1779, Captain James Cook made several extraordinary voyages that added greatly to the scientific understanding of the ocean, geography, and anthropology. In addition to discovering Australia, New Zealand, and Hawaii, he sampled subsurface temperatures, measured winds and currents, conducted soundings, and collected important data on coral reefs.

The earliest successful explorers of the deep ocean were Sir John Ross and Sir James Clark Ross. In 1817 off Baffin Bay, Canada, Sir John collected samples of bottom dwelling organisms including starfish and worms from a depth of 1.8 km. Sir James conducted soundings with a 7-km line during several voyages to the Antarctic from 1839-1843. Their results spurred scientific interest in deep-sea life. In the mid-19th century, scientific exploration of deep waters was further encouraged by the Azoic Theory of Edward Forbes, which held that life did not and could not exist below about 300 fathoms (1,800 ft). The desire to test this hypothesis has led to further exploration until, eventually, no depth has been completely unstudied.

The history of oceanography and deep-sea research has been one of cyclic fluctuations, each cycle involving more sophisticated research as it builds on previous knowledge. These research cycles have always included significant government support, because oceanographic research is very expensive, requires long-term commitments of personnel and assets, and does not necessarily provide information that can be of immediate or specific commercial use.

## Modern Oceanography

Modern oceanography can be considered to have started with the voyage of HMS Porcupine in 1869. However, it is the voyage of HMS Challenger (1872-1876) that is most famous. In both cases, these expeditions were made possible because of government support for exploration and scientific research. During the 127,500-km voyage, the Challenger scientists plotted the first systematic contour lines of ocean basins, currents, and temperatures. Although they labored under conditions much more primitive than those of modern oceanographers, they obtained some remarkable information, including a depth measurement of over 8,000 meters in the Mariana Trench in the western Pacific Ocean.. This measurement was made using piano wire for a sounding line. The Azoic theory was subsequently rejected; abundant life occurred at most depths. More than 4700 new species were collected with nets and bottom dredges.

World War II provided another set of strong reasons for developing a better understanding of the seas. While wars fought at sea were not new, what was new was a major thrust by maritime powers to understand the medium they were using as a battleground in order to improve their fighting and defense capabilities. Thus the U.S. Navy, as well as navies of other developed nations, devoted sizable resources to understanding the oceans and to developing capabilities to improve this understanding. Wartime requirements resulted in improved oceanographic instrumentation, surface and bottom charts, long-range weather prediction, submarine detection equipment and an enhanced understanding of underwater sound.

The past 50 years have seen milestone developments in technologies and capabilities that have greatly contributed to oceanography. Some of these include research submersibles, satellites, sonar technology, surface platforms and, or course, the computer.

# TECHNOLOGY FOR DISCOVERY

## Exploring the Deep Sea

Humans first explored the ocean by directly observing it or by placing samplers and instruments into the sea from their ships. These techniques were limited by the relatively shallow depths then attainable by humans and the relative opaqueness of the sea. Light is rapidly absorbed by sea water, making visibility with conventional techniques virtually impossible beyond shallow depths. Sunlight doesn't penetrate below 300 meters, and relatively few places in the ocean have visibility greater than 30 meters. Thus, observations from the surface are severely limited as are observations by divers alone. In recent years, however, capabilities for ocean exploration have been greatly enhanced by major technological developments that enable seeing far beneath the waves to the seafloor itself.

Although there had been attempts even in antiquity to work underwater, humans had never been able to penetrate very far into the depths until the 1930s. It was then that William Beebe, an American ichthyologist, succeeded in reaching a depth of 1,000 meters in his "bathysphere," and providing exciting reports (by live radio broadcast) of life at those depths. Although there were many limitations to his diving platform, Beebe was overwhelmed by the chance to observe marine life in its own environment. A quarter century later, the bathyscaphe Trieste took two men to a depth of 35,800 ft, the deepest spot in the ocean, the Mariana Trench near Guam, in the western Pacific. Although the Trieste lacked manipulators or samplers, it allowed unprecedented observations from the water surface down to the benthos (organisms that live on or in the ocean bottom) and provided a tantalizing glimpse of future discoveries.

## Modern Equipment for Undersea Exploration

Even when wearing diving gear, humans are limited to relatively shallow depths and short periods of submergence. SCUBA (Self-Contained Underwater Breathing Apparatus), invented in 1943 by French naval engineers Jacques Cousteau and Emile Gagnan, allows excursions to well below 100 feet for significant durations. The ability to live and work underwater has been greatly expanded through advances in diving physiology and technology. Through the use of saturation diving, scientists can live under the sea in "Aquarius," the only undersea habitat devoted to scientific research. (Aquarius is currently located at the base of a South Florida coral reef.) Through techniques such as saturation and mixed-gas diving, scientists can extend their underwater depth and time limits. Yet, while SCUBA has allowed millions of people to become undersea explorers, it still only allows humans the ability to spend relatively short times at comparatively shallow depths.

The development of the occupied research submersible from the late 1950s to the present allows scientists and explorers access to undersea depths of up to 6,500 m (21,326 ft), although most submersibles have much shallower diving capabilities (300 m to 3,000 m). Modern research submersibles generally have manipulators, lighting, cameras, and sensors allowing detailed observations and experiments. Among the most notable submersible discoveries have been the finding of chemosynthetic life at hydrothermal vents, studies of undersea volcanoes and their eruptions, and hundreds of previously unknown species of deep-sea animals. Worldwide, an estimated 1,000 submersible dives per year have taken place since 1970.

Remotely operated vehicles (ROVs), which are tethered, unoccupied robots, have been highly developed and provide some significant advantages over occupied submersibles. They have almost unlimited bottom time, their damage or loss endangers no human lives, and their telepresence capability allows a broader audience to be "present." Vehicles range from the small and portable, capable of working at only a few tens of meters, to the large and somewhat cumbersome (11,000 pounds), capable of working at 10,000 meters while carrying many different sensors and tools. Since the early 1970s, more than a 1,000 ROVs have been placed into service worldwide in support of various tasks including oil exploration and operations, offshore development, and undersea research. In 1966, an ROV was used to find a hydrogen bomb lost at sea after an accident off the coast of Palomares, Spain. Using the ROV Kaiko, Japanese scientists revisited the Mariana Trench in 1995 and documented observations of shrimp, a scale worm, and a sea cucumber at 10,911 m (35,800 ft).

Autonomous underwater vehicles (AUVs) have been recently developed to augment occupied submersibles and ROVs as exploration vehicles. Most of the AUVs now in service are experimental test platforms, although several have been used for scientific purposes. Because AUVs are untethered they can have a much greater horizontal excursion capability than an ROV. Long-range AUVs are currently limited by the lack of cost-effective power supplies. Nevertheless, the future for computer-guided, unoccupied, untethered vehicles appears promising.

Technological advances notwithstanding, humans are still an important part of exploration. Divers are better at working around delicate undersea communities and archeological excavation sites than are robots, and trained observers remain the best detectors of many phenomena, i.e., they do not need to be programmed to identify unexpected discoveries.

Acoustic technology, including sonar (sound navigation and ranging), has become an essential tool for marine exploration. Sound penetrates the ocean much as light penetrates the atmosphere. Sound is carried through water much more readily than it is through air; depending upon frequency, volume, and water characteristics, sounds can be heard thousands of kilometers from their origin. Acoustic technologies are used to explore the distribution of animals in the water, the nature of the sea bottom, to locate objects, discover natural resources, provide undersea navigation, detect submarines, and to improve our understanding of the nature of the ocean itself . With the development of side scan sonars and deep towed echo sounders in the 1960s, detailed sea bottom mapping, which is essential to understanding plate tectonics and other geological processes, has become possible. The recent marriage of computers with acoustic technologies has resulted in the introduction of mapping systems that can provide wide area images of the seabed in real time.

With the end of the Cold War, declassified technologies and resources developed for military purposes have become available to civilians. Among these major resources are formerly classified military oceanographic data, deep-sea submersibles, nuclear submarines, and the Integrated Undersea Surveillance System (IUSS), a listening system developed for submarine detection and location. The availability of these resources has had a significant impact on ocean exploration. A cooperative agreement between the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Navy provides access for civilians to Navy deep submersibles and ROVs, allowing exploration and research to 6,000 m below the surface. Several scientific cruises to the Arctic Ocean using the Navy's nuclear-powered submarines have been made since 1993. These missions have demonstrated the utility of such vessels for oceanographic and geophysical studies of polar oceans. Another dual-use application known as acoustic thermometry uses listening systems to measure whether the ocean is cooling or warming by measuring the speed of sound transmission between two fixed points. Data such as this can provide evidence concerning the status of global climate change. Other cooperative uses for U.S. Navy vessels include mapping and seismic exploration of the ocean floor, tracking and study of whales, retrieval of environmental information from remote instrumented buoys and observatories, and enforcement of fishing regulations.

Remote sensing technologies, such as satellites and radar, are relative newcomers to the toolbox of the ocean explorer. They are capable of providing synoptic information over large surface areas—information previously unobtainable from surface-based platforms such as ships and buoys. Pictures from satellites orbiting the earth provide some of the most valuable—and often, unexpected—information about the ocean. Recently, a satellite found what may be the world's second largest lake beneath Antarctica's thick icecap. Data released within the past year shows the Pacific Ocean may contain more than 50 percent more seamounts than previously thought. This means that more than 25,000 undersea volcanos taller than 1 km are largely unknown and remain uncharted because of sparse bathymetric coverage. (Seamounts are submarine volcanos that can provide information about geological history. Because they often support highly diverse and abundant marine life, they may also provide significant new fishing grounds.) Finally, satellite images can be used to follow pollution discharged from rivers into the sea, locate coral reefs and provide information on their health, measure heat flow from the sea surface, and study the effects of wind and tides on the transportation of sediments. A myriad of possible applications abound.

## THE WEALTH AND WONDER OF THE OCEANS

Oceans continue to arouse some of our most noble and basic instincts. In just a few short decades, research has opened doors to ocean exploration and exploitation that our ancestors could only have imagined. The seas have much to offer of economic importance. Some resources like fisheries and mineral resources are well recognized today. Others offer promise for the future.

Marine mineral resources are extensive and (in deeper waters) poorly known. The exploitation of these resources will require an expansion of geological knowledge in order to locate them. If severe damage to the seas is to be avoided, it will also require a better understanding of the ecosystems with which these mineral resources are associated and the development of technology to extract them without causing significant damage.

Oil use has increased dramatically in recent times, and the seabed holds unexploited reserves. The ocean also has deposits of gravel, sand, manganese crusts and nodules, tin, gold, and diamonds. Many of these deposits are located in coastal areas where potential environmental problems associated with their exploitation may be so serious that they cannot now be mined in a responsible manner. Many of the mineral deposits about which little is known occur in the deep ocean on underwater volcanos and ocean ridges, or on the flanks of the more than 50,000 seamounts in the Pacific Ocean.

Perhaps more important than the search for minerals is the search for medications. Marine plants and animals have biotechnological potential in the treatment of a wide variety of human illnesses. Coral reefs, sometimes denoted as the rainforests of the sea, contain novel chemicals that can be used to fight cancer, AIDS, diabetes, and other diseases. Since the discovery of penicillin in mold more than 60 years ago, scientists have looked for potential drugs in soil microbes, and more recently, in marine microbes. While chemicals from land-based plants and microbial fermentation are on the decline, scientists have barely scratched the surface of the sea's molecular potential.

"Extremophiles", micro-organisms with the ability to thrive in extreme environments such as hydrothermal vents, hold promise for genetically based medications and industrial chemicals and processes. Their unique enzymes, called "extremozymes," enable them to function in such forbidding environments. Last year, the biomedical industry was foremost among industries worldwide which spent more than $2.5 billion searching for potentially useful enzymes. The newest frontiers for this search are the extreme ocean environments.

Some of the most critical exploration is happening closer to home in the shallow waters that surround us. While likely to have been unnoticed at the surface, scientists are working just below the waves to understand the coastal ocean and how human populations interact with it. An example is the underwater observatory, LEO-15, located in 15 meters of water just 10 km off the coast of Atlantic City. Using it, scientists can study estuaries and coastal waters, which are nursery grounds for some of the most important commercial fisheries, now under stress. The disposal of agricultural, industrial, and domestic waste, pressures from overfishing, and shipping are putting the coastal ocean at risk. Scientists are studying the effects of coastal development and the natural processes that circulate material from land into rivers, bays, lakes, and the ocean to determine the fate of contaminants in the environment, the critical role that chemical constituents play in the production of organic matter, and their impact on marine life. For example, scientists are trying to determine what changes in the environment, both natural and man-made, might be promoting the expansion of harmful algal blooms, the demise of coral reefs, the loss of fisheries, global warming, and other problems. Developments in the understanding of ocean chemistry, which are enhanced by rapid advancements in technology such as using molecular techniques to screen seawater samples for microbial populations, mean that researchers may eventually be able to forecast events in the coastal ocean, just the weather can be forecast now.

Perhaps the ocean's greatest unappreciated potential for humans has little to do with new medicines and products, oil, gold, or food. It is the chance to ponder, explore, and enjoy this realm. Recreational activities along waterfront communities such as clamming, crabbing, fishing, swimming, and iceboating are cultural traditions that have been handed down from one generation to another. Surfing is not a recent phenomenon , but a 1,000 year old tradition born in Hawaii. Water skiing, invented in the French Alps by a group of soldiers skilled at skiing the Alps, now has enthusiasts worldwide. Since the invention of the aqualung, millions of SCUBA divers have been given access to the earth's last frontier. Tourist submarines operating at more than 18 sites around the world for the past decade have carried more than six million passengers. Each participant considers himself to be an ocean explorer.

## NAVIGATING THE FUTURE

Exploring and improving our understanding of the ocean and its influence on global events are among the most important challenges today. With the approach of the next millennium, the Earth's ocean and the underlying seabed remain one of our planet's last frontiers. What lies ahead? Clues can be found in recent trends:

- *The United States is no longer the principal nation with interests and capabilities in exploring the oceans.*

  While France and the European Community have growing capabilities, over the past decade Japan has taken the global lead in deep ocean technology. Japan's Marine Science and Technology Center (JAMSTEC) has some of the world's most capable research vessels, including deep submersibles. JAMSTEC operates the world's deepest diving occupied submersible (6,500 m) and the deepest diving ROV (11,000 m). It recently placed into service the 8,600 ton Mirai, the world's largest oceanographic vessel. JAMSTEC's most ambitious project yet planned is a ship capable of drilling 3,500 m into the seafloor, to be launched early next century. In Japan, the ocean sciences enjoy broad popular and political support; their budget has grown at 15 percent per year during the past five years. JAMSTEC has expanded its research program to include life in extreme environments and climate change, and has used international collaboration to develop impressive research programs. The United States is not investing adequately to maintain its expertise, and this will have scientific and economic effects.

- *An end to the Cold War and cutbacks in defense spending have decreased development of new ocean technologies.*

  Large-scale development of ocean technology for military purposes has been reduced. As a consequence, the non-military sector is losing the sizable benefit it enjoyed for many years resulting from military development and operation of expensive ocean technology—i.e., the tools for ocean exploration. On the other hand, many of the expensive devices once not available outside the military community are now open for wider use. The bad news, however, is that civilian budgets in large part cannot afford to operate these capable but costly systems.

- *The need for manned presence under the sea is decreasing.*

  New technologies make it possible for humans to work beneath the waves without actually physically being there. For example, seafloor observatories, like the Long-term Ecosystem Observatory (LEO-15) off the coast of New Jersey, linked electronically to satellites and land-based stations, are being developed. Currently, our opportunities to know what's occurring in the ocean are limited. By combining submersible vehicles and sensors communicating acoustically to a network of moorings equipped with surface buoys and satellite links, scientists are getting a better idea of what's occurring at the seafloor in real time. Satellites like the Geosat and ERS-1 spacecraft, which were used to detect seamounts in the Pacific plate, will be used in combination with conventional seafloor mapping techniques. Assessments done via a number of technologies, including submersible vehicles, will become increasingly important. For many applications, remotely operated systems, which can perform more reliably and cost effectively, are superior to manned systems. Nevertheless, there will continue to be a role for the presence of humans under the sea as divers and in submersibles, especially when the mission is exploration.

- *The high cost of working in the oceans is forging partnerships between organizations that have not traditionally worked together.*

  Partnerships are being formed to support ventures that previously were the sole domain of government. For example, Aquarius, the world's only underwater laboratory, was removed from operation in the summer of 1996 because of lack of sufficient funding. Through an innovative partnership with private industry, the university community, and a private foundation, it was reconfigured and modernized to reduce operational costs, and returned to service in the fall of 1997. Additional partnerships to advance ocean interests are being encouraged and supported through the Congressionally created National Oceanographic Partnership Program.

## The Government Role

Exploration of new ocean frontiers holds the promise to enhance the future of the United States in a myriad of ways, and continued support for this endeavor is considered a vital national need (*Undersea Vehicles and National Needs*, 1996, National Research Council). How might this be accomplished? Japan has now taken the definitive lead in development of undersea capabilities. If the United States wants to retain its status in undersea science, a longer term commitment to support of ocean science and exploration is necessary. Some of the issues that need to be addressed are :

- Government support has always been critical for oceanographic research. The United States cannot maintain its expertise in ocean research unless and until adequate support is provided. Since the early 1980s, funding for ocean sciences, as a percentage of the total U.S. federal basic research base, has been reduced by nearly half.

- As responsible stewards of the environment, ocean exploration must be recognized as an important role within the missions of U.S. agencies charged with ocean-related responsibilities.

- A plan for undersea research that includes better access to assets, refinement and integration of existing systems, development of a strategic plan for future needs, and stable multi-year funding for ocean exploration is needed.

- The oceanographic community must capture the public's attention and imagination. While many space satellites have been launched, nothing comparable can be proclaimed for the ocean. Plans have been proposed for the first attempt of a self-powered autonomous undersea vehicle (AUV) to voyage between North America and Europe this year. Properly promoted, this AUV project could raise general public awareness about the value of marine exploration, and foster continued public interest and support.

- Teaching children about the wonder and science of the ocean may be the best investment for the future. In this new age of science and education technology, students can exchange the confines of the classroom and traditional textbooks for hands-on discovery and real time learning. In 1996, internet history was made when the only undersea laboratory devoted to science became the world's first underwater website. More than two million students had a virtual porthole via video screens to swim with sharks and reef fish, submerge in a nuclear submarine, and live in the underwater habitat Aquarius. This effort, which was part of the Jason Project, transported students via satellite to remote sites where scientists are engaged in research, enabling them to directly observe ongoing investigations of the biological and geological development of Earth. Other innovative examples exist for bringing the ocean into the classroom. Rutgers University has partnered with a number of other organizations to begin a program in New Jersey this past year using the underwater observatory, LEO-15. More innovative approaches such as these are needed to assure the next generation will be well informed stewards and explorers of the ocean.

Fantastic voyages to the planet's inner space are happening close to home in the waters that surround us, and are reminders that the ocean is still brimming with life that scientists are only just discovering. The ocean has been navigated for thousands of years, but exploration of the deepest parts of the ocean is just beginning.

Public opinion polls indicate that Americans care strongly about the ocean and are prepared to support ocean exploration over space exploration. According to a recent survey, eighty percent say that the condition of the ocean is a matter of personal importance. A full 55 percent give priority to funding ocean exploration over space exploration. The survey participants, nearly three quarters (72 percent), also see the health of the ocean as intimately connected to the future well-being of humankind.

## THE FUTURE

Ocean exploration gives mankind a sense of human progress and heritage. It provides the experience and knowledge necessary to undertake stewardship of the ocean and its resources, and thus sets a course for future generations to navigate. What lies ahead is still unknown. Whatever it is, however, will be influenced by what is found through tomorrow's exploration—and, will likely be different than today's predictions!

## REFERENCES

Achenbach, Joel, "The Genesis Problem," *The Washington Post Magazine*, November 2, 1997, pp.13-40.

Attaway, David H., *A Report on Marine Biotechnology in the National Sea Grant College Program*, December 31, 1996.

Broad, W., *The Universe Below*, Simon & Schuster, 1997.

Consortium for Oceanographic Research and Education (CORE), "Oceans 2000: Bridging the Millennia Partnerships for Stakeholders in the Oceans," Leveraging National Oceanographic Capabilities, Joint Hearing, January 25, 1996, pp. 682-719.

Carson, R., *The Edge of the Sea*, Houghton Mifflin Company, Boston, MA, 1955.

"Japan Plunges into Ocean Science," *Science*, Vol. 277, No. 5323, 11 July 1997, pp. 170-172.

Madigan, Michael T. and Marrs, Barry L., "Extremophiles," *Scientific American*, Vol. 276, No. 4, April 1997, pp. 82-87.

Marshall, N. and Marshall, O., *Ocean Life*, The Macmillan Company, 1971.

Smith, Walter H.F. and Sandwell, David T., "Global Sea Floor Topography from Satellite Altimetry and Ship Depth Soundings," *Science*, Vol. 277, No. 5334, 26 September 1997, pp. 1956-1962.

Stone, G. (ed.), "Military Assets for Environmental Research," *Marine Technology Society Journal*, Vol. 27, No. 4, 1994.

"The Global Abyss: An Assessment of Deep Submergence Science in the United States," UNOLS
DESSC Committee, September 1994, 53 pp.

The Mellman Group Survey, "Americans Continue to Worry About the Decline of the Oceans," 1997.

Thurman, Harold V., *Essentials of Oceanography*, Charles E. Merrill Publishing Co., Columbus, OH, 1983.

*Undersea Vehicles and National Needs*, The National Research Council. National Academy Press, Washington, DC, 1996.

Weber, M. and Gradwohl, J., *The Wealth of Oceans*, W.W. Norton & Company, 1995.

Wessel, Paul, "Sizes and Ages of Seamounts Using Remote Sensing: Implications for Intraplate Volcanism," Science, Vol. 277, No. 5327, 8 August 1997, pp. 802-805.

Wilson, E. , Eisner, T, et al., *Life on Earth*, Sinauer Associates, Inc., 1973.

*U.S. GOVERNMENT PRINTING OFFICE 1998/432-031