APPENDIX 5

to the Final Report

# Inventory of U.S. Ocean and Coastal Facilities

U.S. Commission on Ocean Policy

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# Contents

# Introduction to the Inventory

## Chapter 1



The oceans and coastlines bordering the United States are critical to our culture, our economic well-being, and our environmental health. As important as they are, it is difficult to accurately characterize and assess such large and diverse resources. To provide a foundation for building a cohesive national ocean policy, Congress created the U.S. Commission on Ocean Policy, an independent group of qualified citizens impaneled to review the state of marine-related issues and the effects of federal ocean-related laws and programs. Members were drawn from federal, state, and local government; private industry; academic institutions; and public interest groups involved in marine issues.

The Commission, created by the Oceans Act of 2000[a] and appointed by the President in June 2001, is specifically mandated to make recommendations for a coordinated and comprehensive national ocean policy. One of the key requirements of the Oceans Act is for the Commission to conduct "an assessment of existing and planned facilities associated with ocean and coastal activities including human resources, vessels, computers, satellites, and other appropriate

[a] *Public Law 106-256.*

platforms and technologies." The Commission grappled with defining the extent of what this effort should entail, and decided that it would cast a wide net to cover federal and state government, academia, and private-sector facilities. To the best of our knowledge this is the first attempt to capture all this information in a single assessment report to present the full national capability.



# 1.1 Purpose of the Inventory

This Appendix to the Final Report of the U.S. Commission on Ocean Policy is an inventory of current national coastal and ocean facilities. It supports the Final Report by providing an assessment of existing and planned facilities associated with ocean and coastal activities, including human resources, vessels, computers, satellites, and other appropriate platforms and technologies, as required by Congress. An accounting of facilities and resources provides a foundation for adequately assessing our capacity to conduct coastal and ocean activities. The status and condition of these facilities must be assessed to proactively plan for appropriations that ensure uninterrupted and robust implementation of ocean policy.

For the purposes of this Appendix, an "ocean and coastal facility" is defined as the infrastructure and associated human resources that directly support maritime operations, and ocean and coastal research, monitoring, and education or outreach activities. "Facilities" is a purposefully broad term, used with the intention of capturing as much valuable information as possible for the purposes of informing sound policymaking and investment of resources.

# 1.2 Methodology

To collect information for this inventory, the Commission drew data from a wide variety of resources and reached out to a broad range of interested parties. The primary sources of information for this report are:

- Materials the Commission requested from federal agencies
- Materials the Commission requested from coastal states, including the Great Lakes states and the U.S. territories and freely associated nations
- Materials the Commission requested from the ocean industry sectors
- Testimony to the Commission during its public hearings
- Internet searches of pertinent web sites and data bases
- Consultation with various technical publications.

For Chapter 5, which addresses education, the primary source of information is a report from a survey of academic institutions prepared by the Consortium for Oceanographic Research and Education.

Two other important sources of information are the May 2003 Naval Review issue of the journal *U.S. Naval Institute Proceedings*,[b] and the *Sea Technology Buyers Guide Directory*.[c] The Naval Review provides an excellent review of the U.S. Coast Guard and the U.S. Merchant Marine and maritime industry, including descriptions of current assets and plans. The *Sea Technology Buyers Guide Directory* provides an inventory of oceanographic research and geophysical survey vessels and a description of the institutions that own or operate these vessels.

As expected for this first-time effort, there is great variability in the quality and quantity of available data. The depth and scope of the information the Commission received were not uniform, resulting in an uneven level of detail. The inventory is a snapshot in time, and readers should bear in mind that the data compiled here were reported and collected over 18 months in 2002 and 2003. A snapshot has limited value unless it is used as a baseline to improve our understanding and assessment of national capacities for coastal and ocean-based activities. This inventory establishes a baseline of available resources, assets, and facilities that support coastal and ocean activities, and provides a benchmark for shaping and measuring future efforts. Some type of inventory assessment should be conducted regularly to ensure that national ocean policy decisions are based on a current, solid understanding of capabilities.

To facilitate the facilities inventory, the coastline was divided into eight regions, using the framework of the Fisheries Management Councils as a model. The eight regions are the Great Lakes; Northeast (Maine to Connecticut); Mid-Atlantic (New York to Virginia); South Atlantic (North Carolina to Key West, Florida); Gulf of Mexico; West Coast (California, Oregon, and Washington); Alaska; and Western Pacific (Hawaii, Guam, American Samoa, and Northern Marianas).

The Inventory of U.S. Coastal and Ocean Facilities is segmented into four chapters:

- Maritime commerce and transportation
- Ocean and coastal safety and protection
- Research, exploration and monitoring
- Marine education and outreach.

The maritime commerce and transportation chapter addresses facilities that rely on the coastal and ocean environments to support marine-related commerce and transportation, and covers both the marine transportation system and marine-related activities and operations. The marine transportation system examines domestic and international trade, coastal ports, shipbuilding, the U.S. Merchant Marine, and aids-to-navigation.

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[b] *U.S. Naval Institute. 2002. Naval Review. U.S. Naval Institute, Annapolis, Maryland. Proceedings. Vol. 126(5), May 2002.*

[c] *Sea Technology. 2003. Sea Technology Buyers Guide Directory 2003. Compass Publications, Arlington, Virginia. January 2003.*

Marine-related activities and operations include passenger ferry systems, cruise lines, commercial fisheries, recreational activities, transoceanic cables, and marine dredging and salvage.

The chapter on ocean and coastal safety and protection addresses federal facilities that preserve and protect people and natural resources found in or near the coasts and oceans. There are four sections in the chapter: natural resource management, navigation and marine safety, maritime security and enforcement, and environmental protection and response.

Research, exploration and monitoring addresses facilities used by the scientific community to detect and describe the processes occurring in the coastal and ocean environment, and to observe the natural and human-induced changes occurring in the marine environment. This section presents information on seven types of facilities: laboratories, vessels, underwater vehicles, aircraft, satellites, ocean-observing systems, and computers for data storage, data dissemination, and modeling.

The final chapter of this Appendix, marine education and outreach, describes the existing facilities used to educate, train, and transmit knowledge. It encompasses three major topics: formal education, virtual education facilities, and informal education. The formal education discussion addresses the academic institutions of higher learning that train the nation's future marine-related workforce. Virtual education facilities include the dissemination of information through the Internet, and materials and programs provided by federal agencies. Informal education includes the dissemination of information to the public and schoolchildren at marine protected areas, zoos, aquariums, museums, and other similar institutions.

## 1.3 Using This Appendix

Following this introduction, there are four technical chapters as described above. References are numbered and compiled at the end of each chapter. Lowercase letters denote footnotes, found at the bottom of the page. Some information too lengthy to include in the chapters is provided as supplemental material at the end of the document. A list of acronyms is also found at the end of the Appendix.

# Maritime Commerce and Transportation

## Chapter 2

***Marine Transportation System***

***Marine Industries***

Maritime commerce and transportation are important sectors of the U.S. economy — they include international import and export of goods, domestic supplies of oil and natural gas to meet energy needs, and international broad-band communications. This chapter addresses the waterborne movement of people, cargo, and information for commercial, recreational, and governmental purposes. Unlike the other chapters in this Appendix, which focus on all aspects of U.S. facilities, this chapter discusses facilities pertaining to maritime commerce and transportation specifically in an economic context, with the intent of capturing their financial impact on the United States. This chapter divides maritime commerce and transportation into two major sections: the Marine Transportation System (MTS) and Marine Industries.

The MTS is a collection of waterways, ports and their intermodal connections, vessels, and vehicles that are used to transport cargo and people. For this inventory the MTS is divided into three general branches: the transportation of cargo, the transportation of passengers, and the industries that support the MTS. These branches are further broken into 11 segments that are discussed in this chapter:

- Overview of U.S. Waterborne Commerce — addresses the current status of international trade
- Shipping Vessels — describes vessels used in the MTS for cargo transportation
- Trends in Shipping and Cargo Movement — examines possible future trends in shipping and the movement of cargo
- U.S. Coastal Ports System — discusses the regional differences associated with handling waterborne cargo
- Marine Terminals and Intermodal Connections — addresses the movement of cargo after it has been offloaded by other means (e.g., truck, rail)
- U.S. Merchant Marine — examines the capabilities of the U.S. fleet and associated federal maritime defense programs
- U.S. Passenger Ferry System — addresses the transportation of passengers and vehicles over short distances for commuting and recreational purposes
- U.S. Cruise Industry — discusses the transportation of passengers for vacation and recreational purposes
- U.S. Shipbuilding and Repair Industries — describes the ship construction process and provides a snapshot of the national shipbuilding and repair capabilities
- U.S. Marine Salvage and Dredging Industries — describes the U.S. capabilities for recovering damaged vessels and maintaining safe waterways
- Aids-to-Navigation — describes private-sector methods of indicating areas that are safe for vessel movement.

While the facilities of the Marine Transportation System are connected through the movement of cargo and people, the activities described under Marine Industries are not related. Because this sector is so broad and encompasses numerous potential facilities, the U.S. Commission on Ocean Policy (the Commission) selected four facilities it considers economically important. For the purposes of this Appendix, the Marine Industries sector covers U.S. offshore natural gas and oil production, transoceanic communications, U.S. commercial fishing, and marine recreational industries.

# 2.1 Marine Transportation System

The Marine Transportation System is an informal system comprising both physical infrastructure (e.g., ports, vessels) and associated human components (e.g., shipbuilders, merchant marines) that has evolved to handle the movement of waterborne commerce and passengers. Nearly every federal, state, local, and private marine resource that assists with the movement of cargo and passengers falls under this system, from the construction of a vessel to the delivery of its cargo. The MTS does not include activities that support the individual segments, such as the construction of the diesel engine that is used in a ship. This section describes the MTS and the associated economic impact of its components.

The movement of cargo can be measured in two ways: by the volume shipped, or by the value of the cargo. These different measurements provide disparate views on the economic impacts of cargo imported and exported through the U.S. coastal ports system. For example, if measured by volume, ports along the Gulf of Mexico import and export the majority of the cargo. Ports in California, however, typically handle higher-value cargo. The differences among the volume and value of cargo handled lead to significant regional concentrations in terms of the types of vessel calls at a port and the conditions of intermodal connectors. This section examines these aspects in order to provide greater insight into the financial impacts on U.S. commerce and transportation.

The Marine Transportation System is an informal system comprising both physical infrastructure and associated human components that has evolved to handle the movement of waterborne commerce and passengers.

## 2.1.1 Overview of U.S. Waterborne Commerce

Waterborne commerce is cargo that is moved between countries and states using surface ships. Between 1991 and 2000, total U.S. international trade in cargo (exports and imports) more than doubled, from $910.2 billion dollars to almost $2 trillion.[1] In 2001, ships carried 78 percent of U.S. international merchandise trade by volume and more than 38 percent by value, as compared to other modes of transport (e.g., truck, rail).[2] The MTS supported the domestic transport of 362 million tons of U.S. products.[3] Another 1.2 billion tons of U.S. products valued at approximately $719.4 billion were exported to foreign markets through U.S. coastal and Great Lakes ports.[2] Overall, there has been a gradual increase in the U.S.-foreign (i.e., produced in the United States for export) tonnage moved between 1999 and 2001. The value of this cargo decreased by $18 billion between 2000 and 2001, following a $64.8 billion increase between 1999 and 2000.[a]

The 1.2 billion tons of U.S-foreign cargo handled in U.S. ports in 1999 directly and indirectly helped to employ approximately 1.1 million Americans. The cumulative wages for those individuals was $43.8 billion, an average of $40,220 per person, which is considerably above the national average of $29,386.[4] WEFA, a private economic analysis firm, reports that

The 1.2 billion tons of U.S.-foreign cargo handled in U.S. ports employed more than a million Americans in 1999.

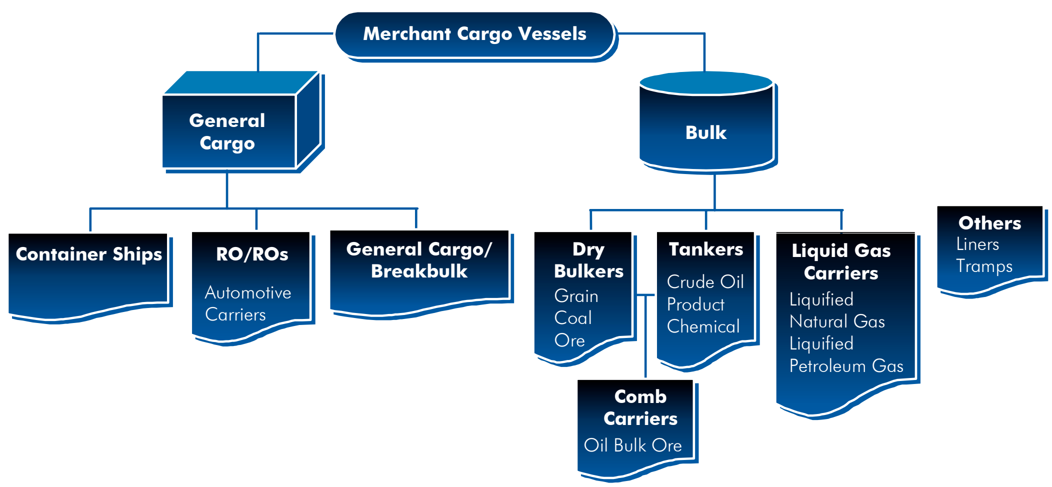
[a] *One limitation in assessing the international shipping industry is that foreign ships frequently are owned in one country, registered in a second country, managed from a third, and manned by an array of international seafarers. Of the 855 vessels that list the United States as their country of domicile, 620 vessels are foreign flagged.*

approximately 4.9 million Americans are employed as a result of producing goods for waterborne export, including nearly 840,000 in farming and food processing, 757,000 in electronics and electronics equipment, and about 620,000 in the industry sector encompassing automobile, farm equipment, and transportation equipment manufacturing.[5] Between 1993 and 1999, direct employment for transportation grew by approximately 5.5 percent.[6] Employment is estimated to continue to increase by 0.5 percent annually through 2004, at which time 176,000 people are expected to be employed in the industry. By 2020, U.S.-foreign maritime trade is expected to be more than double 1996 tonnage levels, with total tons exported projected to grow 3.5 percent annually.[7] This could increase employment rates in the United States.

## 2.1.2 Shipping Vessels

The MTS is served by a variety of vessels designed to facilitate movement of cargo of all types. These vessels can be classified into two major categories: general cargo and bulk (Figure 2-1).[8] General cargo refers to vessels that carry cargo that has been containerized, palletized, or is otherwise too large to be handled by conventional bulk-type techniques. General cargo vessels encompass a wide variety of vessel types, including container ships and roll-on/roll-off vessels (RO/ROs). The term general cargo vessel, however, is more commonly applied to smaller vessels with diverse cargo-handling capabilities.

**Figure 2-1: Merchant Cargo Vessel Categories**




*Merchant cargo vessels are characterized as general cargo or bulk: general cargo vessels typically handle high-value cargo while bulk cargo vessels typically handle high-volume cargo.*

Bulk vessels are ships that carry homogeneous cargo, either in particle or liquid form, which can be transferred by pumps, blowers, conveyers, or grab buckets. Bulk vessels typically carry the largest quantity of cargo by weight and volume, yet the cargo generally is relatively low-value as compared to general cargo. Table 2-1 describes the most common types of vessels and their capabilities.[8]

**Table 2-1: Description of Common Maritime Vessels**

| | Vessel Type | Capabilities |
|---|---|---|
| GENERAL CARGO | Container ship | Carry cargo that has been unitized by packing it into standard-size containers |
| GENERAL CARGO | Liner | A vessel that operates along definite routes on the basis of fixed schedules; generally involves hauling general cargo as distinct from bulk cargo |
| GENERAL CARGO | RO/RO | Cargo is wheeled onto the vessel; have faster cargo-handling rates and shorter port time than most other types of ships |
| GENERAL CARGO | General Cargo/ Breakbulk | Flexible and adaptable to handle most kinds of cargo, typically have some provisions for cargoes other than packaged dry cargo |
| BULK | Bulk Carrier | A single-decked carrier designed to carry dry cargo, such as grain, contained in holds without packaging; usually loaded and discharged by shore-side cargo-handling gear |
| BULK | Tanker | A single-decked carrier designed to transport liquid cargo, such as petroleum products, through an arrangement of connected or independent tanks |
| BULK | Liquified Gas Carrier | Transport liquid petroleum gas or liquid natural gas; differences in the substances' physical properties mandate different vessel designs |
| BULK | Tramp | A vessel that does not operate along a definite route on a fixed schedule, but calls at any port where cargo is available |
| BULK | Other | Includes product carriers, parcel tankers, and chemical tankers |

Typically, liners carry high-value cargo, and tankers and tramps carry higher volumes of cargo (Table 2-2). The different cargo capacities of the vessels result in regional differences in the type of cargo handled, as the typical type of vessel calling at a port determines the equipment at that facility.[9] For example, a port with primarily tanker calls will have the equipment necessary to unload bulk products, while a port with primarily liner calls will have cranes and other equipment necessary to unload the unitized cargo.

**Table 2-2: Value and Weight of Cargo Carried by Common Maritime Vessels**

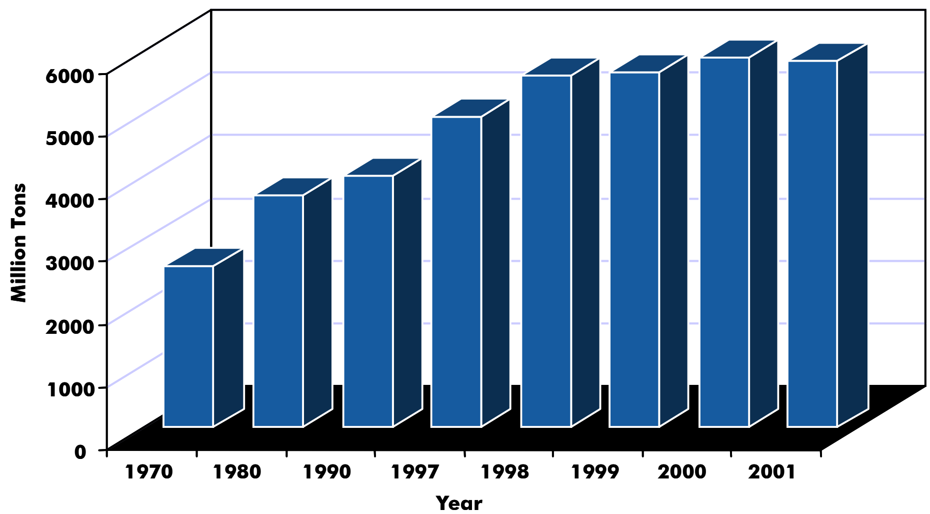
| Type of Ship | 1999 | | 2000 | | 2001 | |
|---|---|---|---|---|---|---|
| | Value (billions) | Weight (million metric tons) | Value | Weight | Value | Weight |
| **Liner** | $471.3 | 142.3 | $484.9 | 148.7 | $488.9 | 150.4 |
| **Tanker** | $78.4 | 586.7 | $126.6 | 601.1 | $112.8 | 628.1 |
| **Tramp** | $122.8 | 400.6 | $125.8 | 408.0 | $117.8 | 382.9 |
| **Total** | $672.6 | 1,129.6 | $737.4 | 1,157.8 | $719.4 | 1,161.4 |

*Liners typically move high-value cargo, while tankers and tramps typically carry high-volume cargo.*

## 2.1.3 Trends in Shipping and Cargo Movement

Over the next 25 years, world population is projected to grow from 6.1 billion to 7.9 billion people.[11] The population growth will result in an increased demand for goods. Although tonnage shipped has become relatively stagnant since 1998 and actually decreased slightly between 2000 and 2001, the amount of cargo carried by waterborne vessels has more than doubled since 1970[b] (Figure 2-2).[12] The projected increases in the population and foreign waterborne commerce, coupled with the decreasing capabilities of the U.S. port and intermodal system, indicate a need for future development of the MTS.

**Figure 2-2: Trend in International Waterborne Cargo Tonnage (selected years)**




*International waterborne trade has increased steadily, from 2,566 million tons in 1970 to 5,832 million tons in 2001.*

During the 1999 to 2004 period, U.S. liner trade (imports and exports) is expected to grow 5.3 percent per year, compared with 2.0 percent for the nonliner trade and 2.2 percent for the tanker trade. Overall, the Department of Commerce expects U.S.-foreign waterborne trade to grow 2.1 percent between 1999 and 2004, down from the 4.2 percent growth during the previous 5 years. Inland waterways and Great Lakes trading activity is predicted to slightly increase during that period.[6]

According to the Department of Commerce, the growth of world waterborne trade generally will exceed fleet growth over the next five years. Many ships in the U.S. commercial fleet, however, are nearing 25 years of service and will need to be upgraded or replaced.[6] Increased waterborne trade coupled with the diminishing and aging capabilities of the U.S. commercial fleet could result in a smaller role for it, if the U.S. fleet is not capable of handling additional cargo.

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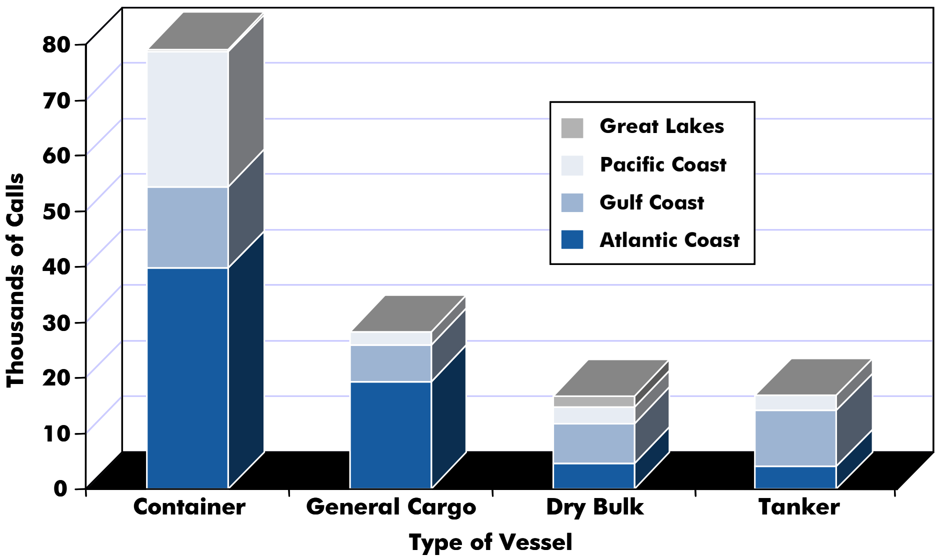
b *Includes international cargoes loaded at ports of the Great Lakes and St. Lawrence systems for unloading at ports of the same system.*

The total number of calls at U.S. ports is also expected to increase between 2000 and 2020, particularly on the Atlantic Coast (Figure 2-3). Container vessels are expected to experience the greatest growth, increasing by almost 80,000 port calls over the 20-year period. The projected increases in waterborne trade and the number of calls at ports will likely result in an increased value of goods traded along the Atlantic Coast.[8]

**Figure 2-3: Projected Total Increase in Annual Number of Port Calls**




*Container ships, which typically carry high-value cargo, are projected to have the greatest increase in annual number of port calls over the next 20 years.*

## 2.1.4 U.S. Coastal Ports System

Ports are the focal points of the MTS. The majority of cargo imported into and exported from the United States moves through a widely distributed network of 326 coastal, Great Lakes, and shallow-draft[C] ports with the capacity for loading and unloading cargo and passengers. This system is supporting an increasing volume of cargo. For example, in 2000, the U.S. port system handled more than 2 billion metric tons of foreign and domestic waterborne cargo.[8] While state and local authorities often govern these ports, many facilities are privately owned. Eighty-seven percent of inland waterway facilities and 66 percent of coastal and Great Lakes facilities are privately held.[7]

Two major types of port facilities support the movement of cargo: (1) deep-draft seaport and Great Lakes port facilities, and (2) inland river and intracoastal waterways, and shallow-draft port facilities. The main activities at these facilities include cargo handling and storing, piloting, stevedoring (the loading and unloading of cargo and passengers), and docking of vessels.

Most imported and exported cargo in the United States moves through a widely distributed network of 326 coastal, Great Lakes, and shallow-draft ports, which handled more than 2 billion metric tons of foreign and domestic waterborne cargo in 2000.

[C] *A ship's draft indicates how deep the ship sits in the water.*

### 2.1.4.1 Deep-Draft Ports

The majority of waterborne cargo is handled in deep-water ports, which are typically at least 25 feet deep. Water depth is important because deep water allows for larger vessels to enter the port. Generally, the deeper the water, the greater tonnage the vessel can handle, although it is not the only element in determining the type of cargo a port typically receives. The U.S. deep-draft port system includes 50 major ports and 300 federal harbor channel projects.[d] Federal channel projects are those where the federal government is involved in some capacity with channel maintenance. Although some ports naturally have deep water, most harbor channels have been deepened. Deepening projects may include breakwaters, seawalls, channel-control structures, dredged material disposal sites, drift removal components, and other related features (marine dredging is discussed later). There is no one-to-one relationship between ports and federal channels; some U.S. ports contain several federal harbor channel projects, while others have none.

In 2000, the Gulf, Mid-Atlantic, and Great Lakes regions accounted for almost 90 percent of the waterborne commerce by volume, led by the ports of South Louisiana and Houston along the Gulf of Mexico.[10] Foreign imports provided the largest volume of cargo at U.S. ports on the Gulf of Mexico. The Mid-Atlantic ports handled the second greatest volume (20 percent) and the Great Lakes region was third (17 percent).[e]

In 2000, only three ports, South Louisiana, Houston, and New York, handled over 100 million tons of cargo. Additionally, the ports of Long Beach and Los Angeles also handled over 100 million tons combined (data on the ports of Long Beach and Los Angeles are often reported together as the Long Beach/ Los Angeles Port Complex). Several ports handle specific types of cargo. For example, the ports of Huntington, Pittsburgh, and St. Louis only handle domestic commerce. Other ports primarily handle foreign cargo. Houston, Los Angeles, and Philadelphia handled at least twice as much foreign cargo as domestic cargo. All six of these ports are in the top 25 ports when ranked by the total volume of cargo handled. Generally, ports located inland tend to handle more domestic cargo, although the differences in the amount of foreign and domestic cargo handled are not typically as vast as those described above.[8] Supplement 2-1 lists all U.S. ports that handled more than one million tons of cargo in 2000.

There are some differences between the principal commodity groups typically carried for foreign and domestic waterborne commerce. Foreign commerce includes exports and imports moved between the United States and foreign countries, while domestic commerce includes goods shipped between states. By volume, petroleum and petroleum-related products is the largest principal commodity group handled by ports in the United States, for both foreign and domestic commerce. Merchant vessels entering U.S. ports carried over one

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[d] *A harbor channel is the entry to a port.*

[e] *These calculations are based on the total tonnage of cargo shipped and do not take into account duplication in reporting.*

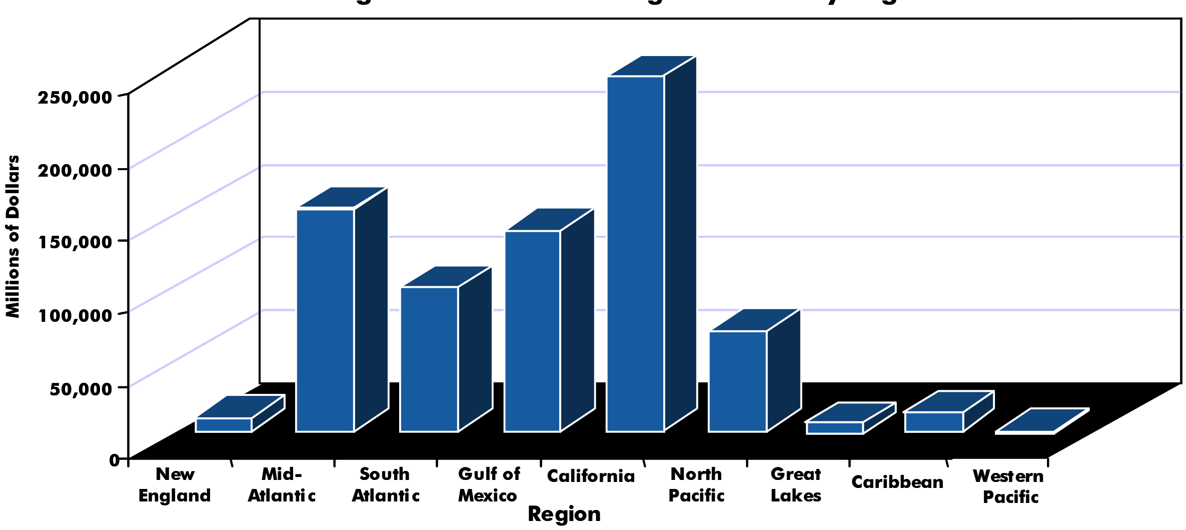
billion short-tons of petroleum products, which represents over 38 percent of the total cargo handled by volume (approximately 35 percent of domestic commerce and nearly 50 percent of foreign commerce). The differences between foreign and domestic commerce are in other commodity groups. For example, over three times as much coal and almost twice the amount of crude materials were moved domestically compared to foreign commerce.[8]

Figure 2-4 illustrates the value of the commerce handled by ports on a regional basis.[13] West Coast ports, specifically California (through trading with the Asian market), tend to handle cargo with higher dollar values than Gulf ports, even though a substantially greater amount of tonnage moves through the Gulf ports. This differential is primarily due to the type of cargo handled. California ports handle many high-value electronic goods, while the Gulf of Mexico ports primarily handle greater volumes of dry bulk cargo.

Ports differ in the types of trade they support and geographic factors (e.g., size of the local import market and the transit time from a U.S. port to key inland points); intermodal transportation capabilities (e.g., on-dock rail facilities and access to interstate highway systems); and cargo throughput factors (e.g., specialized technologies and terminals for different types of commodities, space available for port expansion). The capabilities and location of the port affects whether it handles large amounts of cargo by tonnage or value. In 2001, Mexico, Venezuela, Canada, Saudi Arabia, and Japan were the United States' top waterborne trading partners.[2]

While Figure 2-4 and Supplement 2-1 show the regional differences when measuring cargo by volume or by value, they do not show that trading tends to be heavily concentrated at large ports and is not evenly dispersed, nationally or regionally. For example, 45 percent of the total foreign tonnage

**Figure 2-4: Value of Cargo Handled by Region**




*In terms of dollar value of cargo, ports in California handled the greatest amount in 2000.*

*Note: California is presented separately because the quantity of commerce handled far exceeds the rest of the Pacific Region. The North Pacific Region includes Alaska, Washington, and Oregon.*

is handled at ports along the Gulf of Mexico. Individually, 7 of the top 10 ports for handling cargo by tonnage are located in the Gulf of Mexico region. In 2000, the top 50 ports — coastal and inland — handled 70 percent of the total waterborne trade. Even with this high degree of concentration, 148 ports handled more than 1 million metric tons of cargo in 1997.[10] This concentration is not limited to tonnage alone. In 2000, the top 5 ports by value were responsible for a combined $356 million in trade. The next 45 ports handled a combined $358 million in cargo. Summaries of 51 ports are provided in Supplement 2-2, identifying each port's geographical location, how the port is administratively organized, major commodities moved by the port, major foreign and domestic markets, the current state of the port's infrastructure, and planned improvements.

Even within particular coastal regions, cargo tends to be concentrated among a few ports. For example, the Los Angeles-Long Beach port complex handles approximately 80 percent of all waterborne trade by both value and tonnage in California, and the Port of New York and New Jersey handles roughly 50 percent of Mid-Atlantic traffic by value. Along the Gulf Coast, the Port of Houston manages almost 30 percent of the cargo value in that region, although less than 17 percent of the cargo tonnage. The Pacific Northwest is similar; Seattle and Tacoma, both on the Puget Sound, account for almost 75 percent of the total value of cargo handled within the Northern Pacific region.

These differences reflect the types of vessels calling at U.S. ports. For example, in 2000, approximately 43 percent of all container ship calls on the Pacific Coast were made at the Los Angeles-Long Beach Port complex, representing almost 20 percent of all container ship calls nationwide. As container ships tend to transport high-value items, this heavy concentration of calls at Los Angeles-Long Beach accounts for the port's 80 percent market share of waterborne trade by value in that region. The Port of New Orleans handles over 50 percent of the bulk vessels calls within the region and 23 percent of the nationwide total of bulk vessel calls.[14]

### 2.1.4.2 Shallow Ports

In 1999 there were 1,812 river terminals located in 21 states.[7] The majority of inland facilities (59 percent) are designed for dry bulk transport by barges. The shallow depth of these ports prevents their use by large ocean-going container ships. The advantage of shallow ports is that they have almost limitless access points to the waterways; however, they are unable to handle heavy cargo loads. Data for shallow ports were not readily available for discussion in this Appendix.

## 2.1.5 Marine Terminals and Intermodal Connections

Marine terminals are areas at a port designed for loading and unloading cargo or passengers from a vessel. Marine terminals are generally funded by private-sector investment, although some are funded publicly through state and local agencies, such as port authorities. In 1998, for example, deep-draft public port authorities invested $1.4 billion in capital expenditures (such as terminal improvements, dredging, and intermodal projects) and estimated that they would spend $9.1 billion on capital investments over the next 5 years (1999-2003).[15]

Table 2-3 shows the distribution pattern of the major U.S. seaport terminals by coastal region.[16] There are 1,914 terminals comprising 3,158 berths (the space along a dock where a vessle is moored), including both privately and publicly owned facilities. General cargo berths are the predominant type of berth in all regions except the Great Lakes. Dry bulk facilities account for the majority of berths in the Great Lakes region.

**Table 2-3: U.S. Seaport Terminals and Berths, by Coastal Region (1997)**

| Coastal Region | Number of Terminals | Percent of Total | Number of Berths | Percent of Total |
|---|---|---|---|---|
| North Atlantic | 421 | 22.0 | 761 | 24.1 |
| South Atlantic* | 197 | 10.3 | 349 | 11.0 |
| Gulf of Mexico | 484 | 25.3 | 786 | 24.9 |
| South Pacific** | 223 | 11.6 | 414 | 13.1 |
| North Pacific*** | 249 | 13.0 | 365 | 11.6 |
| Great Lakes | 340 | 17.8 | 483 | 15.3 |
| Total | 1,914 | 100.0 | 3,158 | 100.0 |

*The Gulf of Mexico, the North Atlantic, and the Great Lakes regions have the greatest number of terminals and berths, and handle the highest volumes of cargo.*

* Includes Puerto Rico and the U.S. Virgin Islands.
** Includes Hawaii.
*** Includes Alaska.

Marine terminals are highly dependent on efficient access to other modes of transportation (e.g., trains, trucks, airplanes). These linkages, known as intermodal connections, are situated at land-water boundaries and allow the transfer of cargo and passengers between different modes of transportation. There are three major types of intermodal connections to marine terminals: rail, pipeline, and highway. Private-sector investments typically fund rail and pipeline development projects, while highway connections receive primarily public funding with some private funding.

Importers, exporters, and domestic suppliers depend on the U.S. port system as one component of the intermodal transportation system. With its connections to inland delivery systems (rail and highways), the coastal ports system conveys raw materials and manufactured goods between producer and consumer. In 2001, ships carried 78 percent of U.S. international merchandise trade by volume and more than 38 percent by value (Table 2-4).[2] Excluding trade with Canada and Mexico, waterborne international trade accounted for over 99 percent of all U.S. international trade by tonnage and 60 percent by value.

Shipments of intermodal freight are increasing at a faster rate than freight moved by single modes, although single freight shipments still account for

**Table 2-4: U.S.-Foreign Trade, by Mode (2001)**

| Mode | Weight (millions of short tons) | Percentage (by volume) | Value (billion U.S. dollars) | Percentage (by value) |
|---|---|---|---|---|
| Water | 1,276 | 77.7 | 718 | 38.4 |
| Air | 6 | 0.4 | 519 | 27.7 |
| Truck | 180 | 11.0 | 395 | 21.1 |
| Rail | 97 | 5.9 | 93 | 4.9 |
| Pipeline | 79 | 4.8 | 26 | 1.4 |
| Other | 4 | 0.2 | 121 | 6.5 |
| Total | 1,643 | 100.0 | 1,837 | 100.0 |

*Shipping is the dominant mode of transport for U.S.-foreign cargo, handling 78 percent of cargo volume and 38 percent of cargo value.*

approximately 80 percent of the value and 98 percent of the tonnage moved. These statistics represent all intermodal transportation, not simply cargo originating at a port; however, they do highlight the role of intermodal transportation in the United States.

The U.S. Department of Transportation (DOT) reports diminished conditions at intermodal connectors and port access locations. It concluded that these diminished access capabilities could adversely affect future cargo movement, especially if containerized cargo trade, which tends to be of higher value and more time-sensitive than bulk cargo, increases as predicted.[14,17] Problems frequently cited by DOT include poor local road and rail access, inadequate channel depth, and lack of available traffic information.

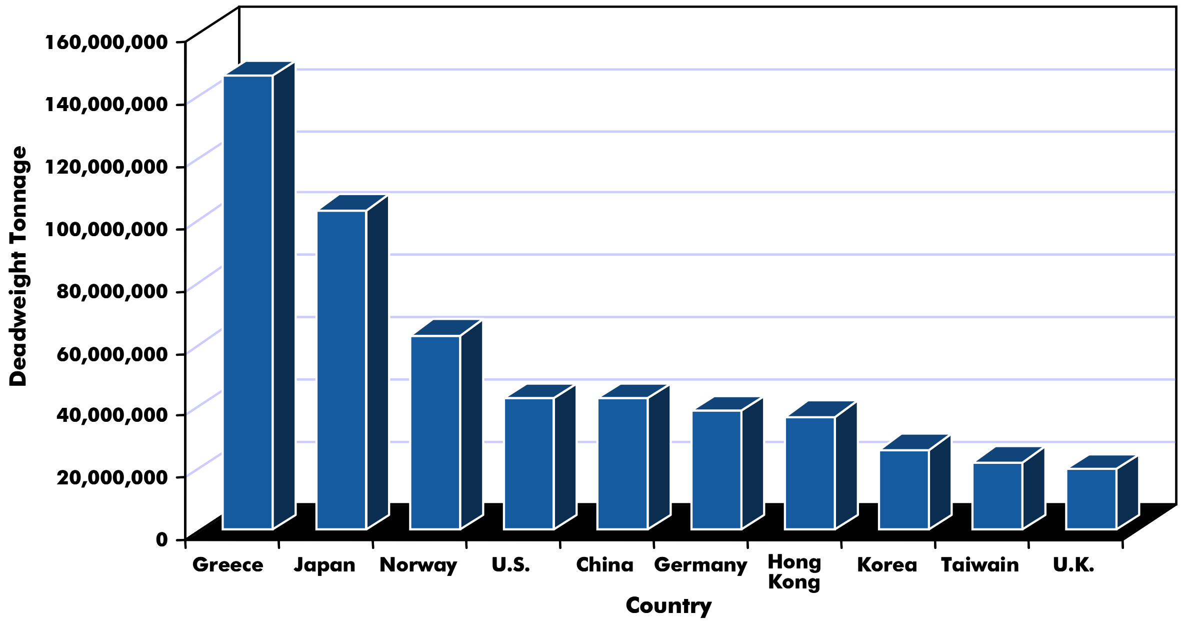
A study by the U.S. General Accounting Office in 2002 identified a need for all levels of government to recognize the interrelatedness of the entire surface and maritime transportation system, and to address transportation with a unified approach rather than focusing on specific modes or types of travel.[18]

## 2.1.6 U.S. Merchant Marine

The U.S. Merchant Marine is a fleet of nongovernmental ships that handles waterborne commerce during peacetime and becomes a naval auxiliary during wartime to deliver troops and equipment. Prior to World War II, international water commerce relied on a huge fleet of relatively small ships; however, since then, the U.S.-flag merchant fleet has been steadily declining. In 2002, the United States ranked eighteenth in the world in the number of ocean-going merchant vessels and fourth in the deadweight tonnage capacity of those vessels (Figure 2-5). This represents approximately five percent of the world's tonnage capacity.[17]

One reason for the decrease in the number of vessels in the U.S. fleet is that many nations have built an international maritime presence. These registries do not have the same requirements regarding protection of seafarer health, welfare and safety as U.S.-flag vessels. Consequently, companies have a financial incentive to register under non-U.S. flags. In addition, foreign-flag vessel owners do not pay any corporate income taxes on the revenue earned in

**Figure 2-5: Deadweight Tonnage Capacity of Major Maritime Countries (2002)**




*In 2002, the U.S. Merchant Marine ranked fourth in the world for deadweight tonnage capacity.*

U.S. foreign commerce. By comparison, vessels operating under the U.S. flag are subject to all the taxes and regulations applicable in the United States, resulting in higher costs for ownership and operation.

Changes in maritime technology and reduction in crew sizes have also contributed to a decrease in the U.S.-flag industry's supply of vessels and manpower. Vessels are larger but require a smaller operating crew. The average capacity of cargo vessels in the U.S.-flag fleet is nearly 28,000 deadweight tons (DWT), compared to 12,000 DWT in 1970. The size of the U.S.-flag fleet has declined in recent years, but the productivity has improved substantially. The U.S.-flag foreign trade liner fleet handles 42 percent more cargo than in 1970, but in fewer, larger vessels.

While the U.S. Merchant Marine operates primarily within the MTS to move cargo, the U.S. military can also use the vessels to move personnel and equipment. DOT's Maritime Administration (MARAD) and the U.S. Department of Defense (DoD) operate several programs that use commercial vessels for military purposes, discussed below. Non-military crews operate both government and private vessels under these programs. Some of the vessels operate continuously for DoD, and some operate only when needed.

The Maritime Security Act of 1996 established the Maritime Security Program to support a fleet of U.S.-flag commercial vessels and American-citizen crews necessary for military purposes. Funding for the program has permitted 47 ocean-going vessels (through 12 total operators) to participate in the program. Eligible vessels are subject to one-year renewable contracts, and funding for the program is subject to annual appropriations from Congress. During peacetime, participating vessels are typically involved with deep-sea international trades; however, participating vessel operators are required to make their ships and other commercial transportation resources available to DoD. As of 2000, 50 vessels participated in this program (Table 2-5).[7]

Designed to augment the Maritime Security Program, the Voluntary Intermodal Sealift Agreement is a standby agreement to make commercial, intermodal, dry cargo capacity, and supporting global infrastructure available to meet DoD's "contingency deployment" requirements. The Sealift Agreement calls for comprehensive and integrated peacetime planning and exercises among commercial entities and the U.S. military. The intent is to bring commercial best practices into military logistics, and to coordinate military and nonmilitary activities for improved asset utilization.

**Table 2-5: Types of Vessels in the Maritime Security Program (2000)**

| Vessel Type | Number |
|---|---|
| Container/RO-RO Vessels | 3 |
| RO-RO Vessels | 4 |
| Container ships | 39 |
| LASH* Vessels | 4 |
| Total | 50 |

* *LASH stands for Lighter Aboard Ship.*

There are several programs in the MTS that fall under the U.S. Merchant Marine. These seven programs are discussed below. While not always interrelated, these programs support a naval auxiliary role during wartime.

### 2.1.6.1 Naval Fleet Auxiliary Force

The Naval Fleet Auxiliary Force is a fleet of over 35 ships, manned by civil service crews, that provides direct support to Navy combat vessels. The Naval Fleet Auxiliary Force is responsible for a variety of support services, including the delivery of food, fuel, parts, ammunition and underway replenishment. Some of the Naval Fleet Auxiliary Force ships are capable of providing ocean towing and salvage services. A unique component of the Naval Fleet is the two hospital ships, the U.S. Naval Ships USS COMFORT and MERCY. These ships, normally maintained in 5-day readiness status, carry 1,200 Navy medical personnel and a crew complement of 70 civil-service mariners when fully activated.[19]

### 2.1.6.2 Special Missions Program

The Special Missions Program involves 27 civilian-manned, government-owned vessels designed to meet specific mission objectives, including oceanographic surveys, cable laying, missile research and range instrumentation, and ocean surveillance. In addition to these government-owned, civilian-crewed vessels, the Military Sealift Command charters six vessels to perform assignments such as deep-water search and rescue and navy submarine test support escorts.[19] The Military Sealift Command is the transportation provider for DoD with responsibility for providing strategic sealift and ocean transportation for all U.S. military overseas.[19]

### 2.1.6.3 Pre-positioning Program

The Pre-positioning Program consists of 33 civilian-manned vessels placed at strategic locations throughout the world to be on-call for rapid deployment. These vessels store military supplies to sustain forward-deployed Army, Air Force, Navy and Marine units. There are three divisions: Combat Pre-positioning Force, which supports Army operations; Maritime Pre-positioning Force, which supports a Marine Corps Air/Ground Task Force; and the Logistic Pre-positioning Force, which supports the Air Force, Navy, and the Defense Logistics Agency.[19]

### 2.1.6.4 Sealift Program

The Sealift Program is composed of ships that transport military cargo. This program has three project offices: the Tanker Project Office, the Dry Cargo Project Office, and the Surge Project Office. The Military Sealift Command maintains long-term charters for a fleet of approximately 10 tankers to meet DoD fuel transport demands. These tankers carry fuel to U.S. military facilities worldwide, make deliveries to military vessels at sea, and service remote federal government installations. The Military Sealift Command executes short-term charters for tankers on an as-needed basis. The Dry Cargo Project Office maintains contracts with private commercial liner operators to transport approximately 80 percent of peacetime transport needs. Twelve chartered cargo ships carry the remaining 20 percent of the military's dry cargo. The fast sealift ships, surge large-medium-speed RO/ROs (LMSRs), and the MARAD Ready Reserve Force (discussed below) comprise the Surge Office Project. These vessels are government-owned and civilian-operated. The 8 fast sealift ships are the fastest cargo ships in the world, and travel at speeds of up to 30 knots, enabling rapid delivery of defense materials. The LMSRs are not as fast as the sealift ships, but can carry up to 380,000 square feet of cargo at speeds of up to 24 knots.

### 2.1.6.5 Ship Introduction Program

The Ship Introduction Program manages vessel acquisition activities of the Military Sealift Command, including new vessel construction, vessel transfers, and conversions, and ensures that all vessel designs are compatible with operational requirements. For example, the program oversees the acquisition of 19 additional LMSRs: 14 vessels through new construction, and 5 through the conversion of existing ships. When completed, the LMSRs will become elements of the Prepositioning Program and the Sealift Program.

### 2.1.6.6 Ready Reserve Force

MARAD maintains 76 vessels in the Ready Reserve Force fleet: 17 breakbulk ships, 31 RO/RO vessels, 7 heavy-lift or barge-carrying ships, 10 auxiliary crane ships, 9 tanker ships, and 2 troopships. The force was created in 1976 following an agreement between DoD and MARAD. For strategic purposes, MARAD maintains the Reserve Force vessels at three sites (Fort Eustis, Virginia;

Neches Rives, Texas; and Suisun Bay, California) in 4- to 30-day readiness status.[f] A civilian crew of 9 to 10 mariners maintains vessels in reduced operating status in the highest state of readiness (4- and 5-day activation). When activated to supply DoD with logistics support, these vessels are fully crewed with civilians, and fall under the operating authority of the Surge Office Project of the Military Sealift Command.[20]

### 2.1.6.7 National Defense Reserve Fleet

The Ready Reserve Force has a larger fleet of inactive vessels controlled by MARAD, known as the National Defense Reserve Fleet. Other than climate control, these vessels are not maintained in any way. As of February 2001, 257 vessels (including the 76 Ready Reserve Force ships) were in the National Defense Reserve Fleet. Another 60 vessels are either owned by the government or secured through various programs, and are afforded basic maintenance services on a cost-reimbursable basis. In total, 317 vessels participate to some extent in the National Defense Reserve Fleet program.[21]

## 2.1.7 U.S. Passenger Ferry System

Each year, passenger ferry vessels transport nearly 90 million passengers on 134 million trips in the United States.[16, 22] Of the 168 U.S. passenger ferry vessel operating systems in the United States, 72 are publicly supported and 96 are privately funded systems. Although ferry systems operate in 35 states, nearly 60 percent are concentrated in 10 states (Table 2-6).[16] As of 1999, the 168 systems encompassed 578 ferry terminals supporting 487 travel routes. Of the 487 routes, however, approximately 71 percent are located in 10 states. In 1999, New York had the most ferry terminals and passengers carried in the United States, more than double the patronage of ferries in Washington, the state with the second highest number of terminals.[22]

Table 2-7 shows the regional distribution of ferry system passenger use as of 1999. The high number of passengers carried in the Mid-Atlantic is driven by passenger traffic in New York. Most ferry service is conducted using passenger ferries, as shown by the large disparity between the total numbers and passengers and vehicles. Almost all of the New York ferry operators who responded to DOT's survey operate passenger-only ferries. Both North Pacific (specifically Washington) and Gulf Coast regional ferry operators tend to use roll-on/roll-off ferries, which permit vehicular transport.[23]

Public ferry systems are typically run by state agencies, although there is some collaboration between neighboring states, such as the Port Authority of New York and New Jersey, which provides ferry service for the New York-New Jersey metropolitan area.[g]

[f] *Readiness status refers to the number of days until a vessel is available for service.*

[g] *The New York-New Jersey metropolitan region consists of the five New York City boroughs of Manhattan, Brooklyn, Queens, Richmond (Staten Island), and the Bronx; the four suburban New York counties of Nassau, Suffolk, Rockland and Westchester; and the eight northern New Jersey counties of Bergen, Essex, Hudson, Middlesex, Morris, Passaic, Somerset, and Union.*

## Table 2-6: U.S. Ferry Terminals (1999)

| State* | Number of Ferry Terminals | Number of Ferry Routes | Number of Passengers Carried (in millions)** |
|---|---|---|---|
| New York | 51 | 56 | 33.88 |
| Washington | 46 | 55 | 16.59 |
| Alaska | 41 | 65 | 0.73 |
| California | 38 | 39 | 9.53 |
| Maine | 33 | 25 | 1.58 |
| Michigan | 31 | 25 | 3.19 |
| Louisiana | 30 | 15 | 4.10 |
| Massachusetts | 27 | 37 | 6.26 |
| North Carolina | 27 | 16 | 2.61 |
| Virginia | 20 | 14 | 2.66 |
| Total top 10 | 344 | 347 | |
| Top 10% of total | 59.50% | 71.30% | |
| Overall Total | 578 | 487 | 113.33 |

*This table includes the 10 states with the greatest number of ferry terminals in the United States, almost 60 percent of the national total.*

* *Although not among the 10 states with the greatest number of ferry terminals, Texas and New Jersey are among the states with the greatest numbers of passengers, carrying 11 million and 7.5 million passengers respectively.*

** *The number of passengers was obtained from DOT's National Ferry Database. Of a total universe of 224 ferry operators identified, only 198 (88.4 percent) responded to the survey. In addition to missing data points, the patronage data are calculated based on the reported starting location of the route.*

## Table 2-7: Regional Distribution of U.S. Passenger Ferry Use

| Region* | Number of Passengers Transported | Number of Vehicles Transported |
|---|---|---|
| Mid-Atlantic | 47,067,247 | 3,842,233 |
| North Pacific | 17,399,395 | 12,130,806 |
| Gulf | 15,541,810 | 8,405,262 |
| New England | 11,166,401 | 2,628,852 |
| Pacific | 9,529,694 | 309,452 |
| Great Lakes | 4,568,629 | 2,507,616 |
| South Atlantic | 3,358,158 | 1,421,878 |
| Other | 1,037,753 | 500,205 |
| Caribbean | 2,093,372 | 51,220 |
| Western Pacific | 369,133 | 0 |
| Canada | 1,200,424 | 362,210 |
| Total | 113,332,016 | 32,159,734 |

*Although in 1999 the greatest number of passengers were transported in the Mid-Atlantic region, the greatest number of vehicles were transported in the North Pacific region.*

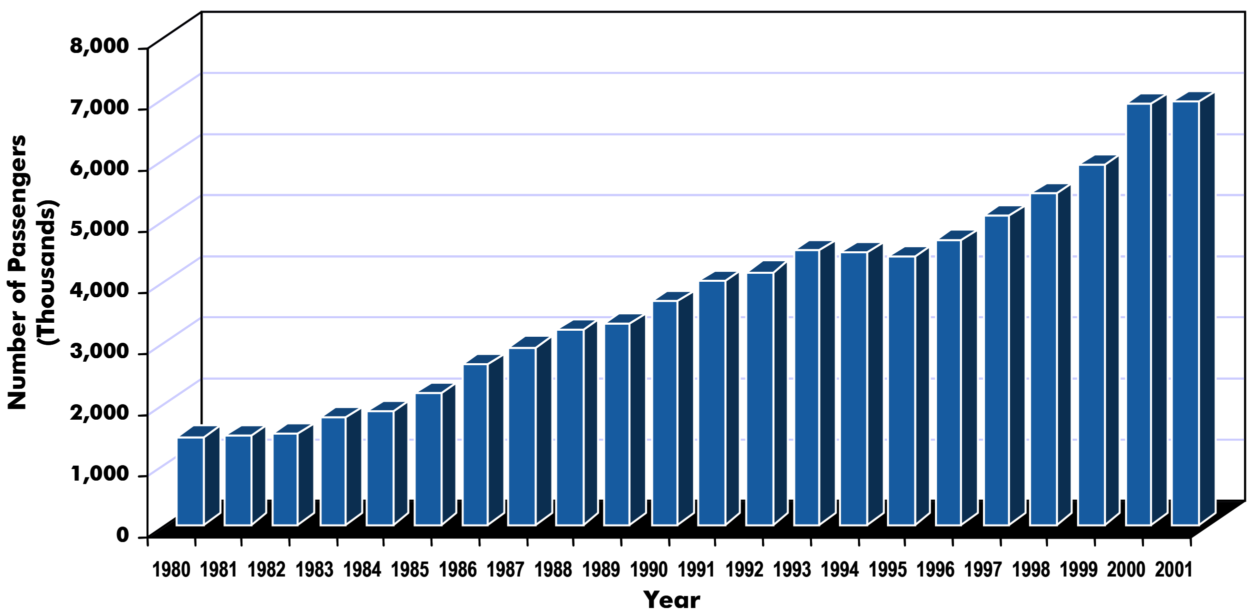
* *The regional breakdown, based on departure location, is as follows:*

- *Mid-Atlantic region is New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and Kentucky*
- *South Atlantic region is North Carolina, South Carolina, Florida, and Georgia*
- *Gulf region is Alabama, Mississippi, Louisiana, Texas, and Tennessee*
- *Pacific region is California*
- *North Pacific region is Oregon, Washington, and Alaska*
- *Great Lakes region is Illinois, Indiana, Wisconsin, Minnesota, and Missouri*
- *New England region is New Hampshire, Massachusetts, Connecticut, Rhode Island, and Maine*
- *Western Pacific region is Hawaii*
- *Caribbean region is Puerto Rico and the Virgin Islands*
- *Other region is all other states*
- *Canada region consists of ferries originating from ports in Canada with final destinations in the United States.*

## 2.1.8 U.S. Cruise Industry

As opposed to the ferry system, the overnight cruise industry relies on deep-draft ports to operate its cruise liners. Cruise ships have become a popular form of vacationing, growing steadily since 1980 (Figure 2-6). According to MARAD, two factors have fueled this growth. First, cruise lines are introducing new ships that offer new technologies and a wide range of options. For example, of the 122 cruise ships serving North American ports in 1998, 33 were less than 3 years old. Second, consolidation, through acquisitions and mergers, has created a core of companies with more financial strength to promote their ships and control costs, contributing to the stability of the industry in the late 1990s. For instance, in 1998 the top 4 North American cruise lines controlled 82 percent of the North American cruise capacity (many of the vessels, however, are under foreign flags, and are not U.S.-owned or -operated).[7] In 2001, approximately 6.9 million passengers vacationed by cruise ship — more than 4 times the passenger traffic in 1980. The increase represents an average annual growth rate of 8.4 percent (Figure 2-6).[24]

**Figure 2-6: Number of Cruise Line Passengers (1980-2001)**




*Cruise ship traffic has steadily increased and is approximately seven times greater than in 1980.*

Unlike cargo traffic at ports, cruise ship traffic is heavily concentrated within certain states. Florida's proximity to Caribbean destinations makes it the most popular departure point in the United States for cruise vacations. In 2001, over 1.2 million Floridians booked cruises, nearly 400,000 more than the second highest state, California.[24] Additionally, about 60 percent (4.1 million) of U.S. cruise embarkations occurred from a Florida port, with approximately 50 percent (3.4 million) of passengers embarking from the Port of Miami.[13, 25] Ten states provide approximately 62 percent of the total North American cruise line passenger traffic, and 2 states provide almost one-third of the traffic (Table 2-8).[24] North American passenger traffic includes the United States and Canada.

**Table 2-8: North American Cruise Line Passenger States of Residence (2001)**

| State | Total Passengers |
|---|---|
| Florida | 1,256,745 |
| California | 860,187 |
| New York | 416,073 |
| Texas | 294,196 |
| Massachusetts | 279,463 |
| New Jersey | 251,562 |
| Pennsylvania | 249,130 |
| Illinois | 197,294 |
| Ohio | 186,696 |
| Georgia | 176,974 |
| Total Top Ten | 4,168,320 |
| Total North America | 6,637,054 |

*In 2001, approximately 30 percent of the total number of passengers lived in Florida or California.*

The Caribbean continues to be the top cruise destination, with a 46.6 percent market share in 2002 (includes the Caribbean and the Bahamas). Other leading markets are Europe at 21.1 percent (divided into Mediterranean ports with 10.2 percent and non-Mediterranean ports such as Norway with 10.9 percent) and Alaska with a 7.9 percent share.[24]

Increased U.S. demand for cruises has dictated the industry's growth. As of 2000, 87 of the 205 deep-draft cruise line vessels and 17 of the 41 shallow-draft vessels in the world fleet were operating in U.S. waters. All cruise ships are less than 47 years old and have draft designs of less than 30 feet (the maximum depth reached by the hull of a ship, which minimizes the number of ports too shallow to enter), including the mega-cruise ships under construction for the U.S. market (Tables 2-9 and 2-10).[26] The Cruise Line International Association predicts the cruise industry will add 42 cruise ships to the North American fleet between 2002 and 2007.[24] Approximately 90 percent of the cruise ships in the orderbook[h] are deep-draft vessels.[i] In general, the cruise ships calling on U.S. ports are larger, newer, and have greater capacity than cruise ships sailing into non-U.S. ports.

[h] *The orderbook represents the number of ships currently on order at a shipyard.*

[i] *Information on the cruise ships that serve the United States could not be easily obtained. Cruise Industry News (CIN), a trade publication, tracks ships that are marketed primarily in North America. Nearly all of CIN's North American fleet call at U.S. ports. Using CIN's North American fleet and information for each ship on scheduled routes and ports-of-call, a U.S. fleet was determined.*

**Table 2-9: International Cruise Ship Fleet**

| | | Shallow Draft | Deep Draft | Total |
|---|---|---|---|---|
| Ships calling at U.S. ports | Existing | 17 | 87 | 104 |
| | On Order | 0 | 24 | 24 |
| | Total | 17 | 111 | 128 |
| Ships not calling at U.S. ports | Existing | 24 | 118 | 142 |
| | On Order | 5 | 13 | 18 |
| | Total | 29 | 131 | 160 |
| World Fleet | Existing | 41 | 205 | 246 |
| | On Order | 5 | 37 | 42 |
| | Total | 46 | 242 | 288 |

*Nearly 42 percent of the existing world cruise ship fleet calls at U.S. ports.*

**Table 2-10: International Cruise Ship Characteristics**

| Vessel Characteristics | U.S. Port-Calling Ships | | | Non-U.S. Port-Calling Ships | | |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Average | Minimum | Maximum | Average |
| Gross Tons | 1,800 | 142,000 | 56,023 | 1,189 | 85,000 | 18,638 |
| Age (years) | 0 | 47 | 14 | 0 | 66 | 27 |
| Passengers | 116 | 3,360 | 1,664 | 67 | 2,112 | 720 |
| Length (ft) | 344 | 1,036 | 741 | 236 | 879 | 505 |
| Beam (ft) | 49 | 157 | 98 | 39 | 108 | 69 |
| Draft (ft) | 13 | 35 | 26 | 13 | 33 | 20 |

*While the average age of cruise ships calling at U.S. ports is 14, the data are somewhat skewed, with the greatest number really being built in the last decade.*

Nearly all new cruise ships are built abroad, but most dry-docking and repairs are performed in North American ports.[i] Based on the average cruise ship's characteristics (Table 2-10),[27] the major U.S. shipbuilding yards have the capabilities to construct and repair most cruise ships. The operative factor in the selection of a repair facility, aside from overall cost, is its proximity to a vessel's sailing area. U.S. shipyards that have completed major cruise ship servicing include Atlantic Marine and Bender Shipbuilding in Alabama, Cascade General - Portland Shipyard in Oregon, Newport News and Norfolk Shipbuilding in Virginia, and Todd Pacific in Washington.[26]

According to a study done for the International Council of Cruise Lines, the cruise industry generated $20 billion in industrial output and 267,700 jobs in the United States in 2001. The cruise industry directly employs 101,000 people. Indirectly, the industry helps create 166,000 jobs in advertising, ship maintenance and repair, and health services, among other industries. These jobs generate $9.7 billion per year in wages.[25]

[i] *New construction of cruise ships is concentrated in four major yards: Kvaerner Masa-Yards in Finland, Chantiers de l'Atlantique in France, Meyer Werft in Germany, and Fincantieri in Italy.*

## 2.1.9 U.S. Shipbuilding and Repair Industries

The U.S. shipbuilding and repair industries are declining, and many companies are consolidating as a result. Shipyards are fixed facilities with dry docks and fabrication equipment capable of building a ship. Other activities at shipyards include the repair, conversion, and alteration of ships; the production of prefabricated ship and barge sections; and specialized services, such as ship scaling.[28]

The U.S. shipbuilding industry has two markets: commercial and military. As of December 31, 1997, the U.S. ranked fourteenth in merchant shipbuilding among all nations, with approximately one percent of the world's gross tonnage on order. Japan and South Korea together accounted for more than 65 percent of the gross tonnage on order.[7] As with other marine-related industries, shipbuilding and repair is concentrated in only a few coastal states. This can be attributed to geographical limitations and the decreased number of major shipyards in the United States.

### 2.1.9.1 Private Shipyards

Private shipyards are grouped based on the potential for construction by vessel length. The majority of the available data address major shipbuilding yards. MARAD has only recently begun collecting data on small and mid-sized shipyards.

#### *2.1.9.1.1 Major Shipyards*

MARAD classifies major shipyards into four categories:

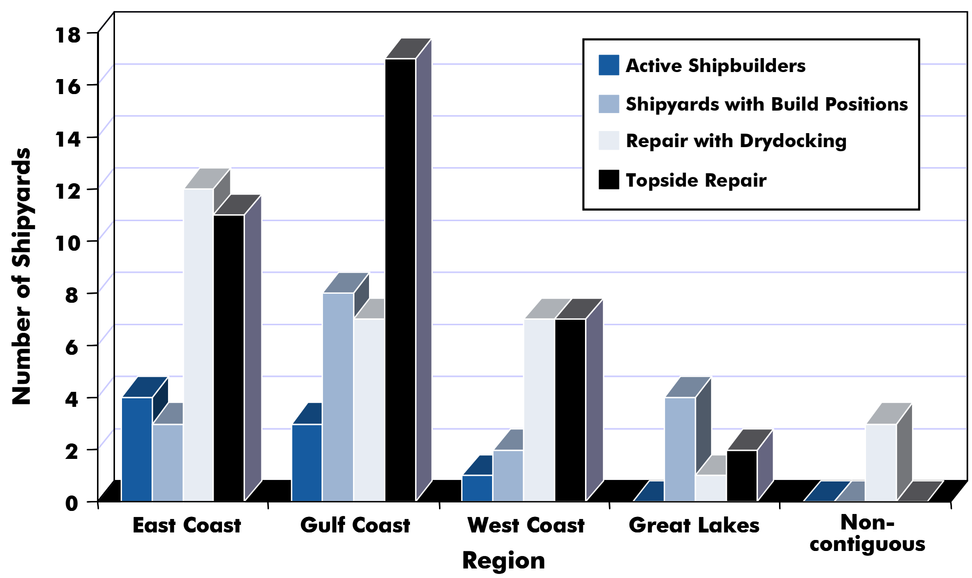
- Active Shipbuilding Yards — privately owned U.S. shipyards and facilities that are open with at least one building position capable of accommodating a vessel 122 meters (400 feet) in length and over, and are currently engaged in the construction of naval ships or major oceangoing merchant vessels.
- Shipyards with Build Positions — privately owned shipyards and facilities that are open with at least one building position capable of accommodating a vessel 122 meters in length and over, and that have not constructed a naval ship or major oceangoing merchant vessel in the past two years. The shipyards may not be capable of ship construction without significant capital investments. These shipyards could, however, be used in module ship construction.
- Repair (with dry docking) — shipyards that have graving docks, floating dry docks or marine rails capable of handling naval ships or major oceangoing merchant vessels 122 meters in length and over. These shipyards may also be capable of constructing vessels less than 122 meters in length.
- Topside Repair — shipyards that have sufficient berth or pier space, including dolphins,[k] to accommodate a naval ship or major ocean-going

[k] *A dolphin is a structure placed near piers or wharves to guide vessels into their moorings; keep vessels away from structures, shoals, or the shore; support navigation aids; or moor a vessel.*

merchant vessel ships of 122 meters in length or over. These shipyards may also be capable of constructing or dry docking vessels less than 122 meters in length.[29]

As shown in Figure 2-7, the majority of the major shipyards in the United States are located on the East and Gulf Coasts.[†, 29] The U.S. Navy and MARAD identify the active shipbuilding base as active shipbuilding yards. As of 2001, there were eight active shipbuilding yards in the United States. Six of those shipyards, referred to as the Big Six, are the primary builders of large U.S. Navy and commercial vessels. Those shipyards are Avondale Industries in New Orleans, Louisiana; Bath Iron Works in Bath, Maine; Electric Boat in Groton, Connecticut; Ingalls Shipbuilding in Pascagoula, Mississippi; National Steel & Shipbuilding Company in San Diego, California; and Newport News Shipbuilding in Newport News, Virginia. In 1998, the Big Six accounted for two-thirds of the industry's total revenue (over $6.7 billion), and performed nearly 90 percent of all military work. Ninety-five percent of the revenues of these shipyards were defense-related.

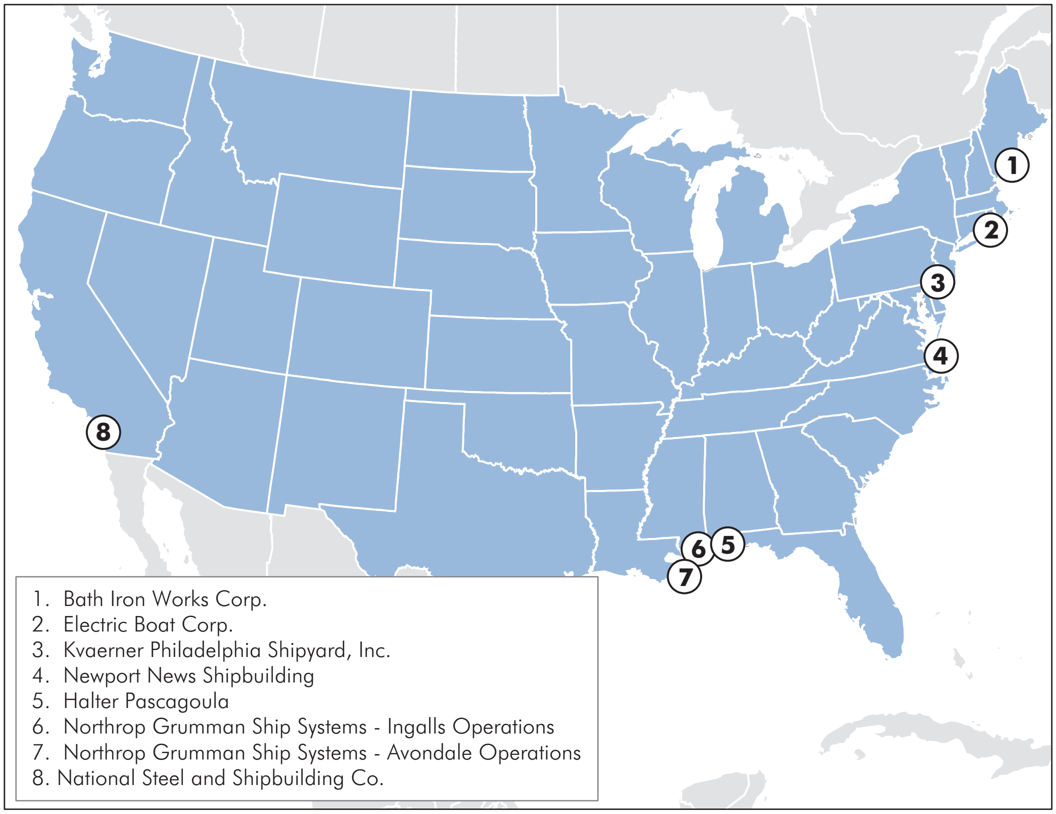
**Figure 2-7: Regional Breakdown of Major U.S. Shipyards (2001)**




*The East Coast and the Gulf of Mexico have the largest concentration of shipbuilding and repair facilities. There are no active shipbuilders located in the Great Lakes or Non-contiguous regions.*

The Big Six also accounted for about 11 percent of the industry's commercial revenues from 1996 to 2000.[30] Two companies own the Big Six shipyards. In 2001, Northrop Grumman purchased Newport News Shipbuilding and Litton Industries, which included the Avondale and Ingalls shipbuilding yards. General Dynamics owns Electric Boat, Bath Iron Works, and National Steel & Shipbuilding Company. Figure 2-8 shows the locations of the eight active shipbuilding yards in the United States.[29]

**Figure 2-8: Location of Active U.S. Shipbuilding Yards (2001)**



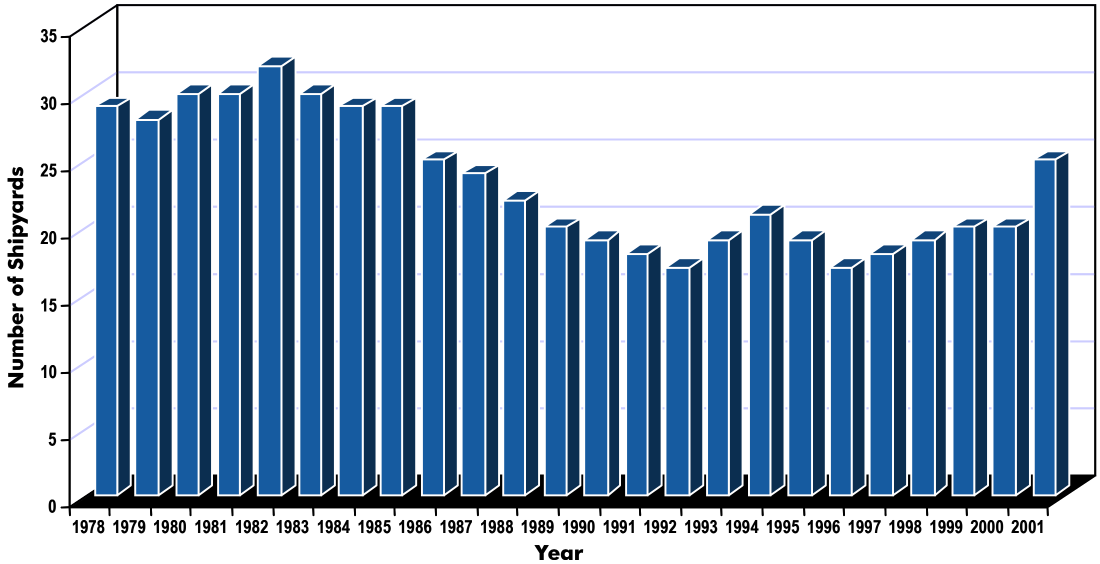

*With the exception of National Steel and Shipbuilding Company, all active U.S. shipbuilding facilities are located in the eastern half of the United States.*

Note: *Active shipbuilding yards are privately owned U.S. shipyards and facilities that are open with at least one building position capable of accommodating a vessel 122 meters (400 feet) in length and over, and are currently engaged in the construction of naval ships or major oceangoing merchant vessels.*

Since 1977, the number of privately owned major shipbuilding yards in the United States has fluctuated between 17 and 32 (Figure 2-9). This includes combined statistics for active shipbuilders and shipyards with build positions.[31] As previously stated, there were only 8 active shipbuilding yards in 2001; 17 of the shipyards reported on had not constructed a major ocean-going vessel in the previous 2 years.[32]

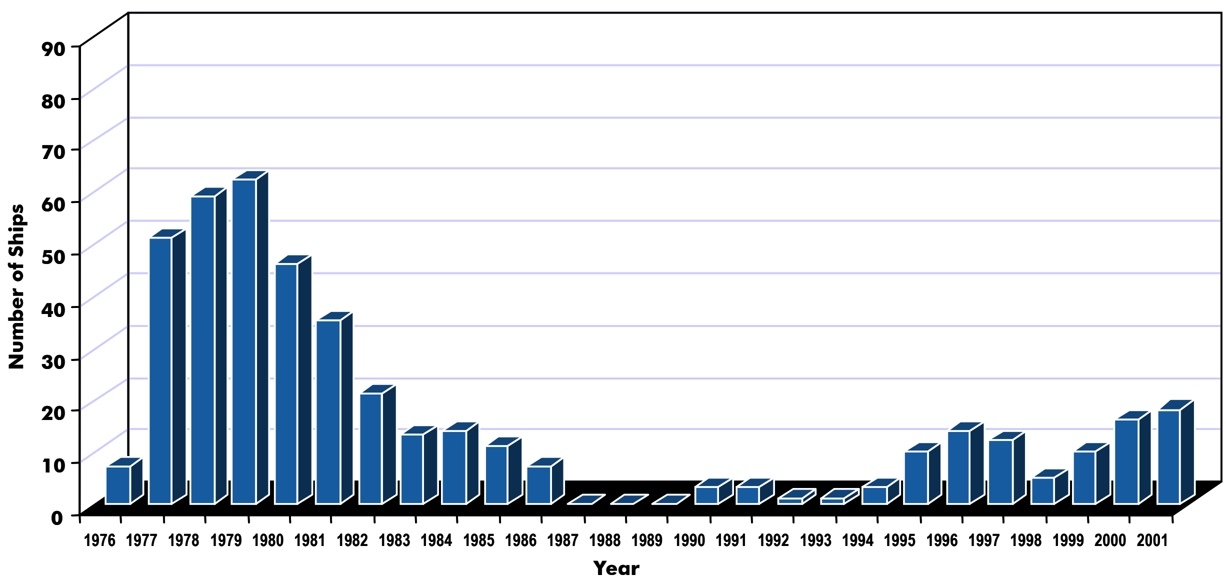
As of October 1, 2001, the U.S. commercial shipbuilding orderbook consisted of 18 ships, with a total estimated value of over $3.2 billion.[15] This figure represents an increase in the number of ships in the orderbook compared to 2000 and is an increasing trend since 1998 (Figure 2-10). The 18 ships in the orderbook, however, represent less than 25 percent of the number of ships in the 1975 orderbook. The recent increase corresponds to the passage of the National Defense Authorization Act for fiscal year 1995 (FY1995), which contained the National Shipbuilding and Shipyard Conversion Act of 1993. This law created the National Shipbuilding Initiative to assist in reestablishing the U.S. shipbuilding industry as self-sufficient and

**Figure 2-9: Number of Major U.S. Shipyards**




*The number of major U.S. shipyards has gradually increased since 1996, but almost three-quarters of those shipyards have not constructed a major ocean-going vessel within the past two years.*

**Figure 2-10: Trends in U.S. Commercial Shipbuilding (1975-2001)**




*The number of major ocean-going vessels in the 2001 commercial orderbook was at the highest level since 1982.*

internationally competitive.[33] Among its provisions, it established a financial incentives program to provide loan guarantees to initiate commercial ship construction, encourage shipyard modernization, and support increased productivity.

U.S. shipbuilders also construct federal vessels. The U.S. Navy shipbuilding program is the principal customer of the U.S. shipbuilding industry.[7] At the end of 1999, there were 46 military ships under construction.

The U.S. Navy's shipbuilding plans for FY1999-FY2004 include the construction or conversion of 66 ships at a cost of about $46 billion. Overall, the U.S. Naval fleet decreased by 208 ships between FY1985 and FY1992, from 541 to 333 ships. This decrease was a contributing factor to the decrease in shipyard employment, since major shipyards depend on Navy shipbuilding and repair.[30] In 2002, the U.S. Coast Guard (USCG) announced its Deepwater Acquisition Program, which will replace or retool much of the Coast Guard's fleet (the Deepwater Acquisition Program is discussed in Section 3.3).

### *2.1.9.1.2 Small and Mid-sized Shipyards*

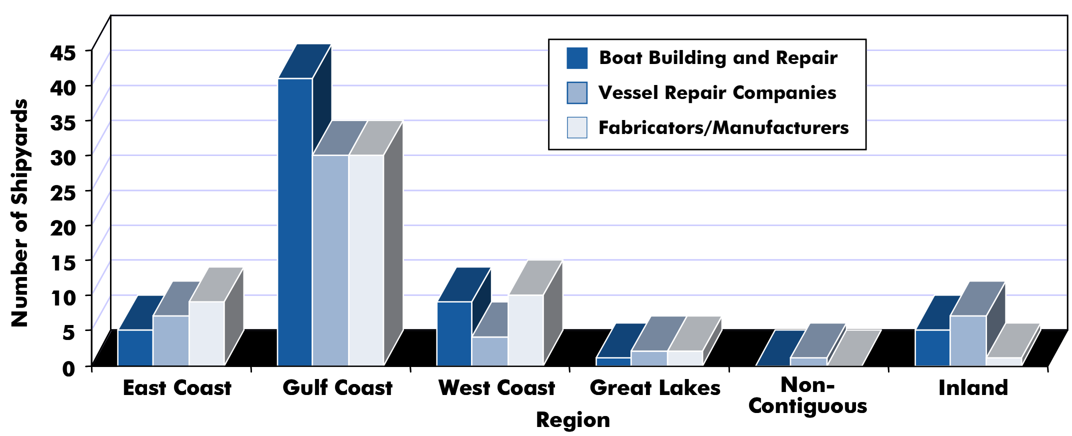
MARAD classifies mid- and small-sized U.S. shipyards into three categories:

- Boatbuilding and Repair Companies — privately owned shipyards capable of building or repairing commercial and military vessels less than 122 meters (400 feet) in length.
- Vessel Repair Companies — facilities that only provide repair services, either repair with dry docking or topside repair, to vessels less than 122 meters (400 feet). These companies must have their own waterfront facilities.
- Fabricators and Manufacturers of Maritime Vessels — companies that build small commercial craft less than 76 meters (250 feet).[29]

As shown in Figure 2-11, the majority of small and mid-sized shipyards are located in the Gulf Coast region.[19]

Because MARAD began reporting on small and mid-sized shipyards in 2001, data are not available to support a trend analysis.

**Figure 2-11: Number of Small and Mid-sized U.S. Shipyards, by Region**

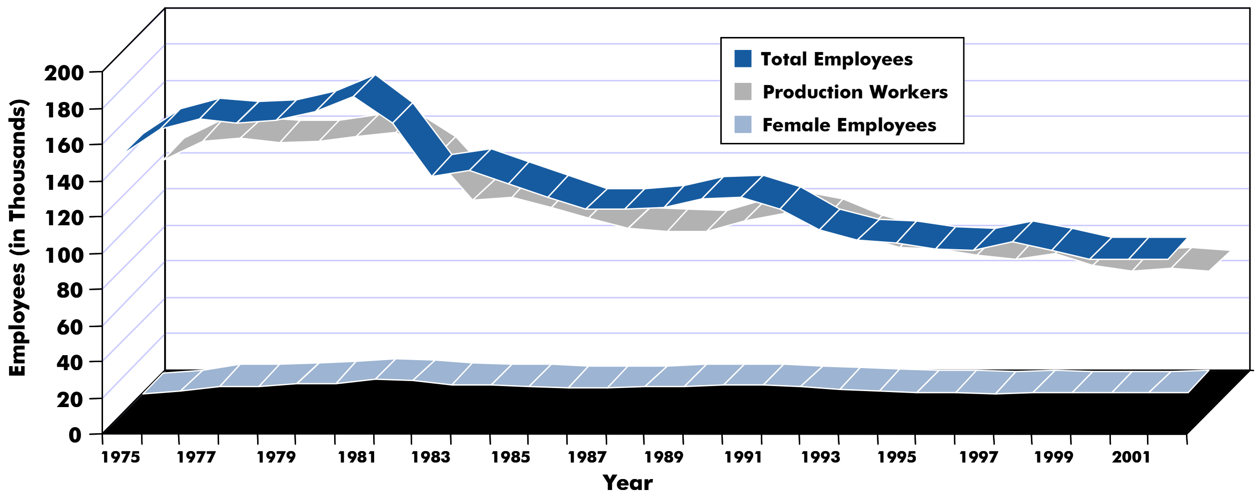



*In 2001, 101 medium and small U.S. shipyards were located in the Gulf Coast region, approximately 62 percent of the nation's total.*

## 2.1.9.2 Employment and Economic Impacts

The shipbuilding and repair industries employed approximately 967,000 people in 2002. Of those, 662,000 were production workers[l] and 112,000 were women.[m] The total employment rate within the industry has declined steadily since 1981, largely due to a decrease in military-related vessel construction (Figure 2-12).[34]

**Figure 2-12: U.S. Shipbuilding Employment History (1975-2002)**




*Total shipyard employment has decreased since 1975 at approximately the same rate as the number of major ships in the commercial orderbook.*

Employment is concentrated in states with active shipyards. Virginia alone accounts for over 25 percent of those employed at major shipyards (Figure 2-13). Of the 75,000 people employed by major shipyards, three-quarters work at active shipyards. The regional differences found in maritime cargo movement do not occur within the shipbuilding and repair industries, although the eastern United States, specifically the Atlantic Coast and the Gulf regions, has a much higher concentration of major shipyards.[15]

As of October 2001, major shipbuilding yards employed approximately 46,600 production workers. Active shipyards employ over 60 percent of the major shipyard production workers, representing approximately 45 percent of the total production workforce (Table 2-11).[29]

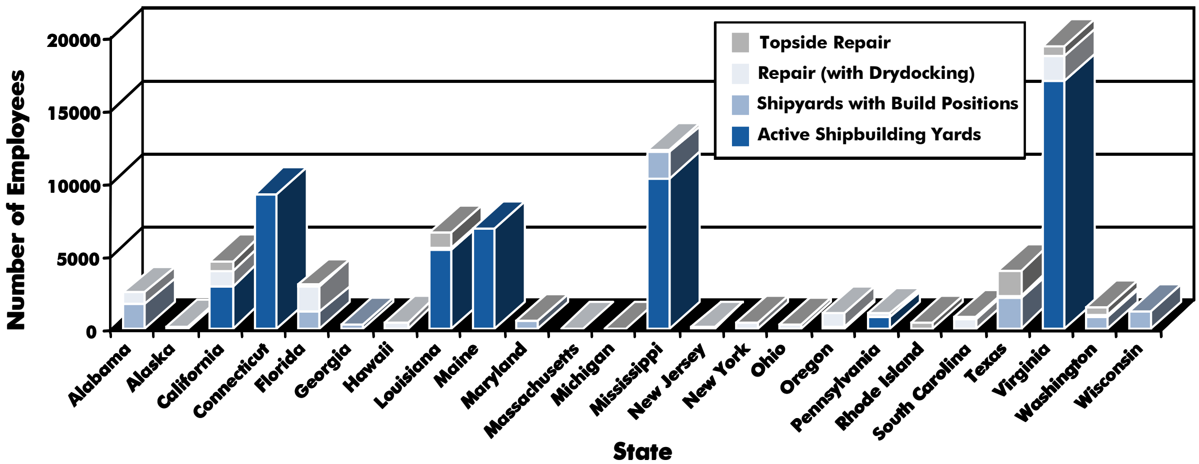
According to a study by the Shipbuilders Council of America, the U.S. commercial shipbuilding industry yielded $3.9 billion dollars in estimated revenue in 2001; the majority of which was generated in the Gulf Coast region (Table 2-12).[35]

---

l *The Bureau of Labor Statistics defines production workers as assemblers and fabricators working in plants that manufacture durable goods; in this case, ships.*

m *Peak employment occurred in 1943 with over 1.3 million individuals employed. Data were first collected on production workers in 1947 and on female workers in 1959.*

## Figure 2-13: 2002 Major Shipyard Employment Rates, by State




*Active shipbuilding yards are the drivers behind shipyard employment.*

## Table 2-11: Number of Shipyard Production Workers, by Shipyard Type

| Classification | Number of Production Workers (thousands) |
|---|---|
| Active Shipyards | 28.1 |
| Shipyards with Build Positions | 7.8 |
| Repair with Dry Docking | 6.5 |
| Topside Repair | 4.2 |
| Total | 46.6 |

*In 2002, active shipyards employed approximately 60 percent of the shipyard production workers in the United States.*

## Table 2-12: Regional Distribution of the Estimated Ship Sales in 2001

| Region* | Billion Dollars | Percent |
|---|---|---|
| Gulf Coast | 2.2 | 55.6 |
| Inland Waterway | 0.4 | 9.3 |
| Atlantic | 0.7 | 15.6 |
| Pacific | 0.8 | 19.5 |
| Western Inland | 0.0 | 0.0 |
| Total | $3.9 | 100.0 |

*In 2001, the Gulf Coast region received the greatest amount of the sales revenue from ship construction.*

** The Gulf Coast region is Texas, Louisiana, Mississippi, Alabama, and Florida. The Inland Waterway region is Minnesota, Wisconsin, Illinois, Indiana, West Virginia, Ohio, Tennessee, Kentucky, Oklahoma, Nebraska, Michigan, Kansas, Iowa, Arkansas, and Missouri. The Atlantic region is Maine, New Hampshire, Vermont, Massachusetts, New York, Rhode Island, Connecticut, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia. The Pacific region is California, Oregon, Washington, Alaska, and Hawaii. The Western Inland region is North Dakota, South Dakota, Montana, Wyoming, Idaho, Nevada, Utah, Arizona, New Mexico, and Colorado.*

### 2.1.9.3 Public Shipyards

In addition to the private, commercial shipyards discussed above, the federal government, specifically the U.S. Navy and USCG, maintains public shipyards. Combined, the U.S. Navy and USCG maintain five shipyards. These shipyards service the existing fleet, as well as assist with the design and construction of new ships.

#### *2.1.9.3.1 U.S. Coast Guard Shipyards*

USCG maintains the Coast Guard Yard in Baltimore, Maryland, to support its fleet. As a full-service shipyard, the yard's capabilities include the facilities to construct, repair, retrofit, and renovate cutters, boats, and various aids to navigation, as well as manufacture unique Coast Guard items. Other support activities, such as casualty response support and design and production engineering, are also conducted at the yard.[36]

#### *2.1.9.3.2 U.S. Navy Shipyards*

The U.S. Navy maintains four public shipyards: Norfolk, Virginia; Portsmouth, New Hampshire; Puget Sound, Washington; and Pearl Harbor, Hawaii. The overall mission of the naval shipyards is to provide maintenance, modernization, inactivation, disposal and emergency repair services to Navy ships and submarines.[37]

Norfolk Naval Shipyard, located near Richmond, Virginia, provides logistic support for assigned ships and service craft, including constructing, overhauling, repairing and outfitting ships and other marine vessels. The Navy maintains seven dry docks on the Norfolk waterfront. Norfolk also operates the Shipyard Instructional Design Center, a training development and media production facility; the Naval Shipyard Development and Integration Test Site, which tests and implements business process improvements in maintenance depots; and several other laboratories and repair facilities.[38]

Portsmouth Naval Shipyard, near Boston, Massachusetts, overhauls, repairs, modernizes, and refuels Los Angeles Class submarines. The facility maintains three dry docks capable of docking all active classes of submarines. It is also operates the Ship Availability Planning and Engineering Center for the Los Angeles Class and the planning yard for the Navy's deep-diving submarine and submersible vessels, as well as other scientific research, defense prototype testing, and submerged rescue platforms. As of October 2002, approximately 4,200 civilian personnel and 104 military personnel worked at Portsmouth. Combined, Portsmouth contributed over $300 million to the local economy in 2001 through wages, local purchases, and contracted services.[39]

Pearl Harbor Navel Shipyard in Hawaii performs periodic vessel inspection and repairs; repairs reported deficiencies; completes modernizations using innovative designs tested on prototypes; performs required maintenance; and serves as a calibration center for the entire Pacific Fleet.[40]

Puget Sound Naval Shipyard, in Bremerton, Washington, maintains naval ships, systems, and ordnance throughout their lifecycle. In 1990 the U.S. Navy authorized a program to recycle nuclear-powered ships at Puget Sound. Approximately 16 percent of the shipyard's workload involves inactivation, reactor compartment disposal, and recycling of ships. In 2001 the Puget Sound Naval Shipyard contributed almost $500 million to the local economy through payroll and local purchases.[41]

## 2.1.10 U.S. Marine Salvage and Dredging Industries

The capabilities of the U.S. marine dredging and salvage industries have declined over the past few years.[42, 43] Marine dredging involves the planning, design, construction, operation, and maintenance of waterway projects to meet navigational needs. The goal of marine salvage operations is to provide assistance to a damaged or stressed vessel, which can include towing a vessel or jettisoning cargo to prevent spills.

### 2.1.10.1 Marine Dredging

The marine construction and dredging industry is a specialty construction trade characterized by equipment that is housed on floating platforms. Dredging is generally required to achieve one of the following outcomes:

- Unimpeded navigation through an existing channel (maintenance dredging)
- Improved navigation channels that provide access for larger vessels (new-work dredging)
- Protecting U.S. shores through beach nourishment
- Environmental restoration of dredged waters or wetlands.

The U.S. Army Corps of Engineers (USACE) is the largest purchaser of marine dredging services. Approximately 75 percent of the 400 million cubic yards of material dredged every year is through USACE direction.[42] USACE's maintenance-dredging budget ranges from $220 to $260 million per year, and its new-work dredging budget ranges from $50 million to $180 million annually. Since the 1990s, the budget for shore protection has grown from about $25 million to approximately $90 million annually. The number of dredging contracts awarded by USACE has gradually decreased since 1999, while the total dollar amount of the bids has increased since 2000 (Figure 2-14).[44]

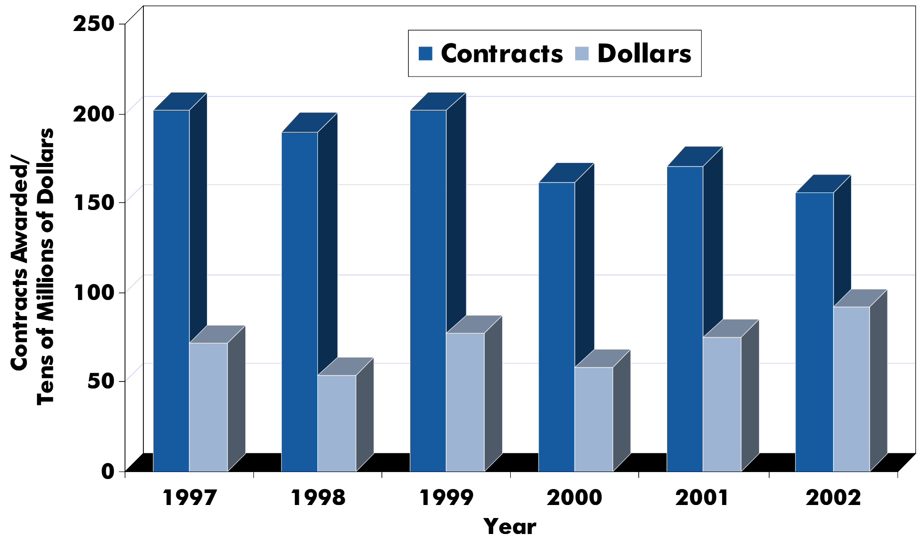
USACE is responsible for approximately 75 percent of the 400 million cubic yards of material dredged every year.

USACE maintains a vessel fleet of 12 dredges consisting of 7 pipeline dredges and 5 hopper dredges (USACE dredging capabilities are discussed in Section 3.3).

### 2.1.10.2 Marine Salvage

In 1994, the National Research Council found that the international marine salvage industry had experienced a decline in the previous two decades, in both dedicated resources and the number of trained salvors, and that the level

**Figure 2-14: USACE Dredging Contracts**




*As the number of USACE contract awards decreases, the national dredging industry is becoming more competitive.*

of salvage activity in the United States continued to be insufficient to support traditional salvage practices.[n] The Council also concluded that marine firefighting capabilities, which fell under the scope of the study, were deficient in port areas.[43]

According to the National Research Council report, several reasons contributed to this decline, including changes in technology, decreased demand for long-range tows, and increased response by both government and industry to vessel casualties. As a result, U.S. salvage capabilities are instilled in small companies that only deal with specialized and limited aspects of salvage. The National Research Council recommended that the federal government should work to maintain or develop salvage capabilities in the United States.[43]

## 2.1.11 Aids-to-Navigation

Navigation is defined as safe movement from one point to another. Aids-to-navigation (AtoN) serve as the marine equivalent of road signs, providing location and safe passage information for vessels.[16] Explicitly, an AtoN is defined as a man-made structure or device designed to assist in determining a vessel's position or a safe course or to warn of dangers or obstruction.[o] Depending on the method of delivery, AtoN can be further classified as visual, audible, radio, or electronic, although there is some overlap between the categories.[45] For example, a device using radio waves can be considered a radio and an electronic AtoN.

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[n] *A salvor is an individual working in the salvage industry.*

[o] *An aid-to-navigation is not the same as a navigational aid. A navigational aid is a more general term that covers any instrument, device, chart, method, and so forth, intended to assist in the navigation of a vessel.*

Although some AtoN are privately operated, most are publicly owned and maintained by USCG (public AtoN are discussed in Section 3.2). Private AtoN include all marine aids operated in the navigable waters of the United States, other than those operated by the federal government or those operated in state waters for private use.[46] Both USCG and USACE must approve private aids-to-navigation.

## 2.2 Marine Industries

This section addresses commercial and recreational uses of ocean and coastal waters that are not covered by the movement of cargo and passengers. The facilities described in this sector are not comprehensive; they provide a general overview of the broad realm of major marine facilities outside of the MTS. Both individual and commercial facilities and activities are addressed. Individual facilities refer to recreational activities, such as fishing or boating. Commercial facilities include offshore oil and natural gas production, long-distance information distribution over transoceanic cables, and commercial fishing.

Billions of dollars are spent annually on commercial and recreational vessels and activities. Unlike many sectors of the MTS, however, the economic impacts of those activities are felt primarily at the state level. This focused impact occurs primarily because the resources needed for some activities, such as oil and gas production, are prevalent only in specific areas. This section examines each of the selected independent sectors and the economic impact on both the national and state economies.

### 2.2.1 U.S. Offshore Natural Gas and Oil Production

A large portion of domestic oil and natural gas is produced on federal marine lands known as the Outer Continental Shelf (OCS). The OCS extends from the seaward boundary of state coastal waters, nominally 3 miles offshore out to 200 miles, and comprises over 1.5 billion acres (Table 2-13).[47] Within the OCS there are approximately 4,000 oil and gas production facilities and over 32,000 miles of pipeline operated by over 45,000 industry personnel.[48] These production facilities contribute about 28 percent of U.S. domestic oil and 25 percent of U.S. domestic natural gas production.

**Table 2-13: Extent of State and Federal Submerged Lands in U.S. Offshore Areas**

| U.S. Offshore/Planning Area | State Offshore (Acres) | Federal OCS (Acres) | Total (Acres) |
|---|---|---|---|
| Alaska | 14,656,000 | 945,569,883 | 960,225,883 |
| Atlantic Coast States | 4,544,000 | 255,356,910 | 259,900,910 |
| Gulf Coast States | 8,640,000 | 159,276,572 | 167,916,572 |
| Pacific Coast States | 2,880,000 | 121,939,940 | 124,819,940 |
| Total | 30,720,000 | 1,482,143,305 | 1,512,863,305 |

*The Minerals Management Service controls approximately 98 percent of the leases in the Outer Continental Shelf.*

The Minerals Management Service (MMS), under the U.S. Department of the Interior, supervises almost 7,500 leases over approximately 38.5 million acres of the OCS (Table 2-14). The majority of these sites are located in waters less than 200 meters deep in the Gulf of Mexico.[49] In 1998, 1,631 sites under federal supervision produced oil or natural gas. All but 43 of those sites were located in the Gulf of Mexico.[47]

**Table 2-14: Federal OCS Lease Offerings by Region (1954-1998)**

| Region | Lease Offerings | Offerings | | Leases Issued | | Under Supervision* | |
|---|---|---|---|---|---|---|---|
| | | Tracts | Acres | Tracts | Acres | Tracts | Acres |
| Alaska | 17 | 25,858 | 141,487,873 | 1,592 | 8,693,378 | 78 | 310,000 |
| Atlantic | 8 | 9,160 | 51,520,603 | 410 | 2,334,205 | 51 | 290,353 |
| Gulf of Mexico | 77 | 191,289 | 1,041,664,409 | 15,739 | 80,928,906 | 7,278 | 37,560,000 |
| Pacific | 11 | 1,903 | 9,823,421 | 470 | 2,540,012 | 83 | 419,411 |
| Total | 113 | 228,210 | 1,244,496,306 | 18,211 | 94,496,501 | 7,490 | 38,579,764 |

*The majority of oil and natural gas produced in the Outer Continental Shelf comes from the Gulf of Mexico.*

* *"Under supervision" indicates all producing and nonproducing offshore mineral leases under MMS as of December 31, 1993.*

As shown in Table 2-15, the majority of active platforms in the Gulf of Mexico are located in shallow waters.[50] There is not a one-to-one relationship between leases and platforms, as the decision to construct a platform is often made by companies following research and exploratory drilling. While deep-water operations are currently the focus of much of the exploration, ultra-deep-water development (exploration and development activity in water deeper than 5,000 feet) is expected to become more common. Seventy-one wells were drilled in water depths of 5,000 feet or more in 2001.[50]

**Table 2-15: Gulf of Mexico Offshore Leases and Drilling Platforms by Water Depth**

| Water Depth (in meters) | Active Leases | Approved Drilling Applications | Active Platforms |
|---|---|---|---|
| 0 to 200 | 3,417 | 39,390 | 3,432 |
| 201 to 400 | 215 | 1,155 | 20 |
| 401 to 800 | 389 | 735 | 10 |
| 801 to 1000 | 316 | 354 | 4 |
| 1000 and Above | 3,286 | 839 | 9 |

*Although there are only 9 active platforms in water over 1,000 meters deep, the high number of active leases at that depth indicates high commercial interest in deep-water oil fields.*

Between 1991 and 2000, the number of exploratory wells and development wells drilled in the OCS increased, from 287 to 396 and 373 to 852, respectively. During the same period, the number of OCS platforms increased from 153 to 175, while platform installations decreased from 153 to 89.[53] Offshore drilling methods can be separated into shallow water and deep-water. Deep-water is drilling in water depths greater than 1,000 feet

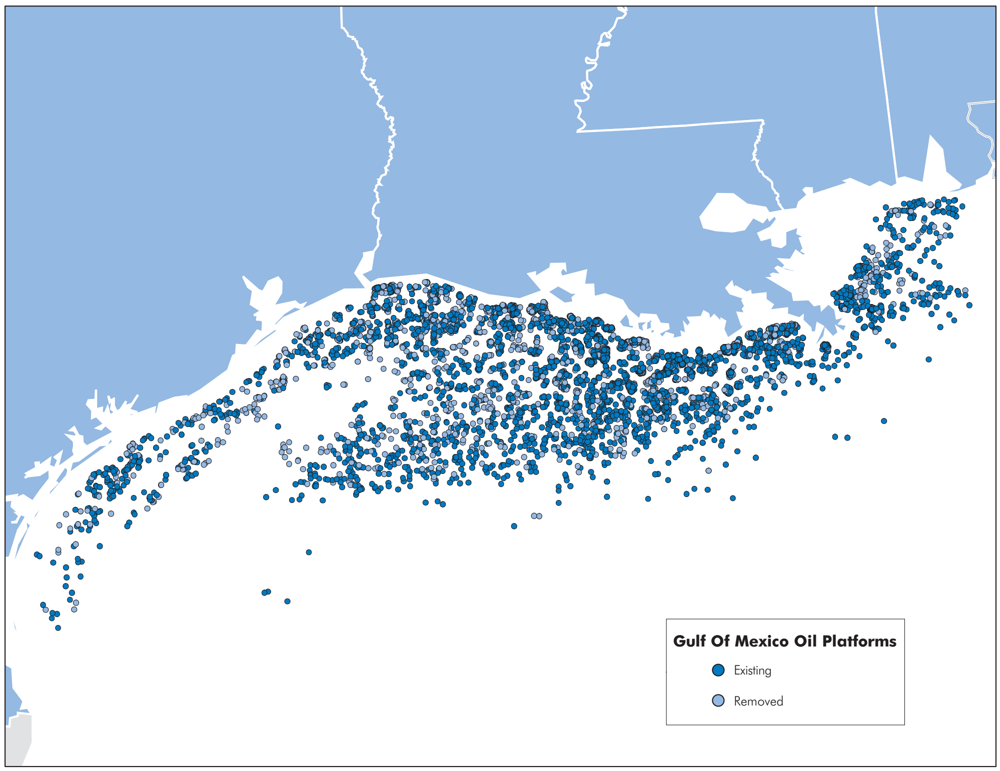
(305 meters). Deep-water operations require more sophisticated technologies and additional technical expertise than conventional operations in shallow waters. There are two basic deep-water development systems currently used in the OCS: bottom-supported and vertically moored structures; and floating production and subsea systems (Table 2-16).

**Table 2-16: Development Systems Used in Deep-water Drilling**

| Deep-water Development Systems | | Description |
|---|---|---|
| BOTTOM-SUPPORTED AND VERTICALLY MOORED STRUCTURES | Fixed Platform | • Consists of a tall vertical section made of tubular steel members supported by piles driven into the seabed (jacket) with a deck on top<br>• Economically feasible for installation in water depths up to 1,500 feet |
| | Compliant Tower | • Consists of a narrow, flexible tower and a piled foundation that can support a conventional deck for drilling and production operations<br>• Can withstand large lateral forces<br>• Usually used in water depths between 1,000 and 2,000 feet |
| | Tension-Leg Platform | • Consists of a floating structure held in place by vertical, tensioned tendons connected to the sea floor by pile-secured templates<br>• Larger platforms have been deployed in water depths approaching 4,000 feet |
| | Mini Tension-Leg Platform | • Is a floating mini tension-leg platform of relatively low cost developed for production of smaller deepwater reserves<br>• Can also be used as a utility, satellite, or early production platform for larger deepwater discoveries |
| FLOATING PRODUCTION AND SUBSEA SYSTEMS | SPAR Platform | • Consists of a large diameter single vertical cylinder supporting a deck<br>• Typically has a fixed platform topside with drilling and production equipment, three types of risers (production, drilling, and export), and a hull which is moored using six to twenty lines anchored into the seafloor<br>• SPAR's are presently used in water depths up to 3,000 feet, although existing technology can extend its use to water depths as great as 7,500 feet |
| | Floating Production System | • Consists of a semi-submersible unit which is equipped with drilling and production equipment, and is anchored in place with wire rope and chain, or positioned using rotating thrusters<br>• Can be used in a range of water depths from 600 to 7,500 feet |
| | Subsea System | • Includes single subsea wells producing to a nearby platform (fixed or tension-leg) to multiple wells producing through a manifold and pipeline system to a distant production facility<br>• Typically used in water depths up to 3,000 feet, but may be used in water depths up to 7,000 feet |
| | Floating Production, Storage and Offloading System | • Consists of a large tanker type vessel moored to the seafloor designed to process and stow production from nearby subsea wells and to periodically offload the stored oil to a smaller shuttle tanker<br>• May be suited for marginally economic fields located in remote deep-water areas where a pipeline infrastructure does not exist |

The majority of the platform installations are located in the Gulf of Mexico (Figure 2-15). There is only one platform in Alaskan OCS waters, which straddles federal-state waters in the Beaufort Sea. The first production from the Alaska OCS began in 2001. There are 24 platforms off the coast of California, and most of those are located in the Santa Barbara Channel. Twenty-two of the facilities in California were installed to produce oil and gas, and the other two were installed as processing facilities.

**Figure 2-15:**
**Oil Platform Installations in the Gulf of Mexico's Outer Continental Shelf**




*In 2002, over 99 percent of the active offshore oil platforms were located in the Gulf of Mexico.*

As of July 2002, over 35,000 miles of pipeline was in place to serve the OCS in the Gulf of Mexico, the majority of that being offshore and operated by the federal government (Table 2-17). Over 60 percent of the pipelines in the Gulf of Mexico are actively moving oil from offshore platforms and vessels to on-shore production facilities. Some OCS pipelines in development are for transport only. For example, in 2001, the Federal Energy Regulatory Commission and MMS met with industrial representatives to discuss preliminary plans for a 750-mile gas offshore pipeline from Sable Island, Canada, to New York City.

At the end of 1998, OCS federal oil production stood at about 1.5 million barrels of oil per day, primarily from the Gulf of Mexico (Table 2-18). Federal sites off the California shore produced approximately 107,000 barrels per day.[48] Sites under MMS's supervision produced over 5 trillion cubic feet of natural gas.[47]

**Table 2-17:**
**Count and Mileage of OCS and State Pipelines in the Gulf of Mexico (2002 Status)**

| Status* | Segments | Mileage | | | | | |
|---|---|---|---|---|---|---|---|
| | | Total | Offshore | Federal | Total State | State Offshore | State Onshore |
| A/C | 276 | 226 | 226 | 214 | 11 | 11 | 0 |
| ABN | 2739 | 3856 | 3856 | 3722 | 133 | 133 | 0 |
| ACT | 6421 | 22250 | 22205 | 21527 | 723 | 678 | 44 |
| CNCL | 898 | 1923 | 1923 | 1889 | 33 | 33 | 0 |
| COMB | 515 | 9 | 9 | 9 | 0 | 0 | 0 |
| O/C | 24 | 118 | 118 | 115 | 2 | 2 | 0 |
| OUT | 1844 | 2008 | 2008 | 1959 | 49 | 49 | 0 |
| PABN | 738 | 869 | 869 | 853 | 16 | 16 | 0 |
| PREM | 8 | 6 | 6 | 6 | 0 | 0 | 0 |
| PROP | 707 | 3987 | 3978 | 3963 | 23 | 15 | 8 |
| REM | 414 | 208 | 208 | 208 | 0 | 0 | 0 |
| TOTAL | 14584 | 35464 | 35411 | 34469 | 994 | 941 | 52 |

*Approximately 62 percent of the pipelines are currently in operation.*

* *A/C are abandoned and combined pipelines. ABN are abandoned pipelines. ACT are active pipelines. CNCL are cancelled permits. COMB are combined segments. O/C are out-of-service and combined segments. OUT are out-of service pipelines. PABN pipelines have been approved for abandonment in place but not yet done. PREM pipelines have been approved for abandonment by removal but not yet done. PROP pipelines are those that have been approved but not yet installed and REM pipelines have been abandoned by removal.*

**Table 2-18: Federal and State Offshore Oil and Gas Production Rates, 1998**

| | Crude Oil Production* | | Natural Gas Production** | |
|---|---|---|---|---|
| State | Federal (Millions of barrels) | State (Millions of barrels) | Federal (Millions of Mcf) | State (Millions of Mcf) |
| Alabama | 0.0 | 0.0 | 1.8 | 213.8 |
| Alaska | 0.0 | 28.3 | 0.0 | 239.1 |
| California | 39.3 | 21.1 | 80.2 | 6.9 |
| Louisiana | 490.5 | 10.1 | 5,116.2 (1998) | 159.1 (1998) |
| Texas | 18.9 | 0.6 | 1,307.3 (1994) | 49.0 |
| State Total | | 60.3 | | 544.4 |
| Federal Total | 535.6 | | 5,136.4 | |

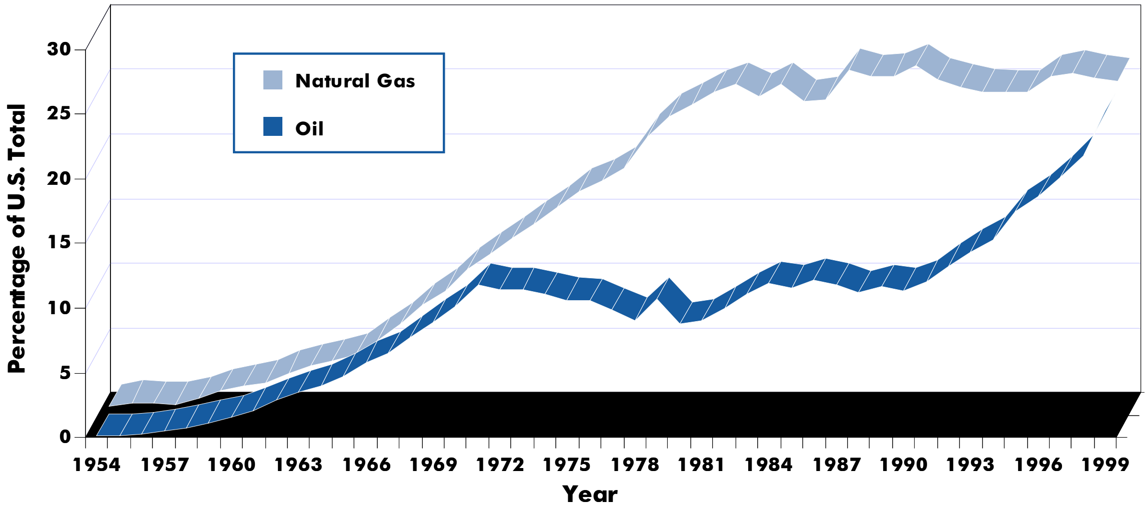
*Approximately 90 percent of the offshore oil from federal leases is produced in the OCS off the coast of Louisiana.*

* *Data are for 1999 unless otherwise noted and reported in barrels (bbls).*

** *Natural gas production is typically reported in thousand cubic feet (Mcf).*

OCS oil production has increased by over 50 percent since 1995 (Figure 2-16). The estimated 2002 federal OCS oil production rate was 627,687 million barrels. The estimated 2001 federal OCS natural gas production was 5,104 billion cubic feet.[50] Complete 2002 natural gas production data are not available. Federal OCS oil and natural gas production represented approximately 30 percent of total oil production in 2002 and 23 percent of the total natural gas production.[50, 51]

**Figure 2-16: Federal Offshore Production as a Percentage of U.S. Total (1954-1999)**




*Offshore oil and natural gas production rates as a percentage of total U.S. production have steadily increased over the past 40 years and are expected to continue to rise.*

The U.S. Department of Energy predicts that offshore natural gas production will increase gradually from 5.3 trillion cubic feet to 5.7 trillion cubic feet between 2001 and 2025. The market share for offshore natural gas, however, is predicted to decline from 27 percent in 2001 to 21 percent in 2025.[52] Offshore oil production (including the Gulf of Mexico and California) is expected to increase to 2.6 million barrels a day in 2007 and then decline to 2.2 million barrels a day by 2025. As shown in Table 2-19, one of the reasons for the growth is the predicted increase in deep crude oil production from 0.9 million barrels a day in 2001 to 1.9 million barrels a day in 2025 from sites in the Gulf of Mexico.[52]

**Table 2-19: Predicted Crude Oil Production from the Gulf of Mexico (millions of barrels per day)**

| Production | 2001 | 2010 | 2020 | 2025 |
|---|---|---|---|---|
| Shallow | 0.7 | 0.8 | 0.3 | 0.2 |
| Deep | 0.9 | 1.6 | 1.8 | 1.9 |
| Total | 1.6 | 2.4 | 2.1 | 2.1 |

*Shallow-water oil well production is expected to decrease as resources diminish, while deep-water well production is projected to increase as new deep-water technologies are developed.*

## 2.2.2 Transoceanic Cables

Submarine cables carry voice calls, data transfers, and Internet traffic across large bodies of water, which account for roughly 90 percent of the telecommunications traffic between the United States and points outside North America.[54] In addition to carrying data, submarine cables are also used for scientific research, such as connecting an acoustic transmitter to the shore. Cables can carry multiple data streams, and many cables are used for both traditional data transfers and research purposes.

### 2.2.2.1 Current U.S. Submarine Cable Capabilities

As of 2002, the United States has 68 active submarine cable landings, as illustrated in Table 2-20. The cable system is relatively young, with approximately 50 cable networks serving the United States going into service since 1990. These do not include cables used for research purposes, which typically are retired from active service. Total investment in submarine cable networks between 1986 and 1998 was $17 billion over an area of 400,000 route kilometers. Investment in undersea optical-cable networks rose from less than $2 billion in 1998 to $6 billion in 2000.

**Table 2-20: Submarine Cables by Region and Status***

| Region** | In Service | | | Planned | | Out-of-Service | |
|---|---|---|---|---|---|---|---|
| | Total Number | Research Cables | Distance (km) | Number | Distance (km) | Number | Distance (km) |
| **Atlantic** | 16 | 0 | 125,829 | 3 | 26,815 | 7 | 40,077 |
| **Caribbean** | 15 | 2 | 49,548 | 0 | 0 | 11 | 19,378 |
| **Eastern Pacific** | 22 | 7 | 214,035 | 2 | 4,564 | 4 | 22,682 |
| **Western Pacific** | 15 | 5 | 163,344 | 1 | 2,064 | 1 | 4,567 |
| **Total** | 68 | 14 | 552,756 | 6 | 33,443 | 23 | 86,704 |

*Many of the submarine cables have multiple landings. For example, one cable goes from California to Hawaii to Guam to Japan to Oregon before returning to California.*

* *The data were submitted by companies to the North American Submarine Cable Association and may not be comprehensive.*

** *Regions were pre-determined by the International Cable Protection Committee (ICPC), a trade organization representing owners/operators of submarine cables. Some overlap may exist within each region. The information in the table was collected by ICPC and may not include cables that are owned/operated by non-ICPC members.*

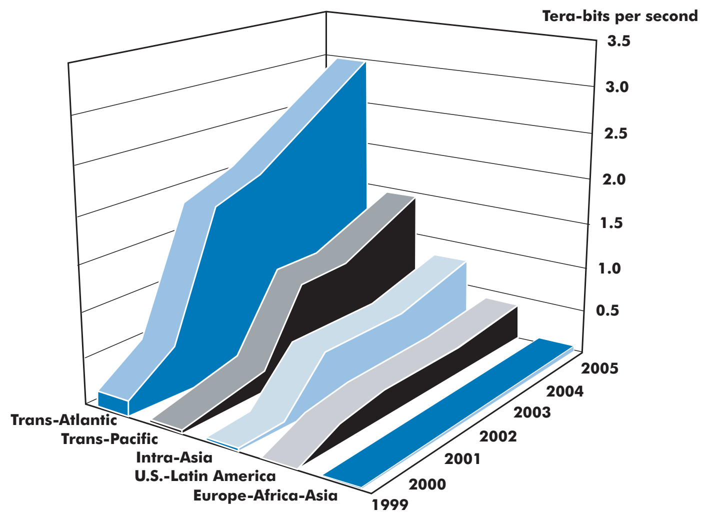
The submarine cables are spread equally across the country's different regions, with landings primarily in New Jersey, Florida, California, and Hawaii.[p] As of 2002, there were four major cable ships registered in the United States and another cable ship homeported in the United States. These vessels are capable of both laying and repairing submarine cables, and have a combined capacity of more than 25,000 tons.

[p] *While most of the cables are international, some have multiple domestic landings.*

### 2.2.2.2 Future Outlook for Transoceanic Cables

While the cable-building industry experienced a boom in cable construction in the late 1990s, construction of new cables has essentially stopped. One reason for this is that cable operators have a great deal of upgradeable capability available to them at a relatively low cost.[58] The current carrying capacity is enough to handle the anticipated continued increase in the usage of submarine cables until approximately 2006, when additional cables will need to be constructed. Figure 2-17 illustrates the estimated increase of submarine cable usage from 1999 to 2005 in the United States.

**Figure 2-17: Submarine Cables Capacity Trends by Use**




*Submarine cable use between North America and Europe is expected to increase steadily over the next few years, primarily as a result of increased information transfers.*

## 2.2.3 U.S. Commercial Fishing Industry

In 2000, the U.S. commercial fishing fleet consisted of approximately 20,000 commercial fishing vessels[q] documented with the federal government, and over 47,000 smaller fishing boats. Combined, there was a slight increase in federally registered crafts when compared to 1999.[59] In 2000 approximately 82,000 U.S. workers were employed with fish processors and wholesalers.[60] The U.S. commercial fishing industry has been relatively stable over the last decade. Since 1990, the peak fish landing was 4.7 million tons in 1994, while the lowest total landing was 4.1 million tons of fish in 2000.[60] Fish landings refer to the number of fish commercially caught and brought to shore.

### 2.2.3.1 Fish Landings

In 2001, 4.3 million metric tons of fish valued at $3.2 billion were commercially landed in the United States. The 2001 amount represents an

[q] *Commercial fishing vessels are defined as crafts greater than five net tons.*

increase of 422.9 million pounds (5 percent) and a decrease in value of $321.2 million (9 percent) compared with 2000 figures. Specifically:

- Finfish accounted for 87 percent of the total landings, but only 46 percent of the value.[r]
- Pollock was the most prolific U.S. domestic species landed in 2001 at 3.2 million pounds, and the most valuable finfish landed at $237 million (fourth overall among domestic fish).
- Shrimp was the most prolific U.S. domestic shellfish landed in 2001 at 324 thousand pounds (seventh overall among domestic fish), and the most valuable fish landed overall at $568 million.[59]

Edible fish and shellfish landings in the 50 states totaled 6.9 billion pounds (3.1 million metric tons) in 2000 — an increase of 80.0 million pounds (36.3 metric tons) compared with 1999. Landings for reduction and other industrial purposes were 2.2 billion pounds (978,400 metric tons) in 2000 — a decrease of 14 percent compared with 1999.[59] In 2001, commercial fishermen brought 834.5 million pounds of fish into the port of Dutch Harbor-Unalaska in Alaska, almost double the catch of any other commercial fishery. Between 2000 and 2001, Dutch Harbor-Unalaska's landings increased by 134.7 million pounds. New Bedford, Massachusetts, was the port that landed the greatest value of commercial fish at $150.5 million, an increase of $4 million from the 2000 landings. Dutch Harbor-Unalaska had the second-most valuable commercial landings in 2001 at $129.4 million; this amount, however, is primarily due to the large volume of fish landed at the port. In contrast, New Bedford only landed 106.9 million pounds of fish (ninth among U.S. ports in 2001), while landing $20 million more than Dutch-Unalaska and double the value of the third port, Kodiak, Alaska.[59]

### 2.2.3.2 Fish Production

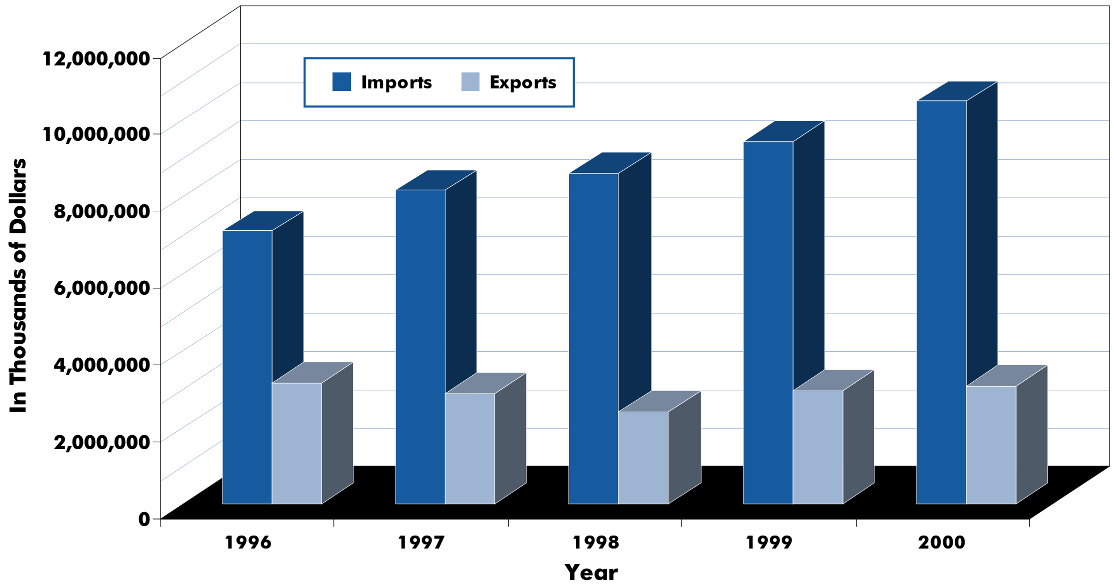
The estimated value of the 2000 domestic production of edible and non-edible fishery products was 7.2 billion, $95.2 million less than in 1999. The value of edible products was 6.7 billion — an increase of $2.5 million compared with 1999. The value of industrial products was 510.1 million in 2000; a decrease of $97.6 million compared with 1999.

### 2.2.3.3 Fish Imports and Exports

The total import value of commercial fish was $10.5 billion in 2000, an increase over 1999 (Figure 2-18). The United States exported $3.1 billion in fish in 2000, also an increase compared to 1999. The National Marine Fisheries Service attributes the difference between imports and exports to the fact that shipping expenses are included in the import value, but not the export value.[59]

[r] *Finfish include baitfish, catfish, salmon, striped bass, tilapia, and trout. Of those, catfish accounts for approximately 80 percent of the total finfish aquaculture production. Shellfish category is composed of clams, crawfish, mussels, oysters, and saltwater shrimp.*

**Figure 2-18: U.S. Imports and Exports of Fish (1996-2000)**




*The United States imports more than twice the amount of fish it exports. This includes fish for consumption and for industrial purposes.*

## 2.2.3.4 Fish Consumption

U.S. consumption of fish and shellfish was 14.8 pounds of edible meat per person in 2001, down 0.4 pound from 2000. Fresh and frozen finfish accounted for 5.7 pounds, fresh and frozen shellfish accounted for 4.6 pounds, and canned fishery products consumption was 4.2 pounds per capita in 2001. The United States ranked as the third largest consumer of seafood in the world, based on the three-year average from 1997 to 1999.[59]

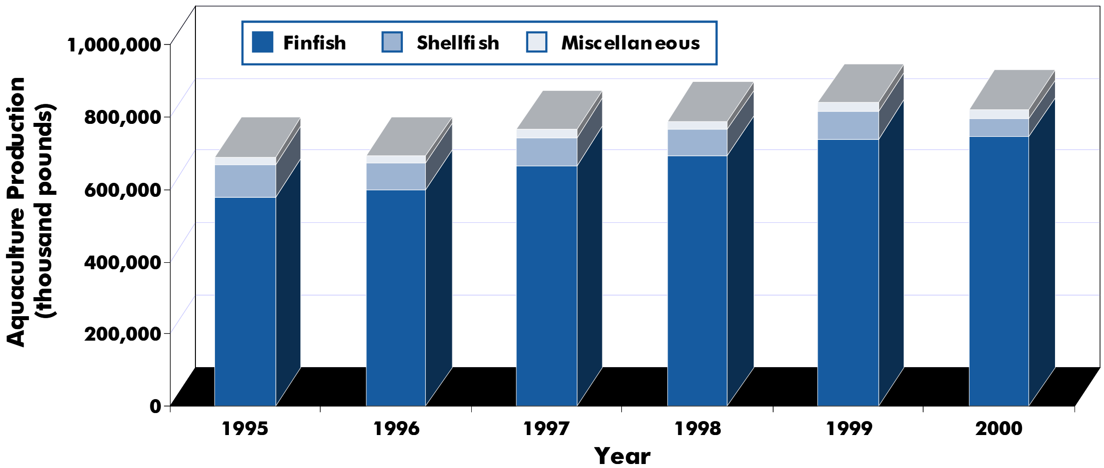
## 2.2.3.5 Fish Products

The value of processed fishery products, including canned fish products and fish oil, was $7.3 billion in 2001, a decrease of $700 million compared to 2000. Of the 2001 total value, $6.8 billion, or 93 percent, was edible processed fishery products, such as fish sticks and canned tuna. The remaining $0.5 billion (7 percent) consists of industrial fishery products, including bait and animal food.[59]

## 2.2.3.6 Aquaculture

The Department of Commerce defines aquaculture as the propagation and rearing of aquatic organisms in controlled or selected aquatic environments for any commercial, recreational, or public purpose.[61] There has been a slight increase in aquaculture each year since 1995, although catfish farming comprises approximately 80 percent of aquaculture production (Figure 2-19).[59] The U.S. Department of Agriculture anticipates increased domestic aquaculture production in 2003.[62] This is based on several factors, including

**Figure 2-19: Trends in U.S. Aquaculture Production**




*Finfish, specifically catfish, dominate U.S. aquaculture production.*

an anticipated higher demand for seafood products and little-to-no growth in wild harvest seafood landings. According to the department, however, these factors could increase the demand for imported seafood if domestic supply cannot meet U.S. needs.

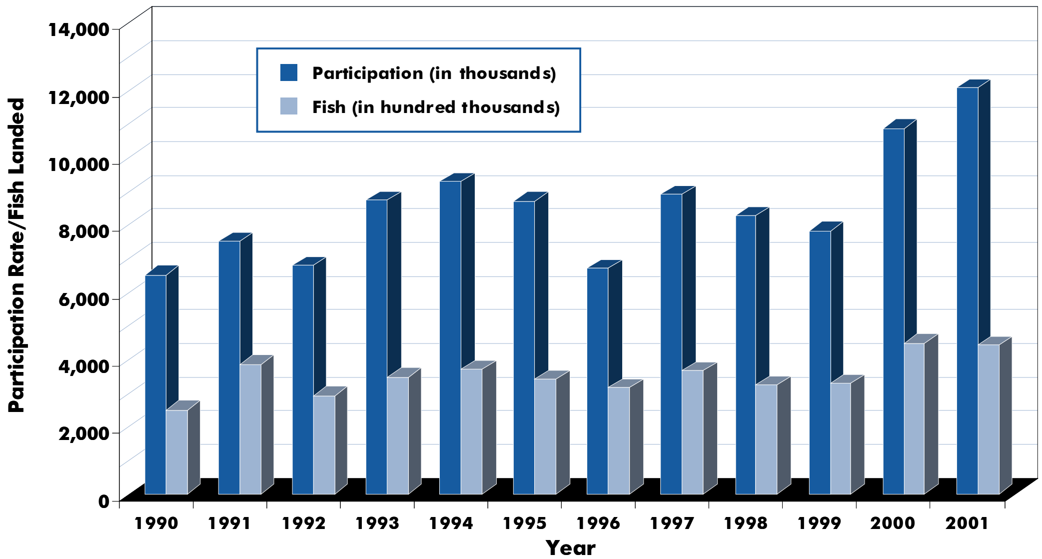
## 2.2.4 Marine Recreational Industries

The nation's coasts and Great Lakes offer many recreational activities, including fishing, boating, and swimming. This section addresses some recreational activities undertaken as a pastime. Unlike the other marine commerce and transportation sectors addressed in this chapter, there are no well-defined data sources for most recreational activities. The limited information presented here is intended to provide a brief illustration and does not encompass the realm of marine recreational activities.

### 2.2.4.1 Recreational Fishing

The National Marine Fisheries Service defines recreational fishing as any fishing in marine waters that does not result in the sale or barter of all or part of the fish harvested.[63] Participation in recreational fishing has grown over the past decade, reaching its highest level in 1999 (Figure 2-20).[64] The National Marine Fisheries Service is in the process of estimating the economic impact of recreational fishing activity in the United States. Two rounds of surveys measuring valuation and expenditure are being conducted to meet these goals.[65]

**Figure 2-20: Participation in Recreational Fishing in the United States**




*U.S. participation in recreational fishing activities has almost doubled since 1990.*

## 2.2.4.2 Recreational Boating and Watercraft

The National Marine Manufacturers Association, a trade association that represents producers of recreational boating products, provides data on recreational boats, including usage and purchases.[66] According to the association, over 68 million people participated in recreational boating activities in 2002, including sailing and water skiing, which resulted in $29.2 billion in retail sales, including new and used boats, and associated equipment.

The Association also reported that 79,300 personal watercraft were sold in the United States in 2002, with an average price of $8,798, and estimates that in 2002, 1,353,700 watercraft owned in the United States. Those watercraft are generally defined as vessels that use inboard motors powering water jet pumps as their primary source of power, and are designed to be operated by a person sitting, standing, or kneeling on the vessel, rather than the conventional manner of sitting or standing in the vessel.

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# OCEAN AND COASTAL SAFETY AND PROTECTION

*Chapter 3*

***Natural Resource Management***

***Navigation and Marine Safety***

***Maritime Security and Enforcement***

***Environmental Protection and Response***

Ocean and coastal safety and protection encompass a wide range of activities involving the use and preservation of natural resources, responses to marine emergencies, and the protection of ocean and coastal waters. These activities are both proactive, such as the protection of living marine resources by enforcing endangered species laws, and reactive, such as marine search and rescue. This chapter presents four dimensions of ocean and coastal safety and protection:

- Natural Resource Management describes facilities that protect, preserve, and enhance marine resources
- Navigation and Marine Safety describes facilities that ensure the safe movement of vessels
- Maritime Security and Enforcement describes facilities used for coastal defense and law enforcement
- Environmental Protection and Response describes facilities used to respond to marine emergencies.

This chapter provides an inventory of the federal facilities and activities involved in ocean and coastal safety and protection. The inventory includes federal facilities that perform an active role in maintaining and protecting ocean and coastal resources, and generally does not attempt to describe federal oversight responsibilities. Some examples of state resources and facilities are included to illustrate typical state capabilities.[a] This inventory is not intended to encompass the realm of state or commercial marine facilities (selected commercial activities are discussed in Chapter 2).

Several federal entities perform related tasks within each dimension of ocean and coastal safety and protection. While the U.S. Coast Guard, the U.S. Navy, and the National Oceanic and Atmospheric Administration (NOAA) lead efforts, other federal organizations address specific issues, including the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency (EPA). With many government agencies involved and the wide range of activities under ocean and coastal policies, interaction and cooperation among the government entities are crucial. For example, while the U.S. Coast Guard (USCG) is the lead agency for ocean environmental disasters, it often receives direct support for cleanup activities from the U.S. Navy and EPA, and indirect help through information assistance (e.g., weather patterns) from NOAA or other federal agencies. Some tasks, such as dredging, are the sole purview of one federal entity, in this case, the U.S. Army Corps of Engineers (USACE). An examination of the federal role in ocean and coastal safety and protection provides insight into how collaborative efforts among agencies can enhance federal capabilities.

To capture and characterize federal capabilities regarding ocean and coastal protection and safety, the U.S. Commission on Ocean Policy (the Commission) collected information from federal and state agencies involved in related tasks. The information presented in this inventory is a compilation of submissions to the Commission from primary federal entities, supplemented by Internet research and testimony given before the Commission. The inventory is not comprehensive; it serves as a snapshot of the involvement of federal agencies in ocean policies and provides a starting point for further discussion of their capabilities. Several federal entities, including the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (FWS), and the National Park Service, did not provide the requested information. As a result, some parts of this chapter are not comprehensive.

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[a] *Thirteen of the 35 coastal states contacted by the Commission submitted responses to a survey on ocean and coastal facilities.*

# 3.1 Natural Resource Management

Several federal agencies are charged with the protection and enhancement of marine natural resources, including NOAA, EPA, and FWS. Natural resources are characterized as living and non-living resources. Living marine resources are fish, marine mammals, and their habitats. Non-living marine resources, which may or may not be man-made, include coastal water and air; oil, gas, and minerals located offshore; and historical and cultural artifacts. These resources are typically naturally occurring, but include man-made items, such as sunken vessels. For example, certain man-made objects are considered integral to resource management because they have been incorporated into the ecosystem by living resources, such as coral and fish.

Living marine resources are fish, marine mammals, and their habitats. Non-living marine resources, which may or may not be man-made, include coastal water and air; oil, gas, and minerals located offshore; and historical and cultural artifacts.

Natural resource management, particularly the management and protection of living resources, lends itself to collaborative efforts, as federal laws have established jurisdictional overlap. For example, some species of salmon live in both coastal and inland waters, which fall under the jurisdiction of separate agencies. NOAA's National Marine Fisheries Service (NMFS) and FWS frequently collaborate on issues involving the protection of marine life. EPA also works collaboratively with other federal and state agencies to protect sensitive coastal ecosystems, such as the Chesapeake Bay. Non-living resources, however, are generally static; therefore, this segment of marine resource management does not prompt the same collaborative efforts as living resources, and federal agencies tend to work independently.

## 3.1.1 Living Marine Resources

Federal and state agencies preserve, protect, and enhance living marine resources using a variety of facilities, including fish hatcheries and monitoring vessels. Living marine resources include organisms that live directly in ocean water (including estuaries) or the Great Lakes. This definition can include fish, marine mammals, other forms of wildlife, and their habitats (e.g., coral reefs). Federally protected species (i.e., endangered and threatened species) are discussed separately because of the unique legal protections afforded them. The following subsections summarize facilities that preserve and protect living marine resources.

### 3.1.1.1 Fish, Marine Wildlife, and Habitats

NOAA is primarily responsible for federal activities to protect marine wildlife and habitats, and many states have separate programs designed to preserve and protect local marine environments. Almost all coastal states are involved in collaborative efforts with the federal government under the national Coastal Zone Management (CZM) program to design and implement local programs to enhance marine environments.

### *3.1.1.1.1 Federal Resources*

NOAA is primarily responsible for protecting all pinnipeds (e.g., seals and sea lions, excluding walruses) and cetaceans (e.g., whales and dolphins) under the 1972 Marine Mammal Protection Act, and operates programs and facilities for that purpose. This protection occurs regardless of population status, including those marine species listed as threatened or endangered under the Endangered Species Act. NMFS, also called NOAA Fisheries, has management responsibility for over 1,050 stocks of invertebrates, fish, and marine mammals. This includes 959 fish stocks, of which 295 have annual landings greater than 200,000 pounds. Landings represent the amount of fish caught over a specified time period. Of those 959 fish stocks, over 40 percent have no index of abundance, and for almost 60 percent of the fish stocks, the level of available information is insufficient to determine whether the stock is overfished. According to NOAA, there is also an information gap regarding the status of over 200 marine mammal stocks, and the identification and assessment of fish habitats.

NMFS maintains six regional offices (Table 3-1), six science centers, and several laboratories and research facilities (research facilities are discussed in Section 4.1). These facilities are engaged in monitoring programs addressing every aspect of the marine ecosystem. NOAA Fisheries employs over 1,000 scientists, including biologists and engineers, to address fish and wildlife concerns.

The conservation strategies for federally managed stocks of fish are contained in 40 Fishery Management Plans created by 8 Regional Fishery Management Councils (Table 3-2), 2 Fishery Management Plans created and managed by NMFS, and numerous inter-jurisdictional Fishery Management Plans and international agreements. Under the Endangered Species Act, NMFS is responsible for more than 56 species listed as threatened or endangered.

Recovery plans have been prepared for 11 populations of sea turtles, 5 species of marine mammals, and 2 species of fish, for a total of 18 of 25 non-Pacific salmon species listed as endangered or threatened under the Endangered Species Act. Under the Marine Mammal Protection Act, three take-reduction plans have been prepared for 11 stocks of marine mammals in 12 fisheries. Of the six depleted stocks of marine mammals, one conservation plan has been developed for northern fur seals, and one is under development for bottlenose dolphins.[1]

**Table 3-1: National Marine Fisheries Service Regional Offices**

| Regional Office | Location | Jurisdiction |
|---|---|---|
| **Alaska** | Alaska | Alaska |
| **Northeast** | Massachusetts | Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia |
| **Northwest** | Washington | Oregon and Washington, and the inland states of Idaho and Montana |
| **Southeast** | Florida | North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Texas; the inland states of Arkansas, Iowa, Kansas, Kentucky, Missouri, Nebraska, New Mexico, Oklahoma and Tennessee; the Commonwealth of Puerto Rico; and the U.S. Virgin Islands |
| **Southwest** | California | California |
| **Pacific Islands*** | Hawaii | Central and Western Pacific, including Hawaii and American Samoa |

* *The formation of the Pacific Islands Regional Office was announced April 2003. Central and Western Pacific were formerly under the jurisdiction of the Southwest Regional Office.*

**Table 3-2: Fishery Management Councils**

| Fishery Council | Location | Jurisdiction |
|---|---|---|
| **New England** | Massachusetts | Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut |
| **Mid-Atlantic** | Delaware | New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and North Carolina (North Carolina is on both the Mid-Atlantic and South Atlantic Fishery Management Councils) |
| **South Atlantic** | South Carolina | North Carolina, South Carolina, Georgia and East coast of Florida |
| **Gulf of Mexico** | Florida | West coast of Florida, Alabama, Mississippi, Louisiana, Texas |
| **North Pacific** | Alaska | Alaska |
| **Pacific Fishery** | Oregon | Washington, Oregon and California |
| **Western Pacific** | Hawaii | U.S. Pacific Islands |
| **Caribbean** | Puerto Rico | Puerto Rico, U.S. Virgin Islands |
| **Council of Great Lakes Fisheries Agencies*** | Michigan | Great Lakes |

* *NMFS does not have a specific Great Lakes Regional Fishery Management Council. The Council of Great Lakes Fisheries Agencies is a joint effort between the United States and Canada to coordinate fisheries research, control the invasive sea lamprey, and facilitate cooperative fishery management among the state, provincial, tribal, and federal management agencies. NOAA is a member of the council.*

### *3.1.1.1.2 State Facilities*

Many coastal states operate fish hatcheries or maintain vessels used to protect and preserve fish and other marine wildlife. The fish hatcheries are used to stock coastal waters, the Great Lakes, local lakes, and rivers. This inventory does not include a comprehensive survey of state facilities involved with living marine resources. An example of state facilities and capabilities used in the protection of marine wildlife, specifically facilities that result in greater marine stocks, is presented below to illustrate this category.

The State of Michigan, through the Michigan Department of Natural Resources, operates six fish hatcheries with a production capability of nearly one million pounds annually (Table 3-3). The goal of Michigan's fish production program is to hatch, rear, and transport fish required for the management of both Great Lakes and inland fisheries.[2]

**Table 3-3: Michigan Fish Hatcheries**

| Hatchery | Year Opened | Production | Staff* |
|---|---|---|---|
| **Harrietta** | 1901 | Brown and rainbow trout | 6-14 |
| **Marquette** | 1922 | Lake and brook trout, splake | 8-10 |
| **Oden** | 1921 (original)<br>2002 (new) | Brown and rainbow trout | 8-10 |
| **Thompson** | 1922 | Atlantic salmon, brown and rainbow trout, steelhead trout, Chinook salmon | 5-8 |
| **Platte River** | 1928 | Chinook and coho salmon | 10 |
| **Wolf Lake** | 1927 | Steelhead trout, Chinook salmon, lake sturgeon, walleye, northern pike, channel catfish, northern muskellunge | 11-13 |

*An examination of Michigan's fish hatcheries provides an example of the aging capabilities of state facilities.*

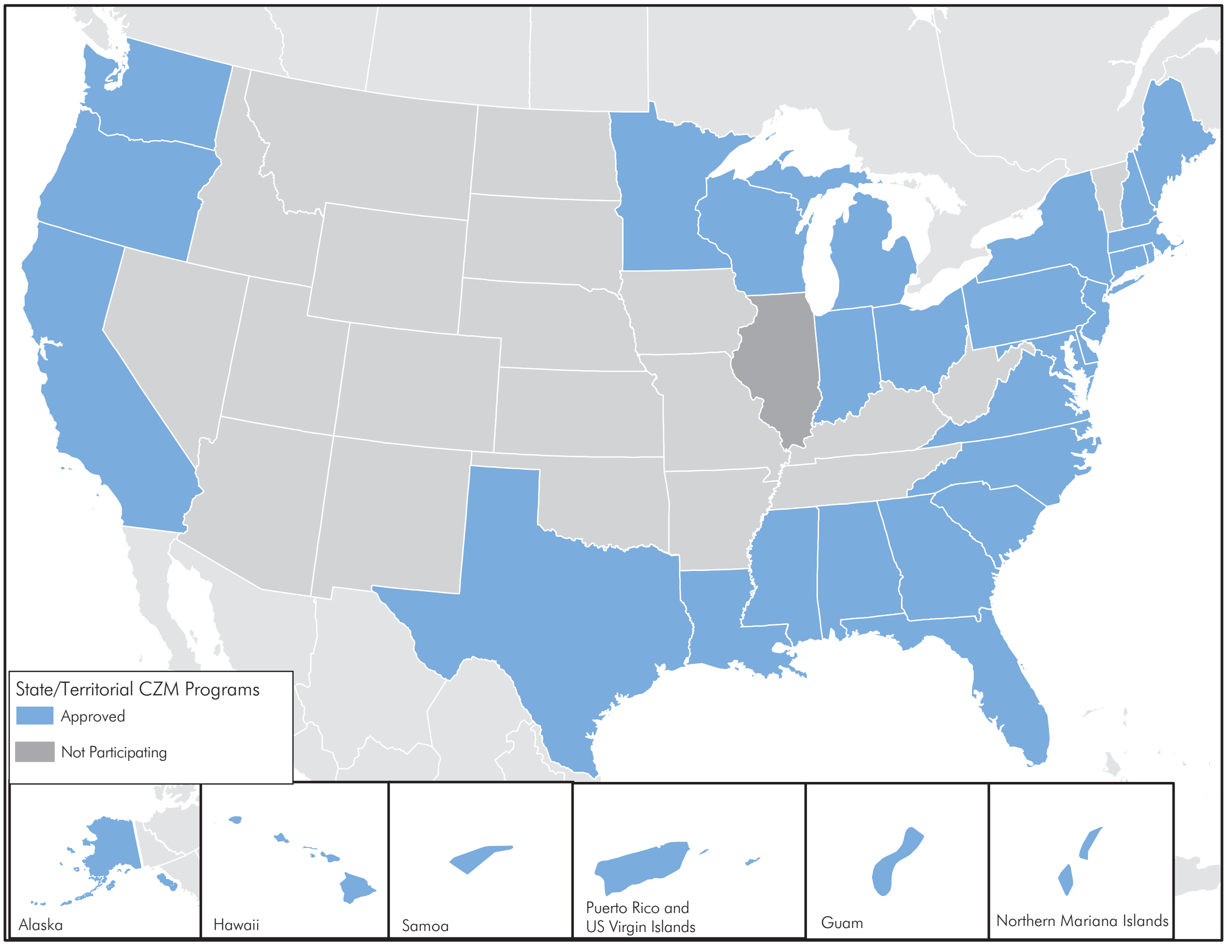
** Some personnel staff multiple facilities, which is not reflected in the staffing quantities. There is also some seasonal variation.*

The Coastal Zone Management Act encourages partnerships between federal and state agencies in the development of land- and water-use programs for coastal areas.

### *3.1.1.1.3 Coastal Zone Management Program*

The Coastal Zone Management Act, enacted in 1972 and reauthorized most recently in 1996, created the CZM program. The program encourages voluntary partnerships between federal and state agencies in the development of land- and water-use programs for coastal areas, and is administered by NOAA. Currently 34 of the 35 coastal states and territories have approved CZM programs. Indiana's CZM program was the most recent to be approved. Illinois is the only coastal state not participating in the CZM program (Figure 3-1).[3]

**Figure 3-1: States Involved in the National Coastal Zone Management Program**




*Almost every coastal state participates in the federal government's Coastal Zone Management program.*

Also under the Coastal Zone Management Act, the Coastal Zone Enhancement program provides incentives for states to make improvements in any of nine areas of national significance. State and local agencies can apply for grants from NOAA for projects to support approved enhancements in the nine areas:

- Wetlands protection and restoration
- Coastal hazards and protection from coastal hazards
- Control of cumulative and secondary impacts of development
- Public access to the coast
- Special-area management planning
- Management of coastal resources
- Reduction in marine debris
- Federal government and energy facility siting
- Facilitating siting and permitting of aquaculture facilities.

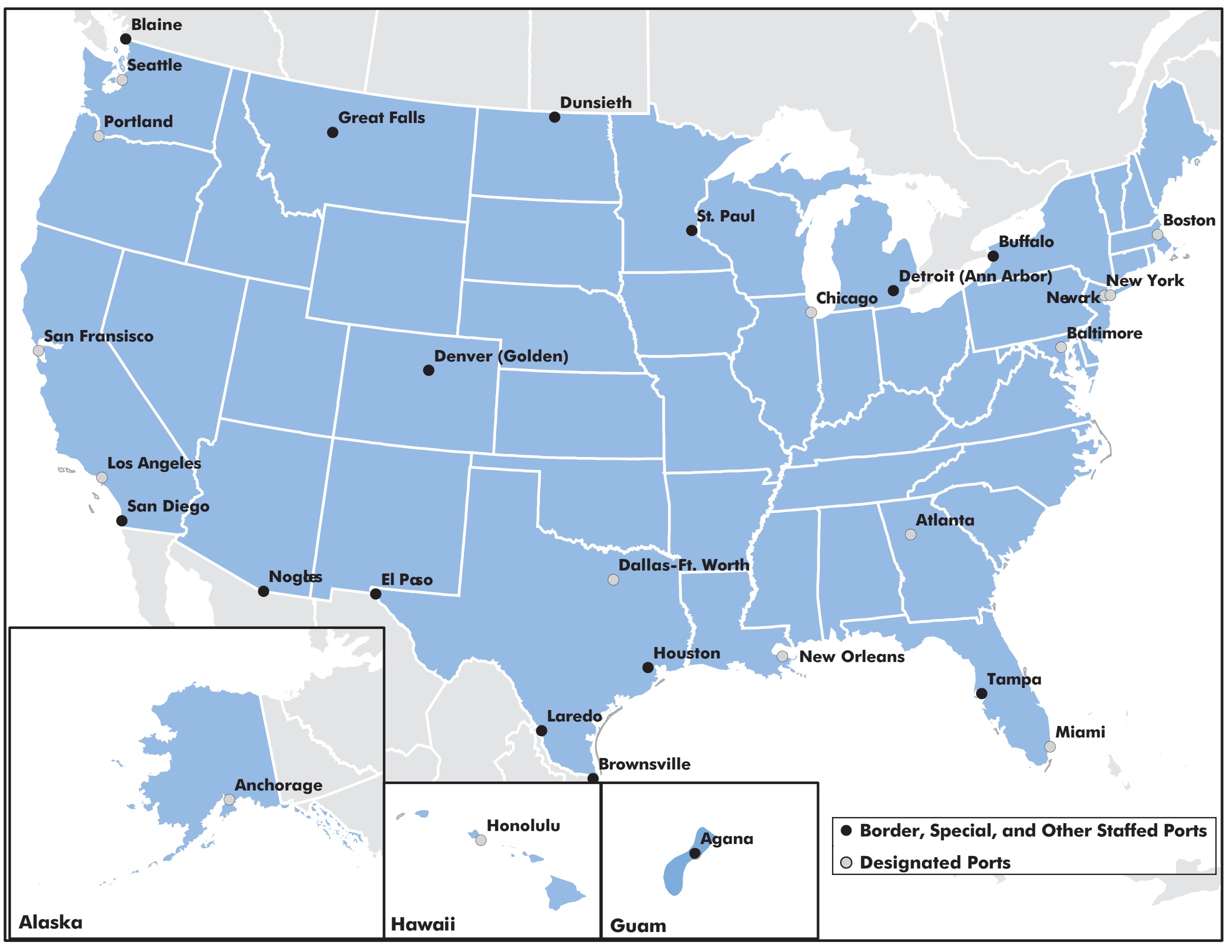
NOAA's Coastal Programs Division in the Office of Ocean and Coastal Resource Management administers the coastal programs at the federal level.

### 3.1.1.2 Endangered Species

FWS and NMFS have shared jurisdiction over endangered species. NMFS has jurisdiction over most marine wildlife, while FWS has jurisdiction over the remaining plants and animals, as well as walruses, polar bears, sea otters, and manatees. There is often overlap between marine and freshwater wildlife, which requires NMFS and FWS to work closely together. For example, the two agencies have collaborated to protect Atlantic salmon populations.

FWS operates an Office of Law Enforcement that works to prevent illegal shipment of wildlife. When fully staffed, the office includes 252 special agents and 93 wildlife inspectors. The Office of Law Enforcement's fiscal year 2001 (FY2001) caseload included 4,291 endangered species and 146 marine mammal protection investigations. This force staffed 13 designated ports of entry and 17 border, nondesignated, and special ports (Figure 3-2), and reviewed 116,535 declared shipments of wildlife and wildlife products worth

**Figure 3-2: Office of Law Enforcement-Staffed Ports of Entry and Other Locations**




*The U.S. Fish and Wildlife Service maintains enforcement offices near most of the major coastal ports of entry.*

$1.488 billion.[b] The 3 busiest ports of entry[c] for the wildlife trade were New York/Newark (28,662 shipments entered or left the country), Los Angeles (18,960 shipments), and Miami (8,159 shipments).[4]

Under NMFS's jurisdiction, there are currently 19 domestic endangered species, 12 domestic threatened species (including 1 plant species), and 8 international species listed as endangered or threatened under the Endangered Species Act. As required under the Endangered Species Act, NMFS has released recovery plans for most of the species that have been added to the threatened and endangered species list. NMFS also maintains an Office of Law Enforcement to enforce the Endangered Species Act, Marine Mammal Protection Act, and other laws and regulations within its jurisdiction. NMFS's Office of Law Enforcement has over 200 personnel, including 150 special agents and 7 enforcement officers. There are currently five Office of Law Enforcement divisions, located in five of the NMFS regional offices (the Pacific Island Islands Regional Office, which NOAA recently created, does not currently have an Office of Law Enforcement).[1]

## 3.1.2 Non-living Marine Resources

Non-living marine resources include any ecological or man-made resources or objects located in coastal waters or the Great Lakes. This section describes facilities for monitoring water and air quality; managing offshore oil, gas, and minerals; and protecting historical or cultural artifacts that are located in coastal waters.

### 3.1.2.1 Marine Water and Air Quality

Several federal networks are currently in place to monitor water and air quality in the oceans and Great Lakes. The data are used for several purposes, including marine weather forecasting, research, and disaster prediction. Some states are also engaged in marine water and air quality monitoring, although these efforts are on a much smaller scale.

#### *3.1.2.1.1 National Oceanic and Atmospheric Administration*

NOAA collects, monitors, and analyzes scientific data to provide information about coastal resource conditions, issues and problems. NOAA operates several ocean-observing arrays that collect data on climate, weather, air quality, and ocean areas. Various NOAA regional offices administer these observing systems (ocean-observing systems are discussed in Section 4.6).

NOAA is also responsible for operating the U.S. polar-orbiting operational and geostationary environmental satellites that support NOAA missions (Table 3-4).[5] Polar-orbiting operational environmental satellites (POES) collect and disseminate data on Earth's weather, atmosphere, oceans, land, and near-space environment. The POES system is supported by NOAA, the U.S.

[b] *While FWS enforcement does include work in coastal areas, the figures presented are nationwide and not coastal-specific.*

[c] *A port of entry is any location (e.g., shipping port, airport) where an individual or cargo can enter the United States.*

**Table 3-4: POES and GOES Systems Information**

| Satellite | Status | Year Launched |
|---|---|---|
| **POES** | | |
| **NOAA-11** | Stand-by | 1988 |
| **NOAA-12** | Stand-by | 1991 |
| **NOAA-14** | Stand-by | 1994 |
| **NOAA-15** | Stand-by | 1998 |
| **NOAA-16** | Primary | 2000 |
| **NOAA-17** | Primary | 2002 |
| **GOES** | | |
| **GOES-8** | Stand-by | Not Available |
| **GOES-9** | Partially operational (provided to Japan) | Not Available |
| **GOES-10** | Primary | 1997 |
| **GOES-11** | Storage | Not Available |
| **GOES-12** | Primary | Not Available |

*NOAA's 2 primary ocean observing satellite systems are less than 20 years old.*

EPA maintains three program offices that encourage collaboration with states and other stakeholders on marine water projects through grants or direct partnerships.

Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA). Geostationary operational environmental satellites (GOES) operate in a geosynchronous orbit, which means that they remain stationary over the same point on the Earth's surface.[6]

NOAA has begun updating its satellite system. In 1998, NOAA and NASA awarded a contract for up to four weather-monitoring GOES satellites. A joint program between NOAA, NASA, and DoD, designed to merge the nation's military and civil operational meteorological satellite systems into a single, national system, is developing the National Polar-orbiting Operational Environmental Satellite System. The first of these satellites is expected to be available for launch in approximately 2008, depending on when the remaining POES and Defense Meteorological Satellite program satellite assets are exhausted.

### *3.1.2.1.2 U.S. Environmental Protection Agency*

EPA maintains numerous facilities designed to monitor and protect water quality. While many of these facilities focus on noncoastal waters, EPA maintains three program offices that encourage collaboration with states and other stakeholders on marine water projects through grants or direct partnerships. These program offices are located near the Great Lakes, the Chesapeake Bay, and the Gulf of Mexico.

The Great Lakes National Program Office in Chicago monitors Great Lakes ecosystem indicators and manages associated data. The office provides grants to local organizations to support habitat protection and restoration programs. In FY2002, the office received approximately $15.5 million and had a staff of 46 federal employees.

The Chesapeake Bay Program is a regional partnership among Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission, EPA, and participating advisory groups. EPA's Chesapeake Bay Program Office in Annapolis, Maryland, coordinates, staffs and provides technical assistance to the partnership's efforts. The 68-person office consists of 18 EPA staff, 14 representatives from five other federal agencies, and 36 grantees providing various types of technical and staffing support to the restoration effort. The Chesapeake office also has 7 full- and part-time staff in EPA's Region 3 Office in Philadelphia, Pennsylvania. In FY2002, the Chesapeake office received approximately $21 million in funding.

The Gulf of Mexico Program Office comprises a consortium of organizations and is located at the Stennis Space Center in Mississippi. The office works with the five Gulf states, Gulf coastal communities, and others to provide direct technical and financial assistance to implement projects. In FY2002, the Gulf office received approximately $4 million in funding and had a staff of 13 federal employees.

#### *3.1.2.1.3 U.S. Navy*

The U.S. Navy's Naval Oceanographic Office (NAVOCEANO) is the U.S. Navy's center for ocean observation and prediction, including the analysis and distribution of real-time oceanographic and riverine data. The Navy's Fleet Numerical Meteorology and Oceanography Center, NAVOCEANO's sister command, provides DoD with atmospheric forecasting.

NAVOCEANO also maintains ocean current measurement systems, consisting of single-point and acoustic profiling instruments. These instruments can be deployed to full ocean depth in either taut-line or bottom-mounted configurations. The Environmental Acoustic Recording System is an autonomous, battery-powered, full-ocean-depth capable, acoustic buoy system for recording omni-directional ocean acoustic ambient noise. Both shallow-water and deep-water configurations are supported. The buoys are also used for marine-mammal monitoring in cooperation with Minerals Management Service and NMFS studies. The buoys are designed to have an operating life of two years.

#### *3.1.2.1.4 U.S. Geological Survey*

USGS, a bureau of the U.S. Department of the Interior, maintains more than 335,000 water quality monitoring sites, many of which are in estuarine waters. USGS also operates three coastal and marine geology program field centers that conduct scientific research along U.S. coastlines by collecting data and monitoring conditions about geologic hazards, environmental conditions, habitats, geologic processes, and energy and mineral resources. Over 300 people are employed in the geology program field centers. Limited information was available concerning USGS and its facilities.

#### *3.1.2.1.5 State Facilities*

Several states operate water quality monitoring systems in coastal waters. The State of Washington, for example, has maintained four SBE-16 temperature and conductivity meters in Willapa Bay, Washington, since 1997. These moorings were installed under an EPA grant, and are presently operated under a NOAA grant. Non-moored monitoring instrumentation used routinely off platforms (ships/seaplane) include two SBE-25 CTD (conductivity, temperature, depth) recorders that monitor such parameters as temperature, salinity, and pH (ocean-observing systems are discussed in Section 4.6).[5]

### 3.1.2.2 Offshore Oil, Gas and Minerals

The Department of Interior's Minerals Management Service (MMS) is the lead authority for offshore oil, gas, and mineral exploration. MMS oversees more than 4,000 leases for private facilities located on the Outer Continental Shelf. MMS has almost 900 staff, including over 350 scientists and engineers. Approximately 535 of the 900 personnel are located in the Gulf of Mexico region, which produces the greatest amount of offshore oil and gas in the United States (commercial offshore activity is discussed in Section 2.4).

To support exploration, MMS is constructing a permanent observation station to study gas hydrate mounds and active gaseous hydrocarbon vents in the Gulf of Mexico, through the Center for Marine Resources and Environmental Technology at the University of Mississippi. The purpose of the station is to study the relationships between these features and episodes of sediment instability that pose a threat to the petroleum industry's infrastructure and safety of operations. The monitoring station is expected to become operational by late 2004. To date, approximately $1.7 million has been spent on the project, including $30,000 from the Naval Research Lab. The Department of Energy's National Energy Technology Lab is also providing funds for the work. An additional $800,000 for the center was included in the MMS appropriations for FY2002.

### 3.1.2.3 Historic and Cultural Resources

The U. S. National Park Service, under the Department of the Interior, investigates shipwrecks and documents their locations and condition. This includes assessing underwater cultural resources in the park system; developing plans for management, preservation, and recreational use of submerged cultural resources; and developing GIS-based,[d] integrated cultural and natural resource data to be used for survey, inventory and evaluation. Limited information was available concerning the National Park Service's facilities.[6]

The U.S. Navy maintains an Underwater Archaeology Branch under the Naval Historical Center that advises on matters related to historic preservation of Navy ship and aircraft wrecks.

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[d] *Geographic Information System.*

# 3.2 Navigation and Marine Safety

Navigation and marine safety addresses the facilities and tools the federal government uses to enable vessels to travel safely and easily. This includes aids-to-navigation, and information and distress response systems. Navigation and marine safety can be segmented into two types of activities: preventative actions and active response. Preventative actions are those undertaken to ensure the safe movement of marine traffic and incident avoidance. This includes installation and maintenance of aids-to-navigation, nautical charting and surveying, vessel inspection, and marine forecasting. Active responses are taken after an event has occurred, such as search-and-rescue efforts. This distinction is made to aid analysis and is not intended to be a clear-cut delineation of tasks.

## 3.2.1 Dredging and Waterways Maintenance

Several federal and state government agencies are involved in dredging and waterways maintenance of ports, coastal waters, rivers, and other bodies of water to enable vessel traffic and prevent environmental degradation. Dredging uses scooping or suction devices to deepen harbors and waterways (commercial marine dredging is discussed in Section 3.2.3). USACE is the only federal entity that is frequently and directly involved in dredging. Waterways maintenance is defined as actions that enable water traffic to move normally (e.g., icebreaking).

USACE is the only federal entity that is frequently and directly involved in dredging.

### 3.2.1.1 Dredging

Dredging to deepen water bodies is necessary to allow large cargo vessels to enter ports and harbors. Private companies under contract to USACE undertake most dredging operations. USACE does maintain a small fleet of 12 major dredging vessels that undertake some of the dredging operations each year (Table 3-5).[8] The USACE vessel with the largest capacity is the WHEELER, which can move almost 11.5 million cubic meters.

### 3.2.1.2 Icebreaking

Icebreaking is the destruction and movement of ice away from frequently traveled routes to permit marine vessels to move safely and efficiently. Both USCG and the U.S. Navy maintain icebreaking programs. USCG is engaged in icebreaking for commercial and research purposes, while the U.S. Navy performs the task for military reasons.

#### *3.2.1.2.1 U.S. Coast Guard Icebreaking*

In addition to conducting domestic and commercial icebreaking operations, USCG is responsible for some international icebreaking missions in the Arctic and Antarctic. To meet operational needs, USCG owns and operates 13 icebreaking vessels: 4 icebreaking cutters (class WAGB) and 9 icebreaking tugs (class WTGB) (Table 3-6). USCG classifies any vessel under 65 feet in length as a boat and any vessel 65 feet or over as a cutter. Three of the cutters are used for icebreaking and supporting logistic and research needs in the Arctic and Antarctic. The fourth icebreaking cutter operates exclusively in

## Table 3-5: USACE Major Dredging Vessels

| | Annual Capacity ($m^3$) | Homeport | Operating Area |
|---|---|---|---|
| **Hopper dredges:*** | | | |
| **ESSAYONS** | 5,390,430 | Portland, Oregon | Pacific Coast |
| **HURLEY** | 6,116,800 | Memphis, Tennessee | Inland rivers |
| **JADWIN** | 1,433,625 | Vicksburg, Mississippi | Inland rivers |
| **MCFARLAND** | 3,173,090 | Philadelphia, Pennsylvania | In reserve |
| **POTTER** | 5,398,993 | St. Louis, Missouri | Inland rivers |
| **WHEELER** | 11,469,000 | New Orleans, Louisiana | In reserve |
| **YAQUINA** | 715,665 | Portland, Oregon | Pacific Coast |
| **Sidecaster dredges:** | | | |
| **FRY** | 188,856 | Wilmington, North Carolina | Atlantic Coast inlets |
| **MERRITT** | 304,310 | Wilmington, North Carolina | Atlantic Coast inlets |
| **SCHWEIZER** | 473,287 | Wilmington, North Carolina | Atlantic Coast inlets |
| **Pipeline dredge:** | | | |
| **THOMPSON** | 755,316 | Saint Paul, Minnesota | Inland rivers |
| **Special-purpose dredge:** | | | |
| **CURRITUCK** | 584,537 | Wilmington, North Carolina | Atlantic Coast inlets |

*Even though USACE maintains a fleet of dredging vessels, much of the work is contracted to private companies.*

* *WHEELER was placed in ready reserve on January 10, 1997, and MCFARLAND was scheduled to be overhauled between 2001 to 2003 and then placed in reserve.*

## Table 3-6: USCG Icebreaking Vessel Characteristics

| Class | Length (feet) | Max. Crew Size | # in Class | Flight Deck Equipped* | | Max Speed (knots) | Cruising Range | |
|---|---|---|---|---|---|---|---|---|
| | | | | HH60 | HH65 | | Distance (nautical miles) | Speed (knots) |
| **WAGB 290 MACKINAW** | 290 | 107 | 1 | No | No | 18.7 | 41,000 | 11.5 |
| **WAGB 399 POLAR class** | 399 | 154 USCG<br>30 Science | 2 | Yes | Yes | 18 | 28,000 | 13.0 |
| **WAGB 420 HEALY** | 420 | 75 USCG<br>50 Science | 1 | Yes | Yes | 17 | Not Available | 12.5 |
| **WTGB 140** | 140 | 17 | 9 | No | No | 14.7 | 4,000 | 12.0 |

*The U.S. Coast Guard's large icebreaking vessels also conduct large research operations in Arctic and Antarctic waters.*

* *Visual Landings Only.*

the Great Lakes. The cutters are specifically designed for open-water icebreaking and have reinforced hulls, special icebreaking bows, and a system that allows rapid shifting of ballast to increase the effectiveness of their icebreaking.[9] The smaller icebreaking tugs are used exclusively for domestic icebreaking operations and use a low-pressure-air hull lubrication or bubbler system that forces air and water between the hull and ice. USCG, as a member of the International Ice Patrol, also monitors icebergs that enter international shipping lanes. In addition, 175-foot (14 vessels) and 225-foot (16 vessels) buoy tenders can support icebreaking missions.

USCG operates two 399-foot POLAR-class icebreakers (POLAR Star and POLAR Sea) and the 420-foot USCG cutter HEALY for use in the Arctic and Antarctica. The POLAR-class cutters were commissioned in the 1970s. The USCG cutter HEALY, commissioned in 1999, is USCG's longest icebreaking vessel. The HEALY is capable of operating with 50 percent of the crew capacity of the older POLAR-class icebreakers and can accommodate 60 percent more research personnel. All three international cutters are homeported in Seattle, Washington (the research capabilities of icebreakers are discussed in Section 4.2).[10]

The USCG cutter MACKINAW, a 290-foot vessel commissioned in 1944 and based in the Great Lakes, was designed and configured to keep shipping lanes open through as much of the winter as possible. In FY1999, Congress funded the construction of a replacement for the MACKINAW (WAGB 30). The new vessel will be able to operate 185 days a year, break 32-inch layered ice, and will be configured for use as an aids-to-navigation tender when not needed for icebreaking. The new vessel will operate with a crew of 50.[11]

USCG maintains eight 140-foot BAY-class cutters that are used for domestic icebreaking duties.[4] The BAY-class vessels are stationed mainly in the northeastern United States and Great Lakes. Two of the BAY-class vessels, the cutters BRISTOL BAY and MOBILE BAY, are augmented by 120-foot aid-to-navigation barges that are specifically designed for maintaining buoys. Both are homeported on the Great Lakes (Table 3-6).[11]

The United States, through USCG, and 18 other contributing governments participate in the International Ice Patrol, which monitors iceberg danger in the Atlantic Ocean. The International Ice Patrol usually focuses on the shipping lanes between Europe and North America. Reconnaissance flights are used to collect information concerning ice conditions and are augmented by information provided by ships in the area. Ships are requested to report the position and time of all ice sightings and make sea surface temperature and weather reports to the International Ice Patrol Operations Center in Groton, Connecticut.[12]

Fixed-wing USCG aircraft, primarily the Hercules HC-130, conduct Ice Patrol reconnaissance flights. The usual patrol time for these long-range, multi-engine planes is between 5 and 7 hours, with each flight covering approximately 30,000 square miles of water. Ice reconnaissance flights are made on the average of five days every other week during the ice season. The Ice Patrol began using HU-25B Falcons for reconnaissance flights in 1987. The Falcons, which have a shorter patrol range than the HC-130, are periodically used at the beginning and end of the ice season when much of the ice has melted and the reconnaissance flights are shorter.

#### *3.2.1.2.2 U.S. Navy Icebreaking*

The U.S. Navy, through the Naval Ice Center, processes available remote sensing data in support of its ice analysis and forecast mission. The Naval Ice Center, the defense contingent of the joint NOAA and U.S. Navy's National

Ice Center, uses a specialized sea ice mapping system with geographic information system (GIS) capabilities.

The National Ice Center also manages the U.S. Inter-Agency Arctic Buoy Program (USIABP), which coordinates the efforts of several U.S. government agencies to support the International Arctic Buoy Programme. International partners include Russia, Canada, Norway, Germany, and Japan. The program's goal is to maintain an adequate array of buoys across the Arctic to provide a basis for research. The National Ice Center employs 68 people (including contractors) from the U.S. Navy, NOAA, and other federal agencies, including 27 physical and research scientists.

Thirty-six operational buoys, 13 of which were provided by the USIABP, populate the array, which collects data on air temperature, surface pressure, and ice drift. Buoys transmit data over the ARGOS satellite communication system to be collected and quality controlled by the Polar Science Center for use by the research community. USIABP data are also available in near-real time over the Global Telecommunication System for use in operational modeling and forecasting. The USIABP is supported by NASA, the International Arctic Research Center, the National Science Foundation, USCG, the U.S. Navy, and NOAA. The annual operating costs for the USIABP are approximately $230,000, exclusive of buoy deployment costs.

## 3.2.2 Aids-to-Navigation and Navigation Systems

USCG is designated as the lead federal agency for lights and buoys, which are termed aids-to-navigation (AtoN). There are two general types of AtoN: short-range aids-to-navigation and radio aids-to-navigation. Short-range AtoN can be buoys; beacons; lights; lighthouses; ranges; sound signals, such as foghorns or bells; or radar-reflecting devices that mark navigable channels and hazards. Radio AtoN consist of three operating radio-navigation systems: LORAN-C, Differential Global Positioning System (DGPS), and radiobeacons. USCG operates AtoN teams and vessels that are trained and designed specifically for AtoN maintenance. DoD operates and maintains Global Positioning System (GPS) facilities, which provide navigational and timing assistance for civil, commercial, scientific, and military users.

### 3.2.2.1 Short-Range Aids-to-Navigation

USCG maintains approximately 50,000 AtoN serving the United States and its territories, including 35,000 aids along the coastline. This does not include the approximately 50,000 private AtoN. USCG has 215 operating facilities engaged in supporting the short-range AtoN mission. Beacons and buoys are the most common AtoN. Beacons are any permanent AtoN structures, including lighthouses and small, single-pile structures, and are located on land or in the water. Lighted beacons are called lights and unlighted beacons are called daybeacons. Buoys are floating aids that are moored to the seabed. The shape, color, and other characteristics of the buoy provide nautical information to vessels, such as potential obstructions.

A private AtoN is a buoy, light or daybeacon owned and maintained by any non-USCG entity. These aids allow individuals or organizations to mark privately owned marine obstructions or other hazards to navigation. USACE is also responsible for regulating private AtoN (discussed in Section 2.1).

### 3.2.2.2 Radio Aids-to-Navigation

USCG operates the Navigation Center (NAVCEN) in Alexandria, Virginia, and two other stations in Petaluma, California, and Kodiak, Alaska. NAVCEN is responsible for providing Long-Range Radio Navigation (LORAN), DGPS, and Nationwide DGPS (NDGPS) services, mainly within the continental United States and portions of Alaska, Hawaii, and U.S territories. NAVCEN manages the NDGPS program in conjunction with the Federal Railroad Administration and other agencies to provide accurate navigation signals.

LORAN-C is a network of 24 manned stations that allow users equipped with appropriate receivers to determine their geographic position to within 0.25 nautical miles and to return to a previously recorded LORAN-C position with a repeatable accuracy between 60 and 300 feet. The maritime DGPS assists maritime vessels, including commercial traffic, by providing navigational accuracy. NDGPS is a planned nationwide expansion of the maritime DGPS capabilities that will be used to assist other modes of transportation, such as trains, by providing location information.

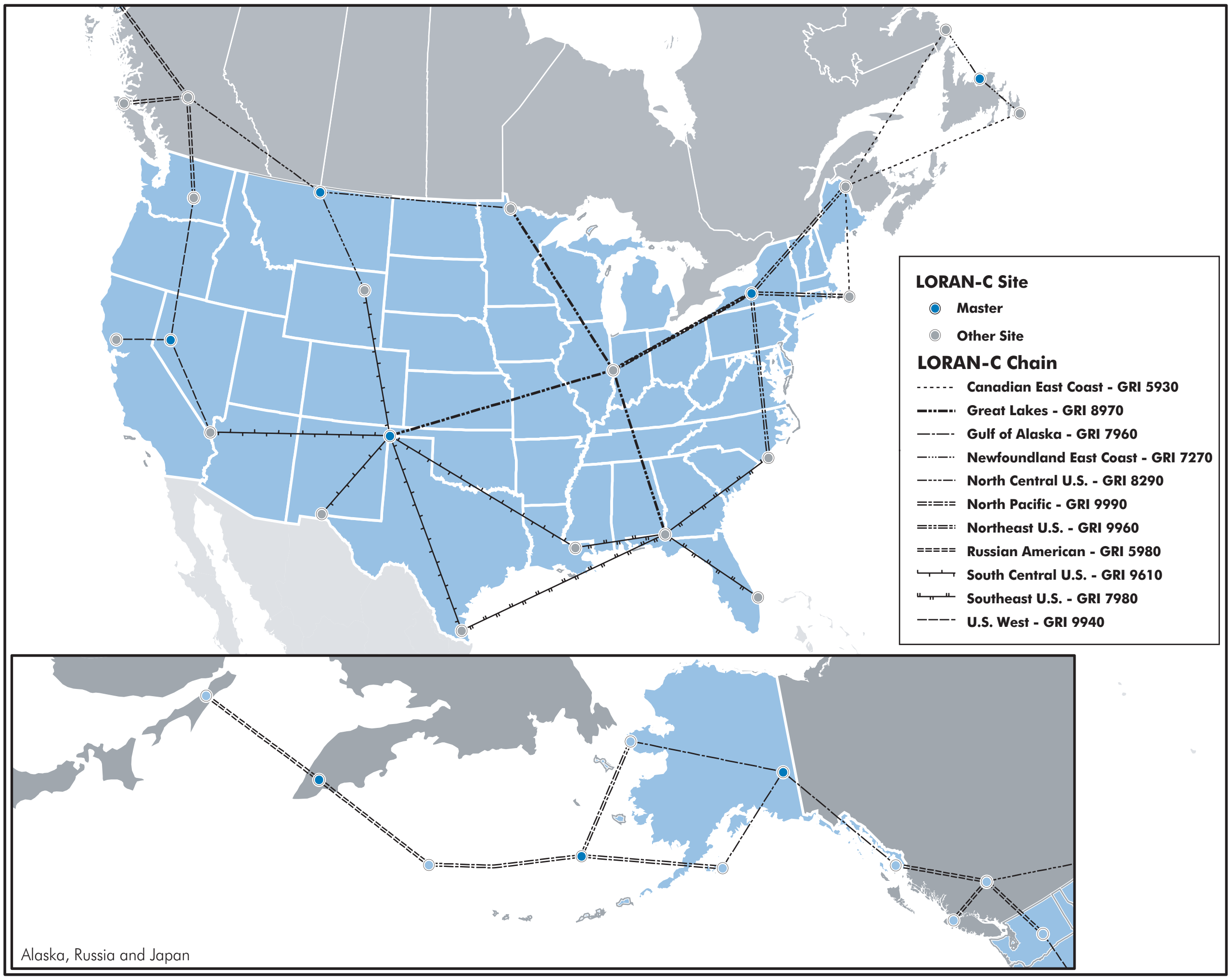
NAVCEN controls and manages USCG's LORAN and DGPS radio-navigation systems from its three stations. NAVCEN also operates the 24-hour Navigation Information System, which provides information for LORAN-C, GPS, DGPS, and NDGPS in the form of Maritime Safety Broadcasts and Local Notices to Mariners. NAVCEN coordinates and manages the Civil GPS Service Interface Committee, part of the U.S. Department of Transportation's efforts to meet the needs of civil GPS users and integrate into civil-sector applications.

#### *3.2.2.2.1 LORAN-C Transmitting Stations*

USCG's 24 manned LORAN-C stations are part of the nation's LORAN-C radio-navigation system. The stations are linked together to create 11 chains (Figure 3-3). The system is supported by the USCG LORAN Support Unit in Wildwood, New Jersey, and the USCG Engineering Logistics Center in Baltimore, Maryland. The LORAN-C radio-navigation system provides navigation, location, and timing services for air, land, and marine users. The system serves the 48 contiguous states and coasts, and portions of Alaska.

In 1999, USCG announced a $110 million recapitalization and modernization plan for the LORAN-C system for continued operation from 2000 to 2008 (an additional $12.5 million was slated for project staffing). That plan provides for the replacement of numerous aging components of the LORAN-C system, including transmitters, timing and control equipment, and several antenna towers. It also funds improvements to the physical plants at a number of the transmitting stations.

**Figure 3-3: LORAN-C Chains**




*Most of the LORAN-C sites are parts of multiple chains. For example, the site in northern Maine is part of the Canadian East Coast and the Northeast U.S. chains.*

### 3.2.2.2.2 Global Positioning Systems

USCG operates and maintains 55 DGPS and 25 NDGPS sites at locations throughout the United States, including some noncoastal areas.[13] The U.S. Department of Transportation is sponsoring the NDGPS, which will expand coverage throughout the continental United States to meet the positioning and navigation needs of the other types of surface transportation. USCG plans to bring five additional NDGPS sites on-line by December 2003. The mission of the Maritime DGPS Service and NDGPS is to provide mariners with a reliable and accurate positioning and navigation augmentation to the GPS. The Maritime DGPS Service provides navigational accuracy within 10 meters (95 percent), with availability for coastal regions of the United States out to 20 nautical miles.

Eleven of the Maritime DGPS sites incorporate NOAA's GPS Surface Observing Systems (GSOS) for measuring weather data and precipitable water vapor measurements for forecasting. In addition, all sites have integrated NOAA's Continuously Operated Reference Station equipment for precise positioning and surveys. The full GPS signal is archived and made publicly available via the Internet for post-processing GPS applications.

The U.S. Department of Transportation is sponsoring the Nationwide Differential Global Positioning System, which will expand coverage throughout the continental United States to meet the positioning and navigation needs of other types of surface transportation.

### 3.2.2.3 Aids-to-Navigation Teams

USCG operates 59 Aids-to-Navigation Teams. These teams have primary responsibility for approximately 60 percent of all coastal aids-to-navigation, and discrepancy response for nearly 80 percent of coastal aids. They operate boats and provide personnel to place, service, and remove AtoN in protected and semi-protected waterways. The teams also contribute to the maintenance of a 99.7 percent overall aid availability throughout the entire short-range AtoN system to assist with waterway navigation.

### 3.2.2.4 Aids-to-Navigation Vessels

USCG maintains and operates several cutters in coastal and deep waters to maintain aids-to-navigation (Table 3-7). Currently there are 30 such vessels in USCG's fleet.[14]

**Table 3-7: U.S. Coast Guard Buoy Tenders**

| Class | Vessel | Size (feet) | Crew Size | Number In Service | Commissioned |
|---|---|---|---|---|---|
| **WLB 225** | Seagoing Buoy Tender JUNIPER Class | 225 | 40 | 11 (16 total planned) | 1997-Present |
| **WLB 180** | Seagoing Buoy Tender BALSAM Class | 180 | 53 | 5 | 1942-1944 |
| **WLM 175** | Coastal Buoy Tender KEEPER Class | 175 | | 14 | 1996-2000 |

*The U.S. Coast Guard is replacing the 180-foot WLBs with the 225-foot WLB. The U.S. buoy tender fleet will then be less than seven years old.*

#### *3.2.2.4.1 180-Foot and 225-Foot WLBs*

Buoy tenders maintain, maneuver, and position AtoN. These vessels typically have a crane and a buoy deck lower than the main deck of the vessel designed to accommodate AtoN. Additional missions may include maritime law enforcement, search and rescue, and military readiness. The WLB-class vessels have good towing capabilities, can lift up to 20 tons, and have been used to recover small aircraft and capsized vessels. The next-generation WLB, the 225-foot WLB, is being phased in to replace the 180-foot WLB and has similar search-and-rescue capabilities. Both WLBs are ice-capable to approximately 18 inches for search-and-rescue in ice-covered waters.

### *3.2.2.4.2 175-Foot WLMs*

The 175-foot WLM-class of cutter has a 3-day unreplenished endurance, a maximum transit speed of 12 knots, and exceptional station-keeping abilities. WLMs are equipped with firefighting and dewatering equipment, have a 10-ton lift capacity, and are able to transport additional fuel, water and cargo. The 175-foot WLM can operate at 3 knots in 9 inches of frozen ice or 3 feet of brash ice (floating ice made up of ice fragments from other forms).

## 3.2.2.5 Physical Oceanographic Real-Time System

The Physical Oceanographic Real-Time System (PORTS) is a navigation system program under NOAA's National Ocean Service. This system integrates real-time environmental observations, forecasts and other geospatial information to improve maritime safety. PORTS measures and disseminates observations and predictions of water levels, currents, salinity, and many meteorological parameters (e.g., winds, atmospheric pressure, visibility).[15]

The objectives of the PORTS program are to promote navigation safety, improve the efficiency of U.S. ports and harbors, and ensure the protection of coastal marine resources. PORTS real-time monitoring also provides an understanding of ecosystem processes by measuring the effects of oceanographic changes, coastal habitats, productivity, and coastal ecosystem health. PORTS operates in 10 locations in the United States (Table 3-8).

**Table 3-8: PORTS System Stations**

| Location | Number of Sites |
|---|---|
| San Francisco Bay | 8 |
| Tampa Bay | 5 |
| Soo Locks | 2 |
| New York/New Jersey Harbor | 7 |
| Chesapeake Bay | 12 |
| Los Angeles/Long Beach | 9 |
| Port of Anchorage | 2 |
| Houston/Galveston | 6 |
| Narragansett Bay | 6 |
| Delaware River and Bay | 11 |

*PORTS system stations are generally located in high-activity areas, including both commercial and recreational traffic.*

## 3.2.2.6 Vessel Traffic Services

USCG operates vessel traffic services in 10 key ports, including New York/New Jersey, New Orleans, and Los Angeles/Long Beach. The service system at each port consists of a Vessel Traffic Center that receives vessel movement data from the Automatic Identification System, surveillance sensors, directly from vessels, and other sources. The compiled information is then provided to other operators through relevant advisories and notifications to prevent collisions, groundings, maritime casualties, and environmental damage.

### 3.2.2.7 Global Positioning System Capabilities

The GPS was designed primarily to support military navigational needs. The system, however, is now used to support land, sea, and airborne navigation, surveying, geophysical exploration, mapping and geodesy, vehicle location systems, and a wide variety of additional applications for the civil, commercial, scientific, and military sectors. GPS is managed by the Interagency GPS Executive Board, which is a policy-making body chaired jointly by the departments of Defense and Transportation. Its membership includes the departments of State, Commerce, Interior, Agriculture, and Justice, as well as NASA and the Joint Chiefs of Staff.[16]

The basic GPS is a constellation of satellites, navigation payloads that produce the GPS signals, ground stations, data links, and associated command-and-control facilities. Operated and maintained by DoD, the current GPS constellation consists of 29 Block II/IIA/IIR satellites, which were launched in 1989. There are two basic services: the Standard Positioning Service and the Precise Positioning Service. The standard service is a free positioning and timing service available to all GPS users, while the precise service is used for more accurate military positioning, velocity and timing services.

## 3.2.3 Nautical Charting and Surveying

Nautical charting and surveying are necessary for marine vessels to operate safely and efficiently. They involve data collection, primarily through research vessels that gather physical data concerning the marine environment. The study of physical features of bodies of water for the purpose of developing nautical charts is called hydrography.

Two federal agencies develop nautical charts. NOAA is the lead agency for the development of nautical charts for public use, while the U.S. Navy develops nautical charts for military purposes. The development of nautical charts includes surveying the ocean floor.

### 3.2.3.1 National Oceanic and Atmospheric Administration

NOAA, through the Office of Coast Survey, is responsible for compiling and maintaining the national suite of nautical charts.[17] This office collects and evaluates marine hydrographic data, such as depth soundings, for the construction and maintenance of over 1,000 nautical charts and other related marine products to satisfy the nautical charting requirements for both commercial and recreational users. NOAA conducts hydrographic surveys and operates data centers that manage nautical information.

NOAA is the lead agency for the development of nautical charts for public use, while the U.S. Navy develops nautical charts for military purposes.

NOAA, through the National Geodetic Survey, is developing the National Spatial Reference System to provide a reference base for position, height, distance, direction, and gravity values, and how these values change with time. According to NOAA, this information is essential in ensuring the reliability of multiple systems and programs, including transportation, communication, and defense systems; land records; mapping and charting;

public utilities; coastal zone management; and natural resource mapping. The National Geodetic Survey also conducts a coastal mapping program that includes surveying the U.S. coastline and determining precise positions of the shoreline and other features in order to produce navigational charts.[17]

NOAA maintains a fleet of vessels to conduct hydrographic surveys. The hydrographic data are generated from soundings and are used to develop nautical charts. NOAA's fleet includes five vessels that support this mission (Table 3-9).[18, 19]

**Table 3-9: NOAA Fleet Nautical Charting Vessel Characteristics**

| Ship | Hull No. | Length in Feet | Beam in Feet | Draft in Feet | Displacement Tons |
|---|---|---|---|---|---|
| FAIRWEATHER | S220 | 231 | 42 | 14.3 | 1,800 |
| RAINIER | S221 | 231 | 42 | 14.3 | 1,800 |
| LITTLEHALES | S3xx | 208 | 42 | 14.0 | 2,238 |
| WHITING | S329 | 163 | 33 | 12.2 | 907 |
| RUDE | S590 | 90 | 22 | 7.2 | 220 |

*The LITTLEHALES, which was transferred in 2003 from the Navy's Military Sealift Command, replaced the WHITING, which was decommissioned.*

NOAA also maintains a fleet of 13 aircraft (11 fixed-wing and 2 rotary planes) based in Tampa, Florida, which are often used for shoreline surveys (NOAA's aircraft fleet is discussed in Section 4.4).

### 3.2.3.2 U.S. Navy

NAVOCEANO conducts hydrographic surveys to measure and describe the physical features of the ocean.[20] The data are provided to DoD's National Imagery and Mapping Agency for producing nautical charts. Military surveys are not the same as marine scientific research surveys. The United States considers military surveys to be activities undertaken in the ocean and coastal waters, involving unclassified and classified marine data collection for military purposes. While equipment used for data collection during military surveys is similar to that used in marine scientific research, information from military surveys, regardless of security classification, is not available for general use by the scientific community. The data are only used to support military operations.

NAVOCEANO maintains a fleet of eight survey ships that collect oceanographic, geophysical and hydrographic data in, on, and above all of the oceans. Two classes of survey ships, T-AGS 51 and T-AGS 60, collect military survey data. The two 208-foot T-AGS 51 Coastal Hydrographic Survey ships collect deep-water hydrographic data using hull-mounted and towed sonars. Each ship carries two 34-foot hydrographic survey launches that collect bottom soundings in shallow water. The mission of the T-AGS 51 class ships is to survey the ocean floor and collect hydrographic data necessary to chart coastlines that are not adequately charted for support of wartime missions.

The 329-foot T-AGS 60 class ships provide multipurpose military survey capabilities in coastal and deep-ocean areas, including physical, chemical, and biological oceanography; ocean engineering and marine acoustics; marine geology and geophysics; and bathymetric surveying. T-AGS 60 class ships may also have hydrographic survey launches.

U.S. Navy aircraft are also used to collect oceanographic and acoustic data during exercises and airborne military surveys. The U.S. Navy maintains airborne laser instrumentation that allows for hydrographic mapping via laser profiling. The laser instrumentation is a joint capability with the U.S. Army and NOAA as part of a center of expertise in airborne laser identification detection and ranging hydrography. NAVOCEANO also maintains several unmanned vessels that are used in ocean surveying (NAVOCEANO research capabilities are discussed in Section 4.7).

Navigation systems aboard NAVOCEANO survey platforms use sensors and receivers to provide precise position, velocity, time, and attitude data. Position information is used to georeference environmental data sets and to merge multiple data sets. Timing and attitude data are used to correct for the effects of vessel motion on multi-beam and single-beam sonar systems during survey operations.

These systems rely on the use of the satellite-based GPS. Wide-area differential, geodetic, and kinematic corrections are applied to provide mission-specific position accuracy that range from less than 10 centimeters to 10 meters. These position systems are integrated with ring laser gyrocompasses, inertial measurement units, vertical displacement sensors, time code generators, and various communication data links. The combination of the positioning systems and these devices form complete integrated navigation systems that support ship operations. The annual operating cost for NAVOCEANO's navigation systems and aids is estimated to be $180,000, which includes satellite coverage area fees and equipment maintenance.

There are almost 900 personnel, including 588 scientist and engineers, employed at NAVOCEANO. NAVOCEANO expects that the workforce will remain stable for the next few years and then increase.

### 3.2.4 Marine Forecasting

Marine forecasting is the collection and analysis of data for the purpose of predicting weather. The data collected can include water temperature and depth, salinity, or current (a complete inventory is discussed in Section 4.10). NOAA's National Weather Service alone employs over 200 oceanographers, meteorologists, and physical scientists to support ocean and coastal programs for marine forecasting. NOAA maintains several offices and major marine observing systems to support marine forecasting activities. The major observing systems are:

- National Weather Service's Marine Observation Network, which comprises moored buoys and Coastal Marine Automated Network (C-MAN) stations, the Deep-Ocean Assessment and Reporting of Tsunamis (DART) Project buoy array, and the Voluntary Observing Ship program
- National Ocean Service's National Water-Level Observation Network (NWLON) and PORTS
- Office of Oceanic and Atmospheric Research's Tropical Atmospheric Ocean (TAO) buoy array
- Office of Oceanic and Atmospheric Research's drifting buoy program.

### 3.2.4.1 Marine Observation Network

The Marine Observation Network is a collection of several networks of buoys, data stations, and vessels that gather information to assist in predicting weather patterns. The systems, operated by the National Weather Service, include moored buoys, Coastal Marine Automated Network stations, Deep-Ocean Assessment and Reporting of Tsunamis buoy array, and the Voluntary Observing Ship program.

#### 3.2.4.1.1 Moored Buoys

The National Data Buoy Center operates moored buoys that are deployed in the coastal and offshore waters from the western Atlantic to the Pacific Ocean around Hawaii, and from the Bering Sea to the South Pacific. They are designed to measure and transmit ecological and oceanographic data, such as barometric pressure, wind direction, air and sea temperature, and wave energy. The Buoy Center's fleet of moored buoys includes 3-meter, 10-meter, and 12-meter discus hulls; and 6-meter boat-shaped (NOMAD) hulls (Table 3-10). The choice of hull type used usually depends on the deployment location and measurement requirements. As of September 2001, 80 moored buoys were operating in coastal waters with depths from 13 to over 5,000 meters.[21]

#### 3.2.4.1.2 Coastal Marine Automated Network

The Coastal Marine Automated Network, or C-MAN, is a series of data recording stations that monitor baseline measurements, such as wind speed, direction, and air temperature. At various stations within the network, the configuration is augmented to satisfy other specific requirements, such as enhanced meteorological and oceanographic capabilities.

There are 56 operational C-MAN stations — 49 of which are sponsored by the National Weather Service. Seven C-MAN stations are either fully or partially supported by organizations other than the National Weather Service, such as NOAA's Office of Atmospheric and Oceanic Research and the U.S. Department of Transportation. C-MAN stations have been installed on lighthouses, at capes and beaches, on near-shore islands, and on offshore platforms. All 56 C-MAN stations are displayed in Figure 3-4.[22]

**Table 3-10: NOAA Moored Buoys**

| Buoy | Number | Description/Capabilities |
|---|---|---|
| Discus | 59 (total) | • Circular hulls<br>• Designed in three sizes: 12-meter, 10-meter, and 3-meter |
| 12-meter | 1 | • Steel-hulled<br>• Sturdier than 10-meter discus buoy<br>• More costly to maintain<br>• Generally must be towed to appropriate location |
| 10-meter | 6 | • Steel-hulled<br>• Has been known to capsize in certain environmental conditions<br>• Overall motion of the buoy is more dynamic than that of the 12-meter buoy<br>• Generally must be towed to location |
| 3-meter | 48 | • Aluminum-hulled<br>• More cost-effective than 12- and 10-meter buoys<br>• Does not offer long-term survivability that larger discus hulls provide<br>• Can be easily carried on a flat-bed trailer<br>• Less likely to corrode than 12- and 10-meter buoys |
| NOMAD | 25 | • Aluminum-hulled, boat-shaped buoy<br>• Relatively cost-effective<br>• High long-term survivability in severe seas<br>• Highly directional with a quick rotational response<br>• Size allows for transport via flat-bed trailer, rail, or ship<br>• Less likely to corrode than 12- and 10-meter buoys |

*The type of buoy used is based on anticipated ocean conditions.*

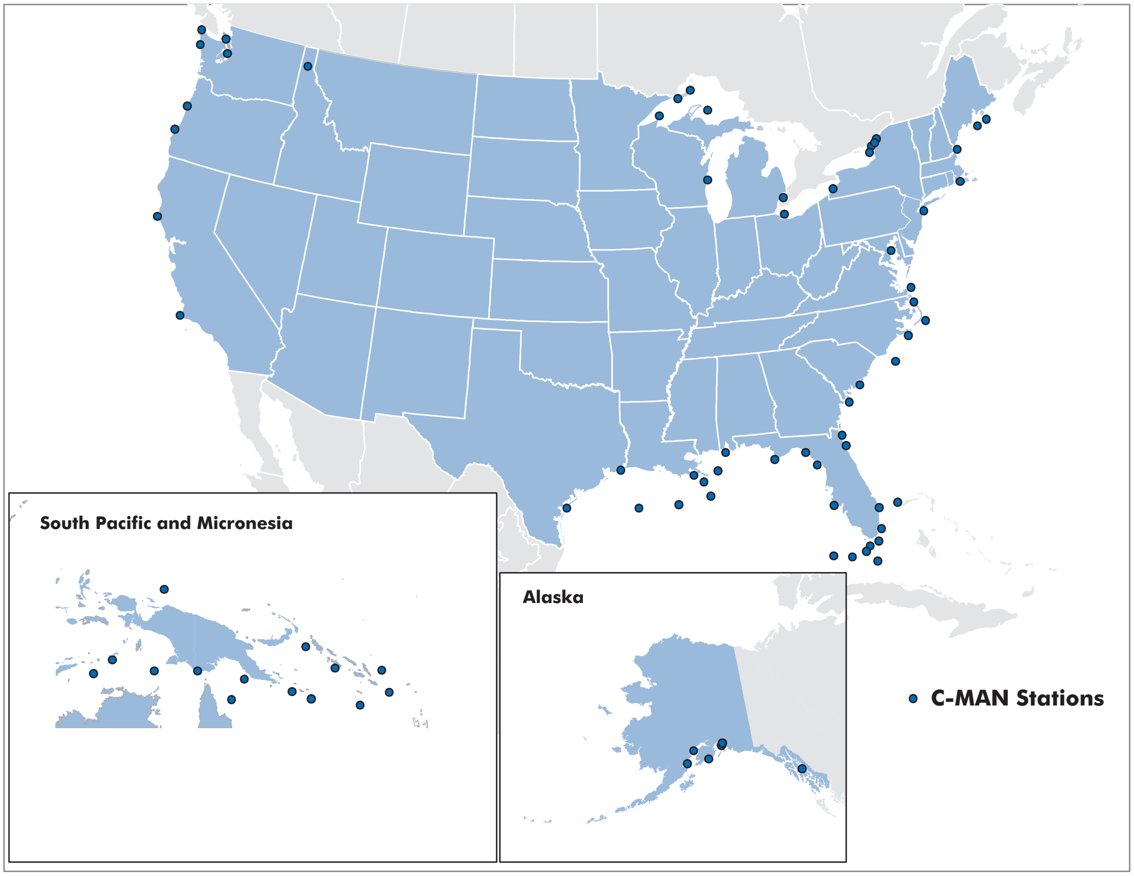
### 3.2.4.1.3 Deep-Ocean Assessment and Reporting of Tsunamis

The Deep-Ocean Assessment and Reporting of Tsunamis Project is an ongoing effort to maintain and improve capabilities for the early detection and real-time reporting of tsunamis in the open ocean in the Pacific. The program maintains a six-buoy operational array completed in 2001. The standard Deep-Ocean Assessment and Reporting of Tsunamis surface buoy provides real-time data to the National Data Buoy Center and has a current design life of one year. Each buoy has a corresponding anchored seafloor bottom pressure recorder that has a life of two years. [23]

### *3.2.4.1.4 Voluntary Observing Ship Program*

The U.S. Voluntary Observing Ship program's mission is to obtain weather and oceanographic observations from moving commercial ships. As of 1994, the Voluntary Observing Ship program had 49 countries participating, with the United States contributing over 1,600 of the approximately 7,200 participating vessels. At its peak, 7,700 vessels were participating in the program (1984-1985). Observations are taken by deck officers and transmitted in real time to the National Weather Service. These observations assist with marine weather forecasts in both coastal and high seas areas. As might be expected, real-time reports from the Voluntary Observing Ship Program are heavily concentrated along the major shipping routes, primarily in the North Atlantic and North Pacific Oceans.[24]

**Figure 3-4: C-MAN Stations**




*The majority of the C-MAN stations are located in the eastern half of the United States.*

## 3.2.4.2 National Water-Level Observation Network

The National Water-Level Observation Network consists of approximately 175 water-level measurement stations distributed along U.S. coasts, the Great Lakes and connecting channels, and U.S. territories and possessions. There are 140 stations that have been in operation for at least 19 years that are still in continuous operation and transmit data in near-real time. The National Water-Level Observation Network is currently being upgraded to a fully integrated, state-of-the-art electronic data collection, processing, and dissemination system called the Next Generation Water-Level Measurement System. More than 75 percent of the National Water-Level Observation Network stations have been upgraded to Next Generation Water-Level Measurement System.[25]

The National Water-Level Observation Network is currently being upgraded to be called the Next Generation Water-Level Measurement System.

## 3.2.4.3 Tropical Atmospheric Ocean Buoy Array

The TAO buoy array (renamed the TAO/TRITON array in 2000) consists of approximately 70 moorings in the tropical Pacific Ocean. NOAA and the Japan Marine Science and Technology Center (JAMSTEC) jointly operate and maintain the moorings of the array. The data are managed and distributed as a unified data set. NOAA manages the Autonomous Temperature Line Acquisition System (ATLAS) moorings in the array (located between the U.S. coast and 165 degrees East), and JAMSTEC maintains the Triangle

Trans-Ocean buoy network (TRITON) moorings (located between the coast of Japan and 165 degrees East). France, through the Institut de Recherche pour le Developpement, also participates in the project.[26]

The array sends oceanographic and meteorological data in real time via satellite. The NOAA ship KA'IMIMOANA (Ocean Seeker), a 224-foot former U.S. Navy ship commissioned into the NOAA fleet in 1996, is specifically designed for and dedicated to maintaining the TAO buoy array in the tropical Pacific Ocean.

TRITON is a series of buoys that measure surface meteorology and gather upper ocean characteristics, such as salinity. The buoys are deployed in collaboration with other countries in and around the Pacific Ocean as part of international climate research programs, specifically to study how warm water in the equatorial part of the ocean impacts world climate change. JAMSTEC is scheduled to deploy 18 buoys in the tropical Pacific and 2 buoys in the north Pacific.

#### 3.2.4.4 Drifting Buoy Program

The National Data Buoy Center deploys drifting buoys to measure atmospheric pressure, air and sea temperature, wind speed, and wind direction. The buoys are expendable systems launched from ships or aircraft into specific ocean areas. As the buoy relays information to NOAA through various satellites, the buoy's position is identified to determine drift. Since the mid-1980s, over 330 drifting buoys have been deployed in support of the Tropical Ocean and Global Atmosphere Research Program, and most have operated for 12 to 18 months. Drifting buoys have been used by both domestic and international organizations for a variety of scientific programs, including the departments of Commerce, Interior, and Defense.[27]

### 3.2.5 Vessel Inspection and Registration

USCG administers navigation and vessel inspection laws, rules, and regulations governing marine safety. By law, vessel inspections are required periodically for certification and can occur between required inspections. The purpose of the vessel inspection is to examine the vessel's equipment and operating practices.[28] Additionally, vessels are required to be registered for licensing, enforcement, and financial reasons.

#### 3.2.5.1 Container Inspection Training and Assistance Team

USCG maintains the nine-person Container Inspection Training and Assistance Team (CITAT), located in Oklahoma City, Oklahoma, to provide container inspection assistance to USCG units implementing the national container inspection program. This inspection program was created to prevent the improper shipping of hazardous materials in intermodal transportation, since intermodal freight containers can be used by several modes of transportation from shipment origin to destination. Inspections conducted under the program are intended to be dedicated hazardous materials inspections that target cargoes and not facilities. CITAT promotes the standardization of inspection procedures by providing deployable on-site training packages to USCG units involved in container inspection, assisting Marine Safety Offices, and coordinating joint inspections with federal, state and local agencies.

#### 3.2.5.2 National Documentation Centers

USCG also maintains two centers for vessel documentation. The National Vessel Documentation Center in Falling Waters, West Virginia, provides a registry of vessels that are available in time of national emergencies or war. The National Maritime Center in Arlington, Virginia, is responsible for the coordination and oversight of mariner licensing and document activities and services. The National Maritime Center maintains central records for nearly 200,000 active merchant mariners and administers merchant mariner personnel programs for documentation, examination administration, course approvals, licensing, and compliance with international standards.

### 3.2.6 Search-and-Rescue

Under the National Search and Rescue Plan, USCG is the lead agency for maintaining and operating search-and-rescue facilities to respond in international waters and waters subject to U.S. jurisdiction. Other federal agencies are also involved in marine search-and-rescue. For example, DoD maintains facilities and resources to support defense-related operations, NOAA provides nautical charts and marine forecasts, and NASA maintains aircraft and communication networks that can assist in search-and-rescue operations.

USCG facilities, vessels, and aircraft serve a multitude of missions, but search-and-rescue capabilities are consistently a priority. Any operational vessel or aircraft in the USCG fleet can be used for search-and-rescue, including icebreaking and AtoN vessels. The information provided here is limited to those facilities and vessels that are primarily designated for search-and-rescue missions.

#### 3.2.6.1 U.S. Coast Guard Groups and Bases

USCG maintains 39 Groups and Bases under 9 District offices that provide command, control, communications, and other support to stations, aids-to-navigation teams, patrol boats, and tenant commands.[e] Areas of emphasis for each group vary, depending on local threats, environment (e.g., coastline, weather, water temperature), type of commercial waterways users, and other factors. Groups and Bases have equipment unique to the mission and area of emphasis, including unique piers, boat ramps, docks, seawalls, boat lifts, and aircraft maintenance equipment, such as washdown racks, hangars, and ramps (for Groups with co-located air stations).

[e] *A tenant command is a command located on a installation or facility with a different mission. For example, a U.S. Coast Guard station located on an Air Force base.*

## 3.2.6.2 Multi-Mission Stations

USCG maintains 186 multi-mission stations that operate boats and provide personnel to conduct a variety of operations, including search-and-rescue, law enforcement, and marine environmental protection missions. These stations are primarily located in coastal towns and, like the USCG Groups, each station's areas of emphasis vary depending on local conditions. Stations usually possess equipment and facilities that support the areas of emphasis for the station, such as including piers, boat ramps, docks, seawalls, and boat lifts to support operations. Multi-mission stations also house 52-foot and 47-foot motor lifeboats and 41-foot utility boats.

## 3.2.6.3 U.S. Coast Guard Marine Vessels

As previously stated, USCG classifies its vessels by hull length into two categories: boats and cutters. Any vessel under 65 feet is classified as a boat, while any vessel 65 feet or longer is a cutter. Boats are typically multi-mission vessels that operate in coastal and inland waters, and are not intended to operate independently for long periods of time. Cutters are typically deep-water vessels with a large range of mission capabilities (cutters are discussed in Section 3.3.1).

### *3.2.6.3.1 U.S. Coast Guard Boats*

There are two types of USCG boats: standard and nonstandard. Standard boats are designed for search-and-rescue missions, although each has different characteristics reflecting its area of operation (e.g., surf waters, coastal waters). Nonstandard boats are often designed primarily for other missions, such as cable boats, although they have search-and-rescue capabilities.

USCG's standard multi-mission boats are designed to perform search-and-rescue missions in adverse weather and sea conditions (Table 3-11). Each boat has different design capabilities; some are designed for search-and-rescue operations in adverse conditions, while others are designed for speed.

There are 410 nonstandard boats in 11 different categories in service throughout the United States, although not all categories are represented USCG-wide. These platforms represent 42 percent of the entire USCG boat inventory. Some perform a variety of missions, while others are used exclusively in specialized missions (e.g., cable servicing boats, ferries, ice rescue skiffs). Nonstandard boats are capable of carrying out search-and-rescue missions.

### *3.2.6.3.2 U.S. Coast Guard Tugboats*

USCG tugboats are often used for search-and-rescue, particularly for towing or firefighting. They also serve as primary assets for assistance to vessels in distress due to ice conditions. Because they are slow and have poor sea-keeping ability in adverse weather, they operate primarily in protected waters.

**Table 3-11: Operational Characteristics of Select USCG Boats**

| Class | Maximum Operational Range * | Surf / Bar Conditions | Towing Capabilities | Max. Wind (knots) | Additional Information |
|---|---|---|---|---|---|
| **30-Foot Surf Rescue Boat** | Less than 10 nautical miles offshore | Up to 10 ft | Up to 40 ft (towing not recommended) | 40 | • Designed for surf and bar operations<br>• Fast response boats<br>• Alternative, not a primary resource<br>• Used to arrive on scene quickly and stabilize situation |
| **41-Foot Utility Boat** | Less than 10 nautical miles offshore or 30 nautical miles with operational LORAN-C or GPS, moderate conditions | No surf<br>Up to 8 ft seas | Up to 100 gross tons | 30 | • Considered to be the general workhorse of multi-mission unit<br>• Designed to operate under moderate weather and sea conditions<br>• Operation is not permitted in breaking surf or bar conditions<br>• 168 boats in service<br>• Vessels will be replaced beginning in FY2004 |
| **44-Foot Motor Life Boat (MLB)** | Up to 50 nautical miles offshore | Up to 20 ft | Up to 125 gross tons | 50 | • Designed to perform in adverse sea and weather conditions<br>• Considered standard heavy weather and surf rescue response platform.<br>• Capable of self-righting and self-bailing within 30 seconds of capsizing<br>• Nearing the end of useful service life<br>• Being replaced by the 47-foot MLB |
| **47-Foot MLB** | Up to 50 nautical miles offshore | Up to 20 ft | Up to 150 gross tons | 50 | • Replacing the 44-foot MLB<br>• Can withstand maximum seas of 30 feet, 20 feet of surf, 50-knot winds<br>• Self-righting capabilities<br>• USCG also operates four 52-foot MLBs in the Pacific Northwest |

* *Maximum operational range is adversely affected by long tows.*

The 65-foot harbor tugs normally operate only in protected waters in seas less than 6 feet. They can tow vessels up to 300 tons, break ice up to 12 inches, and have either a 3- or 4-meter rigid-hull inflatable boat. The tug's endurance is 2 days without replenishment and maximum speed is 10 knots.[14]

### 3.2.6.4 U.S. Coast Guard Aircraft

USCG operates 25 air stations of various sizes, depending on the geographic location and the size of the station's coverage area. Air stations provide mission-capable aircraft and aircrews to USCG and other government agencies in support of search-and-rescue, maritime law enforcement, maritime homeland security, marine environmental protection, logistics, military readiness, and enforcement of U.S. laws and treaties. Typically, both large and small air stations perform search-and-rescue and law enforcement missions. Larger air stations may receive heavy tasking across all USCG missions.

USCG's fleet of aircraft is designed to provide support for all missions, including search-and-rescue operations. Aircraft extend USCG's range of presence, detection, and interdiction capabilities. The fleet is divided into fixed-wing aircraft (Table 3-12) and helicopters (Table 3-13). USCG maintains approximately 70 fixed-wing aircraft, and all but 2 are multi-mission aircraft that are used for a variety of USCG missions. The remaining two are logistical aircraft that do not have the capabilities of the larger aircraft.[14]

Currently, USCG maintains 146 helicopters. Most of these helicopters are multi-mission, and can be used for search-and-rescue, marine enforcement, or other USCG tasks. A few of the helicopters are designed explicitly for marine enforcement tasks.

## 3.2.6.5 U.S. Coast Guard Search-and-Rescue Systems

USCG maintains two systems to assist with search-and-rescue operations: the Atlantic Merchant Vessel Emergency Reporting (AMVER) System and the National Distress Response System. AMVER allows the USCG to identify and divert merchant ships near an area of distress. The National Distress Response System is a communications system used primarily by recreational and commercial vessels that USCG monitors.

USCG maintains two systems to assist with search-and-rescue operations: the Atlantic Merchant Vessel Emergency Reporting System and the National Distress Response System.

### *3.2.6.5.1 Atlantic Merchant Vessel Emergency Reporting System*

The AMVER system is a voluntary, computer-based global ship-reporting system used to arrange for assistance during search-and-rescue missions. With AMVER, rescue coordinators can identify participating merchant ships in the area of distress and divert the best-suited ship or ships to respond. Approximately 12,000 ships from over 140 nations participate in AMVER. In 2002, an average of 2,760 vessels actively participated in the AMVER system each day, and the AMVER Center computer tracked over 100,000 voyages annually.[13]

### *3.2.6.5.2 National Distress Response System*

The National Distress Response System is a communications system that provides very high frequency-frequency modulation (VHF-FM) coverage in coastal areas and navigable waterways where there is commercial or recreational vessel traffic. The system was built to provide USCG with a means to monitor the international VHF-FM distress frequency (channel 16), coordinate search-and-rescue response operations, and communicate with commercial and recreational vessels.[14]

## Table 3-12: USCG Fixed-Wing Aircraft Characteristics

| Class | # in Class | Speed (knots) | | Range (NM) | Additional Information |
|---|---|---|---|---|---|
| | | Max. | Cruise | | |
| **HC-130H Hercules** | 27 | 310 | 250 | 4,000 | • USCG's Long Range Search (LRS), 4-engine turboprop, multi-mission maritime patrol aircraft<br>• Two series of "H" model C-130s; 1500s and 1700s<br>• Equipped with APS-137 sea-search radar<br>• 1500 series are also equipped with Side-Looking Airborne Radar (SLAR)<br>• Has the longest range and endurance capabilities of all USCG aircraft<br>• Certified for all-weather operations<br>• Going through extensive sensor upgrades |
| **HU-25 Guardian or Falcon*** | 41 | 350-380 | 250 | 1000-1500 | • Medium-range search (MRS) fixed-wing, twin turbofan jet, multi-mission maritime patrol aircraft<br>• Conducts maritime patrols, air intercepts, and in-flight delivery of emergency rescue equipment to vessels and personnel<br>• Enlarged search window on both sides of the aircraft and a drop hatch in the forward floor<br>• Fastest operational air asset in the USCG inventory<br>• Certified for flight under all weather conditions, except for severe air turbulence and icing conditions<br>• Has standard complement of deployable SAR equipment: gas-powered de-watering pump, a self-inflating life raft, a radio, a data marker buoy, smoke flares, and small message blocks |
| **VC-4A** | 1 | | 250 | 1500 | • Serves primarily as a logistics aircraft supporting Seventh USCG District operations |
| **VC-20A** | 1 | | 450 | 3500 | • Only dedicated command-and-control support aircraft in the USCG inventory<br>• Certified for flight under all weather conditions, with the exception of severe air turbulence and severe icing conditions |

*The HC-130H is the primary aircraft used by the U.S. Coast Guard in International Ice Patrol missions.*

* *Only 17 of the 41 HU-25s are operational.*

## Table 3-13: USCG Helicopter Characteristics

| Class | # in Class | Speed (knots) | | Range (NM) | Additional Information |
|---|---|---|---|---|---|
| | | Max. | Cruise | | |
| **HH-60J Jayhawk** | 42 | 180 | 125 | 700 | • Twin-engine, all-weather medium-range recovery, multi-mission helicopter<br>• Operates up to 300 NM offshore<br>• Can fly at 120 knots for 5 1/2 hours<br>• Can be carried aboard 270-foot medium endurance cutters<br>• Can be fitted for night vision<br>• Equipped with a rescue hoist rated for 600 pounds and a heavy lift external cargo hook capable of lifting 6000 lbs |
| **HH-65B Dolphin** | 96 | 165 | 130 | 300 | • Twin-engine turboshaft, short-range recovery, multi-mission capable helicopter<br>• Can operate up to 120 NM offshore<br>• Can fly at 120 knots for 2 1/2 hours<br>• Can be deployed aboard polar, medium- and high-endurance cutters<br>• Certified for operation in all weather nighttime operations, with the exception of icing<br>• Only USCG aircraft routinely deployed aboard cutters and ships |
| **MH-68A** | 8 | 168 | 137 | 363 | • Twin-engine, short-range interdiction, single-mission leased helicopter<br>• Supports counter-drug operations<br>• Primarily a shipboard deployed asset operating within 70-90 NM of the vessel<br>• Can fly at 120 knots for two hours<br>• Can be carried on board 210 and 270-foot medium-endurance cutters, and 378-foot high-endurance cutters<br>• All-weather helicopter<br>• Can be fitted for night vision<br>• Equipped with a rescue hoist rated for 600 pounds |

*All U.S. Coast Guard helicopters can be used for search-and-rescue missions.*

The system is a network of approximately 300 antenna high-sites[f] with VHF-FM analog transceivers that are remotely controlled by regional communication centers and selected stations. The network provides coverage extending out to approximately 20 nautical miles from shore in most areas. The system provides continuous monitoring of channel 16 and the use of additional maritime channels for USCG-to-public communications and USCG-to-USCG command-and-control communications.

#### *3.2.6.5.3 Rescue 21*

USCG is currently implementing Rescue 21, a modernization program for the National Distress Response System. Rescue 21 will update the existing communications system, add new equipment, and eliminate coverage gaps. The project, which began in the mid-1990s, will increase USCG's ability to:

- Coordinate search-and-rescue response operations
- Communicate with commercial and recreational vessels
- Provide command and control for Coast Guard units (active, auxiliary, and reserve) that perform maritime missions.

Deployment is scheduled to begin in FY2003 and conclude in FY2006. The system will provide coverage out to 20 nautical miles seaward off the U.S. coastline, and the Hawaii, Puerto Rico, Virgin Islands, Guam, and Gulf of Alaska coastal zones. Coverage will also include the Great Lakes, navigable waters of the U.S. Intracoastal Waterway System, and the western rivers.

### 3.2.6.6 Communications Stations

USCG provides internal and external communications through a pair of Communications Area Master Stations in Chesapeake, Virginia, and Point Reyes, California (Table 3-14). These Master Stations support operations at five Communications Stations that provide communications support and services to USCG Operational Commanders, other government agencies, and the maritime community.

[f] *High-sites are towers located at higher elevations, such as hills and mountains.*

**Table 3-14: USCG Communications Station Assets**

| Communications Station | Key Assets |
|---|---|
| **Master Station Chesapeake** | 32 transmitters in total<br>• 24 Collins AN/URT-41(V)2 HF 10KW transmitters<br>• 6 Harris RF-755 HF 10KW transmitters<br>• 2 Nautel Medium Frequency (MF) transmitters<br>56 High Frequency (HF) receivers |
| **Master Station Point Reyes*** | • 20 Collins AN/URT-41(V)2 HF 10KW transmitters |
| **Boston** | 14 transmitters in total<br>• 12 Collins AN/URT-41(V)2 HF 10KW high power transmitters<br>• 2 Nautel MF Transmitters<br>15 HF receivers |
| **Miami** | 10 transmitters in total<br>• 3 Collins AN/URT-41(V)2 HF 10KW<br>• 5 Collins AN/URT-41(V)1 HF 1KW<br>• 2 Nautel MF transmitters<br>18 HF receivers |
| **New Orleans** | 17 transmitters in total<br>• 12 Harris RF-755 transmitters<br>• 3 Collins AN/URT-41(V)1 HF 1KW<br>• 2 Nautel MF transmitters<br>19 HF receivers |
| **Honolulu** | 15 transmitters in total<br>• 8 Collins AN/URT-41(V)2 HF 10KW transmitters<br>• 7 Harris RF-755 transmitters for a total of 15 transmitters<br>COMMSTA Honolulu Transmitter Site has 10 physical (14 electrical) antennas including one Rotatable Log Periodic antenna |
| **Kodiak** | • 23 Collins AN/URT-41(V)2 HF 10KW transmitters<br>• 29 HF antennas for these transmitters |

*The U.S. Coast Guard maintains seven communications stations, each with transmitters and antennas, to manage both internal and external communications.*

** Point Reyes is currently in the third year of a five-year project to replace the majority of antennas at the transmitter site. Upon completion, the site will have 10 physical (20 electrical) omni-directional antennas and one Rotatable Log Periodic antenna.*

## 3.3 Maritime Security and Enforcement

Maritime security and enforcement denote defense and law enforcement activities that occur in coastal and marine waters. This includes drug activity, illegal immigration, and hostile actions. Maritime security and enforcement are separated into two segments in this inventory: coastal patrol and defense, and ports and harbor patrol. This separation is used because different conditions in each area require different equipment.

While USCG has command responsibilities for the U.S. Maritime Defense Zone, which includes U.S. coasts, ports, and inland waterways, several agencies conduct operations in coastal waters or have a role in maritime security. These agencies include the U.S. Customs Service, the Immigration and Naturalization Service, and the Drug Enforcement Agency. The involvement of federal entities whose primary missions are not marine-related often results in collaboration among federal agencies. The security and enforcement discussion is largely based on information from agency submissions to the Commission and is supplemented through Internet research. The smaller federal entities whose primary mission is not marine-related are not included in the inventory.

## 3.3.1 Coastal Patrol and Defense

Coastal patrol vessels are designed to operate in deep, coastal waters and in aggressive conditions for enforcement and defense missions. The U.S. Navy and USCG are the two federal agencies most heavily involved with patrolling the more than 95,000 miles of U.S. coastline.[29] In addition, several states maintain more general marine patrols that are used for a variety of tasks, included coastal patrols and law enforcement.

### 3.3.1.1 U.S. Navy Coastal Patrol

The U.S. Navy maintains 13 vessels that are used for coastal patrol and interdiction surveillance. The CYCLONE PC-1 class's mission is maritime homeland security and has been employed jointly with USCG to help protect U.S. coastlines, ports, and waterways from hostile actions. Nine ships operate out of the Naval Amphibious Base in Little Creek, Virginia, and four operate from the Naval Amphibious Base in Coronado, California. These ships provide the U.S. Navy with a platform that can respond in a shallow-water environment. The lead ship of the class, CYCLONE (PC-1), was decommissioned and given to the Philippine government.[30]

### 3.3.1.2 U.S. Coast Guard Coastal Patrol

USCG's cutters, other than the previously mentioned POLAR-class icebreakers, are classified as either deep-water or coastal assets. Deep-water assets are currently being renovated or replaced as part of a 23-year strategy to modernize USCG's deep-water fleet of cutters and aircraft (USCG's Deepwater Program is discussed in Section 3.3.3). As part of this project, USCG's communications system is also being modernized to allow full interoperability of all assets: surface, air, and ashore. Table 3-15 shows the deep-water cutters by classification.

### 3.3.1.3 State Patrols

Several states maintain marine patrols to monitor, enforce, and protect coastal areas. These patrols protect fisheries and other environmental areas, perform search-and-rescue missions, and augment ongoing police activities. For example, the Massachusetts Department of Law Enforcement operates two 48-foot offshore patrol vessels that conduct investigations of illegal fishing practices and marine theft cases, and enforce boat registration and titling requirements. In addition, coastal officers closely monitor fish markets and processing facilities for operating irregularities, shellfish digging, and all-terrain vehicle use on beaches. The department also patrols in numerous smaller craft and aircraft.[31]

**Table 3-15: USCG Deep-Water Cutters**

| Class | Length (feet) | Crew Size | # in Class | Flight Deck Equipped | | Max. Speed (knots) | Cruising Range | | Additional Information* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | HH60 | HH65 | | Distance (NM) | Speed (knots) | |
| **WHEC 378 HAMILTON** | 378 | 161 | 12 | Y | Y | 29 | 11,000 | 11 | • Commissioned between 1967 and 1972<br>• Tasked to operate offensively in a low-to-medium intensity, multi-threat environment as a surveillance and interdiction platform |
| **WMEC 282 ALEX HALEY** | 282 | 99 | 1 | Y | Y | 16 | 10,000 | 13 | • Commissioned in 1971<br>• Used primarily for fisheries enforcement and SAR off the Alaska coast |
| **WMEC 270 FAMOUS** | 270 | 98 | 13 | Y | Y | 19 | 9,900 | 12 | • Commissioned between 1983 and 1991 |
| **WMEC 230** | 230 | 78 | 1 | N | N | 14 | 22,000 | 8 | No information available |
| **WMEC 213** | 213 | 75 | 1 | N | N | 15.5 | 9,000 | 15 | No information available |
| **WMEC 210 RELIANCE** | 210 | 75 | 14 | N | Y | 18 | 6,100 | 13 | • Commissioned between 1964 and 1969 |
| **WPB ISLAND** | 110 | 13 | 49 | N | N | 29.5 | 3,000 | 12 | • Commissioned between 1986 and 1992 in three classes<br>• Tasked to operate in a low-to-medium intensity, multi-threat environment as a surveillance and interdiction platform<br>• Primary difference between the classes is configuration of interior spaces |

*Much of the U.S. Coast Guard's deep-water cutter fleet will be replaced or refitted over the next 20 years.*

** Every cutter also carries at least one rigid inflatable boat, commonly called a cutter boat. There are over 450 cutter boats in service that are designed to increase the ship's effectiveness, contributing to search-and-rescue, enforcement, and AtoN missions.*

## 3.3.2 Port and Harbor Patrols

In addition to coastal patrols, USCG and states maintain port and harbor facilities to preserve port security and enable vessel traffic to move safely. The units and vessels that operate in these conditions are typically smaller and faster, because the conditions within the port are harbor are generally less aggressive than in open water.

### 3.3.2.1 U.S. Coast Guard Port and Harbor Patrols

USCG operates several facilities and systems to ensure port and harbor security. These include Marine Safety Offices, Port Security Units, Maritime Safety And Security Teams, and the Universal Automatic Identification System. Many of these facilities have additional roles, since they are often located in remote areas. In addition to enforcing port and harbor security, these facilities assist with navigational and marine safety and enforcement, including search-and-rescue operations and vessel registrations.

### 3.3.2.1.1 Marine Safety Offices

USCG maintains 42 Marine Safety Offices that combine the functions of the Captain of the Port, the Officer in Charge of Marine Inspection, and the On-Scene Coordinator. These offices respond to and investigate oil spills and hazardous material releases; ensure the safety and security of waterfront facilities and navigable waters; investigate marine casualties; inspect U.S. commercial vessels for certification; perform state port oversight and examination of foreign vessels; and plan and prepare for emergencies, contingencies and marine-related disasters.

USCG operates 4 Marine Safety Units and 20 Marine Safety Detachments under the command of the Marine Safety Offices. They perform the same tasks as the offices, but are typically located in a remote location where the mix of anticipated operations is complex. USCG has also established one Marine Safety Satellite Office under a safety office. The operational satellite office is small and located in a remote area where the operational tempo and complexity are expected to be relatively limited.

USCG operates two international Marine Inspection Offices: one in Rotterdam, The Netherlands, and the other in Yokota, Japan. USCG has also established a Marine Inspection Detachment at PSA Sembawang Terminal, Singapore. Inspection offices examine U.S. commercial vessels undergoing new construction or major repair work in foreign shipyards, and conduct routine periodic inspection of U.S. commercial vessels operating predominantly out of foreign ports. Due to their overseas location, they also perform limited international affairs functions, including the development of informal contacts with various foreign government agencies, and the provision of teaching assistance to the International Maritime Organization's World Maritime University.[29]

### 3.3.2.1.2 Port Security Units

A Port Security Unit is a deployable unit organized for sustained operations and capable of deploying within 96 hours to establish port operations. The units are tasked with providing waterborne and limited land-based port security and force protection of shipping and critical port facilities. To carry out this mission, each unit has six heavily armed and maneuverable port security boats. USCG operates six Port Security Units.[29]

### 3.3.2.1.3 Maritime Safety and Security Teams

USCG Maritime Safety and Security Teams are deployable units organized for homeland security operations within a port and capable of deploying to other ports for threat deterrence or response. Patterned after Port Security Units, Maritime Safety and Security Teams are tasked with providing waterborne and limited land-based port security and force protection of shipping and critical port facilities within the U.S. Sea Lanes of Communications, not including open water. Each team is outfitted with six armed and agile boats that can be transported to other ports. USCG operates four Maritime Safety and Security Teams.

#### *3.3.2.1.4 Universal Automatic Identification System*

The Universal Automatic Identification System is a shipboard broadcast system that acts like a transponder and operates in the VHF maritime band (156-162 megahertz). The system is capable of handling over 4,500 reports per minute and provides automatic updates as often as every two seconds. Automatic Identification System updates provide information about the ship, including its identity, position, course and speed. The International Maritime Organization, to which the United States is a signatory, recently adopted amendments that require the installation of Automatic Identification Systems on ships.

### 3.3.2.2 State Port and Harbor Patrols

Several states maintain port and harbor patrols that are responsible for law enforcement, firefighting, and rescue operations, among other tasks. For example, the Port Authority of New York and New Jersey maintains a police force of over 1,400 officers to patrol the area within a 25-mile radius of the Statue of Liberty, including the ports, airports, bus terminals, tunnels, and bridges. Specific information addressing the number of vessels in the Port Authority's fleet was not available. The police force has full law enforcement powers in both New York and New Jersey, and often works collaboratively with federal, state, and local agencies. Over 14.5 million tons of cargo and thousands of ships are handled by Port Authority marine terminal facilities each year.[32]

## 3.3.3 U.S. Coast Guard Deepwater Program

In 2002, USCG announced a 20-year program entitled the Integrated Deepwater System Program (commonly called the Deepwater Acquisition Program) to replace or retool the majority of the Coast Guard's cutters, offshore patrol boats, fixed-wing aircraft, multi-mission helicopters, communications equipment, sensors (e.g., radars, thermal imaging devices), and the logistics required to maintain the equipment in an immediately available status.

Among the surface ships, the first National Security Cutter, a newly designed vessel, will be delivered during the first five years of the program; 42 existing major cutters will receive upgrades; and 49 110-foot patrol boats will receive 15-year service life extensions and be converted to 123-foot patrol boats to increase their capabilities. Later in the program, the 123-foot cutters will be replaced near the end of the Deepwater project by a new cutter yet to be developed (U.S. shipbuilding capabilities are discussed in Section 2.1).[33]

### 3.3.4 U.S. Coast Guard Intelligence Coordination Center

USCG maintains the Intelligence Coordination Center, which produces and disseminates information from national sources that is relevant to USCG missions. The Intelligence Center, located in Suitland, Maryland, supports USCG's major mission functions, including drug and migrant interdiction, homeland security, fisheries enforcement, maritime environmental issues, port safety, and military readiness by providing strategic intelligence and indications and warnings intelligence for decision makers.

## 3.4 Environmental Protection and Response

Marine environmental protection and response address federal facilities that respond to environmental disasters, such as chemical and oil spills, and damaged or destroyed vessels. This section examines the federal facilities that are used for response and cleanup — specifically, those used for environmental cleanup, primarily of oil spills, and marine salvage operations.

Marine response is under the jurisdiction of USCG, which is assisted by several other federal agencies, including the U.S. Navy, EPA, and NOAA. Several state agencies are also involved in marine pollution response, although the state facilities are typically not dedicated solely to environmental protection and response. An example of state capabilities is provided.

Similar to the management of living marine resources, environmental protection lends itself to collaborative efforts. Even though USCG has lead agency status on marine environmental response actions, many other federal agencies, including EPA, the U.S. Navy, MMS, and NOAA, provide expertise and equipment to clean up environmental disasters. The capabilities of federal agencies involved in salvage missions are included in this discussion and a discussion on private marine salvage capabilities can be found in Section 2.1.10. The United States does not have a national salvage infrastructure, public or private. This can limit response efforts.

### 3.4.1 Marine Pollution Assessment and Response

Pollution prevention and response can include cleaning up releases, primarily oil or other hazardous substances; natural disasters; or marine accidents. Federal entities that maintain facilities for environmental response include USCG, the U.S. Navy, and EPA. Many states also maintain facilities for marine pollution assessment and response (marine environmental research is discussed in Section 4.1).

The National Contigency Plan outlines the federal government's response procedures for both oil spills and hazardous substance releases.

## 3.4.1.1 Federal Facilities

Emergency response to oil and chemical spills is handled through the National Response System under the National Oil and Hazardous Substances Pollution Contingency Plan. The contingency plan outlines the federal government's response procedures for both oil spills and hazardous substance releases. Under the response system, USCG is designated as the Federal On-Scene Coordinator for any discharge of oil or release of chemicals into coastal or major navigable waterways (EPA is the coordinator for inland areas). The National Response Team, a group of 16 federal agencies that provides expertise on pollution response, assists the On-Scene Coordinator. The Response Team is a planning and policy body, and does not respond directly to an incident. While much of the equipment described in this inventory pertains to oil spills, some of it can also be used for hazardous substance releases. Information concerning equipment specific to hazardous substance cleanup was not available.

To assist with emergency response, there are 27 major federal pre-positioned equipment sites — 5 Navy and 22 USCG sites — and 1,218 individual resource sites owned by 120 oil spill removal organizations.[34] Even with the federal pre-positioned sites, the majority of oil spill response equipment is privately owned (Table 3-16). Equipment from USCG Marine Safety Offices and smaller pre-positioned Navy sites was not included in the total.[34]

**Table 3-16: Federal and Private-Sector Oil Spill Response Equipment**

| Equipment Category | Federal Resources (in thousands) | Private Resources (in thousands) | Total Resources (in thousands) |
|---|---|---|---|
| **Booms (reported in total feet)** | | | |
| **6-18 inches in height** | 0 | 3,456 | 3,456 |
| **19"-41"** | 0 | 1,660 | 1,660 |
| **>41"** | 160 | 483 | 643 |
| **Skimmers (EDRC)*** | 69 | 2,700 | 2,768** |
| **Temporary Storage (barrels)** | 135 | 2,111 | 2,246 |
| **Vessels with Storage (barrels)** | 0 | 4,686 | 4,686 |
| **Vacuum Storage (EDRC/barrels)** | 0/0 | 1,712/114 | 1,712/114 |

*The federal government does not maintain the majority of the nation's oil spill response equipment.*

* *EDRC equals Effective Daily Recovery Capacity. It indicates the amount of oil that could be recovered in a 24-hour period solely on the pumping capacity of the device in barrels per day. One barrel equals 42 gallons.*
** *There are 1,384 total skimmers in the United States.*

### *3.4.1.1.1 U.S. Coast Guard Response Capability*

As the On-Scene Coordinator, USCG maintains a National Strike Force to respond to marine environmental emergencies. The Strike Force comprises the National Strike Force Coordination Center and three Strike Teams

(Atlantic, Pacific, and Gulf). The Coordination Center maintains 22 pre-positioned sites to respond to an emergency. The pre-positioned site equipment packages include a Vessel of Opportunity Skimming System (VOSS) and 5,000 feet of foam-filled boom. VOSSs are portable side-skimming oil-recovery systems that can be deployed from most work vessels over 65 feet in length.

In addition to the pre-positioned equipment, each Strike Team has a variety of equipment, including 10 reels (6,560 feet) of inflatable boom, pump/dracone off-loading systems, command trailers, temporary storage devices, dry storage shelters, and V-sweep type booms. All equipment is packaged, containerized, and stored on trailers as "ready loads" for quick transport by truck or air.

USCG also maintains the National Pollution Funds Center, located in Arlington, Virginia, to act as the fiduciary agent for the Oil Spill Liability Trust Fund and any other funds that are accessible to USCG. The Funds Center, which is staffed by 114 employees, provides funding for removal actions and the initiation of natural resource damage assessments (oil only), compensates claimants who demonstrate that certain damages were caused by oil pollution, recovers pollution costs and damages from responsible parties, and certifies the financial responsibility of vessel owners and operators.

#### *3.4.1.1.2 U.S. Navy Response Capability*

The U.S. Navy's Office of the Director of Ocean Engineering, Supervisor of Salvage and Diving (SUPSALV) has the capability to respond to pollution incidents anywhere in the world. SUPSALV maintains a system of equipment, personnel, planning and training designed to provide support to all Navy activities and vessels for emergency oil and hazardous substance spill response. SUPSALV also works with other federal agencies to develop plans, conduct training, and respond to emergencies.[35]

An inventory of equipment is maintained at four response bases in Williamsburg, Virginia; Port Hueneme, California; Anchorage, Alaska; and Pearl Harbor, Hawaii. Equipment includes booms, skimmers, support craft, portable storage, logistics support systems, cleaning systems, and various systems to support this specialized mission (Table 3-17). SUPSALV is also the DoD representative on the National Response Team.

#### *3.4.1.1.3 U.S. Environmental Protection Agency Capability*

EPA maintains several vessels that support coastal and marine protection programs. The Ocean Survey Vessel PETER W. ANDERSON (OSV ANDERSON) primarily sails along the Atlantic and Gulf Coasts and in the Caribbean. OSV ANDERSON collects information from harbors, ports, and offshore waters to identify and monitor potential environmental concerns. The 165-foot ship is equipped to support physical, chemical and biological investigations. A wet lab is available for processing biological samples, as well as a sonar system for seafloor mapping and over-the-side sampling equipment.[36]

**Table 3-17: SUPSALV Equipment List**

| Spilled Oil Recovery | Casualty Off-Loading | Ancillary Support Equipment |
|---|---|---|
| • Containment Booms | • Oil Transfer Pumps and Hoses | • Personnel Support Vans |
| • Open-ocean Skimmers | • Floating Hose Systems | • Maintenance Vans |
| • Small Skimmers | • Hot Tap Systems | • Support Vessels |
| • In-situ Burning Equipment | • Portable Generators | • Cleaning Equipment |
| • Sorbent Materials | • Portable Firefighting | • Pumps Command Vans |
| • Vacuum Recovery Systems | • Hydraulic Power Packs | • Communications Systems |
| • Floating Storage Bladders | • Salvage Equipment | • Small Boats |
| | | • All-terrain Vehicles |
| | | • Material Handling Equipment |

EPA also operates the 180-foot Research Vessel (R/V) LAKE GUARDIAN, which is the only self-contained, nonpolluting research ship on the Great Lakes. As part of its long-term trends program, EPA conducts biannual monitoring surveys of the Great Lakes from the R/V LAKE GUARDIAN. A third EPA vessel is the R/V LEAR, a 35-foot Bertram with twin 350 gas engines. EPA maintains the R/V MUDPUPPY, a flat-bottom boat specifically designed for sediment sampling in shallow rivers and harbors in and around the Great Lakes, and the R/V LAKE EXPLORER (EPA research capabilities are discussed in Chapter 4).[37]

### *3.4.1.1.4 Minerals Management Service Capability*

MMS manages the Oil and Hazardous Materials Simulated Environmental Test Tank (Ohmsett), which is the national oil spill response test facility. Ohmsett, located in New Jersey, has a large outdoor, aboveground concrete test tank that measures 203 meters long, 20 meters wide, and 3.3 meters deep. Filled, the tank holds 9.84 million liters of salt water. Ohmsett provides a simulated marine environment, with reproducible test conditions for oil spill response equipment testing and evaluation, and is used to test and evaluate oil spill response equipment, conduct research and development projects on new, or refined, oil spill response equipment, and for training of oil spill response personnel with real equipment and oil in the tank. In addition to a facility manager, there are 12 staff members, including a mechanical engineer, a chemical engineer, and several technicians, that operate and maintain the facility.

### *3.4.1.1.5 National Oceanic and Atmospheric Administration Response Capability*

NOAA operates programs to respond to oil and chemical spills. NOAA's Office of Response and Restoration maintains a Hazardous Materials

Response Division that consists of an interdisciplinary scientific team that responds to oil and chemical spills and other emergencies in coastal and navigable waters.[38] It also operates a Coastal Protection and Restoration Division that works with EPA by placing scientists in EPA's regional offices to provide technical advice on ecological risk, contaminated sediments, and remedial issues at over 350 coastal waste sites. The Damage Assessment Center employs scientists and economists to develop natural resource damage assessment for releases of oil and hazardous substances.

NOAA's Damage Assessment and Restoration Program conducts natural resource damage assessments and restoration of coastal and marine resources injured as a result of oil spills, releases of hazardous materials and ship groundings.[39] Within the Restoration Program NOAA has a Rapid Assessment Program — an on-call team of NOAA scientists and contractors responsible for evaluating oil and hazardous substance spills. The Rapid Assessment Program is coordinated from Seattle, Washington, and other regional responders are located in Anchorage, Alaska; Sandy Hook, New Jersey; St. Petersburg, Florida; Long Beach, California; and Silver Spring, Maryland. Additionally, NOAA maintains contracts for rapid assessment response in Seattle, Washington; Boston, Massachusetts; Narragansett, Rhode Island; and Columbia, South Carolina.

### 3.4.1.2 State Environmental Response

Several states maintain vessels for environmental response and monitoring, among other tasks. The Washington State fleet discussed here provides an example of state capabilities and resources.

Washington State agencies operate several fleets of vessels. The Washington Department of Ecology operates a 26-foot Almar; a 20-foot Boston Whaler with small davit; two17-foot Boston Whalers used for environmental sampling in both marine and coastal freshwater areas, servicing moorings, water-quality sampling, sediment sampling, and fish trawls; and a Smith-Root 17-foot electrofishing boat. The Washington Department of Ecology also contracts several other vessels owned by other state agencies and private contractors for servicing moorings, conducting marine sediment monitoring, or quick trips when this is advantageous. The Washington Department of Natural Resources uses 16-, 17-, 27-, 34-, and 42-foot vessels for fishery enforcement and beach surveys. These vessels are also used on an incidental basis in support of other activities, such as removal of derelict vessels and gear, underwater investigations, aquatic lands management and maintenance, and direct fishery surveying efforts. The state's Department of Fish and Wildlife uses several small vessels for a variety of research, monitoring, and regulatory activities.

## 3.4.2 Marine Salvage Capabilities

Marine salvage operations provide assistance to damaged or stressed vessels. Assistance can include towing a vessel or jettisoning cargo to prevent spills. Although the United States does not have a national salvage strategy, both the U.S. Navy and USCG maintain some salvage capabilities (see Section 2.1.10).

### 3.4.2.1 U.S. Navy Salvage

SUPSALV, located in the Washington Navy Yard in Washington, D.C., is under the Naval Sea Systems Command. SUPSALV is responsible for all aspects of ocean engineering, including salvage, in-water ship repair, contracting, towing, diving safety, and equipment maintenance and procurement for the U.S. Navy.[40]

The U.S. Navy maintains four manned rescue and salvage ships designed to render assistance to disabled vessels and to provide towing, salvaging, diving, firefighting and heavy-lifting capabilities. The mission of the rescue and salvage ships is to:

- Fill stranded vessels on the beach
- Provide heavy-lift capability from ocean depths
- Tow vessels
- Support manned diving operations.

For rescue missions, these ships are equipped with fire monitors that can deliver either firefighting foam or sea water. The salvage ships' holds are outfitted with portable equipment to provide assistance to other vessels in dewatering, patching, supplying electrical power, and other essential services required to return a disabled ship to an operating condition. The U.S. Navy has responsibility for salvaging U.S. government-owned ships and, when it is in the best interests of the United States, privately owned vessels as well.[41] Two of the rescue and salvage ships are based in Virginia and two are based in Hawaii.

The U.S. Navy also operates several unmanned vehicles used in salvage operations. The Deep Drone 7200 remotely operated vehicle (ROV) is designed for deep-ocean recovery at depths of up to 7,200 feet. The system is transportable on military cargo aircraft and is designed to operate from various ships. The operator can control the ROV in all six degrees of freedom. The vehicle carries a target-locating sonar and has two manipulators capable of working with tools and attaching rigging. For photographic documentation, the vehicle has a 35-millimeter still camera and both black-and-white and color television cameras that produce quality videotape. A diesel generator or the power system of the supporting ship, if compatible, provides electrical power for the system. For special operations, the ROV can accommodate custom, skid-mounted tool packages. These packages could include trenchers, specialized salvage tools, and instrument packages or other mission-oriented equipment.[42]

CURV III is a 20,000-foot depth-rated ROV designed for deep-water recovery. CURV III consists of a 13,000-pound vehicle, a fiber-optical umbilical cable, a motion-compensated crane handling unit, a dampened latch/launch assembly, a umbilical traction winch, a umbilical storage reel, a deck system hydraulic power unit, a generator, an operations van, and a spares van. The ROV has a lift capacity of 2,500 pounds and a payload of 300 pounds. CURV equipment modules are designed for ground or air shipment, and can operate from any capable ship of opportunity.[43]

The Magnum ROV is a 8,200-foot depth-rated work vehicle designed for use in high currents. The ROV is deployed on a high-strength armored cable from any suitable vessel of opportunity. The side-entry cage provides protection and weight to assist in passing through surface currents. The ROV is deployed from the cage on a 600-foot tether. Magnum system components include a 3,500-pound (air) ROV, armored umbilical cable on a hydraulic-powered cable reel, a frame launching assembly, and three deck vans. The ROV is equipped with two seven-function manipulators, high-efficiency thrusters, telemetry/control computers, three video cameras, lights and an onboard navigation system. The sonar equipment can detect acoustic pingers and identify small targets at a distance of 2,000 feet. The ROV has a lift capacity of 8,000 pounds and a payload of 300 pounds.[44]

The U.S. Navy's two mini-ROVs are standard commercial, 1,000-foot depth-rated ROVs used for the U.S. Navy's shallow-water surveys, photographic documentation, and light salvage/recovery. They are transportable on cargo aircraft and operate with minimum support from select vessels of opportunity, piers or shorelines. They carry a high-resolution target locating sonar and have a manipulator capable of working with simple tools. Additionally, the mini-ROVs have a 35-millimeter still camera and a color television camera that produces quality videotape. For special operations, the ROVs can accommodate some small tools or instrument packages.[45]

The U.S. Navy's Shallow Water Intermediate Search System (SWISS) is a dual-frequency towed side-scan sonar system mounted inside a torpedo-shaped tow body. The sonar is towed behind a vessel at slow speeds, generally from one to five knots. Sonar signals are processed producing both an analog and a digital display of features on the ocean bottom. Trained operators interpret these displays to identify potential targets. The lower frequency is generally used for primary searching, and the higher frequency can give an extremely fine-grain trace of bottom features and contacts, which allows for detailed analysis.[46]

The Orion Search System (Orion) is a side-scan sonar system that has long-range detection and high-resolution capabilities. The system has floodlights that provide illumination for a video camera. Orion can be towed by any vessel of opportunity by a 36,000-foot fiber-optic cable. A deck control van incorporates high-resolution color graphic digital recorders and navigation controls for ship and Orion position. The system has a depth rating of 20,000 feet.[47]

### 3.4.2.2 U.S. Coast Guard Salvage

USCG's Salvage Engineering Response Team comprises 8 to 10 staff engineers who assist and support USCG Captains-of-the-Port during emergencies. Team members are naval architects trained to conduct technical analysis in the areas of vessel stability and structural integrity. When activated, the salvage team provides technical support during marine casualties, such as groundings, collisions, explosions, and fires. The team has mobile computing capability for on-scene deployment.

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# Research, Exploration, and Monitoring

## Chapter 4



The United States has an array of institutions dedicated to research, exploration, and monitoring of the ocean and coastal environment. These institutions range from major, complex organizations with multiple science and engineering programs, such as the Woods Hole Oceanographic Institution (WHOI), to small, unique organizations with very specialized missions such as the U.S. Food and Drug Administration's (FDA's) Seafood Safety Laboratory. A variety of facilities support the missions of these institutions, including laboratories, vessels, underwater vehicles, aircraft, remote-sensing satellites, ocean-observing systems, and computers for data storage and dissemination, modeling, and numeric analysis. Information from federal and state agencies, academic institutions and technical sources was gathered to describe the facilities used to conduct coastal and ocean research, exploration, and monitoring. A brief summary of these facility categories follows.

This inventory encompasses laboratories dedicated primarily to coastal and ocean research, exploration, or monitoring. During recent years, joint institutions and partnerships have been developed to promote synergistic opportunities among scientists and engineers and to help defray the capital investment and maintenance cost of marine laboratories. This inventory does not include commercial facilities that have research and development laboratories for ocean technologies.

The inventory identified over 400 large vessels used in ocean research, exploration, or monitoring activities. Most of the vessels are more than 20 years old, and very few are scheduled for replacement. Academic and commercial vessels comprise close to 69 percent of the vessels identified.

A review of underwater vehicles indicated a significant change over the last 20 years. The number of manned submersibles has slightly declined, but more importantly, the United States lost its capability to conduct deep-water (20,000 feet) manned submersible missions. In contrast, the use of remotely operated vehicles and autonomous vehicles has increased significantly as their cost has been reduced, and some are capable of operating in deep waters. Technological advances in computer hardware and software, fiber optics, and robotics have also helped fuel the use of remotely operated vehicles.

The use of aircraft for coastal and ocean research now includes the use of unmanned aerial vehicles. New and better unmanned aerial vehicles are being developed. During the last two decades, the use of satellites for remote sensing has proven to be one of the most significant advances in coastal and ocean sciences. The amount of information gathered by satellite sensors in a few days is more than what can be collected in the field through decades of observation. The nation now has research and operational satellites that provide information for scientific investigations and are used every day to support recreation, safety and commercial activities.

The use of ocean-observing systems has also increased dramatically in the last few years. Now more than 40 independent ocean-observing systems are deployed along our coastlines. These systems are the first step in the development of a coordinated, nationwide ocean-observing network that could provide the public with a service similar to that provided by the National Weather Service.

Technological developments that support coastal and ocean science activities depend heavily on computers to help store, process, analyze and disseminate data. During the last 20 years, advances in computer storage and processing capacity have exceeded the expectations of most people. For many ocean scientists, however, currently there are not adequate computer facilities that can handle the computational requirements for some ocean models.

# 4.1 U.S. Marine Laboratory Infrastructure

The national marine laboratory infrastructure consists of more than 100 academic, independent nonprofit, federal, state and private institutions that actively conduct research, exploration or monitoring activities anywhere from coastal regions (e.g., estuarine wetlands) to the ocean's deep-water environments. Most of the institutions are located along the coastline, including the Great Lakes region and U.S. territories (e.g., Puerto Rico, Guam). Some institutions, such as the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, conduct numerical analysis and modeling of coupled atmospheric-ocean processes and are located away from the coastline. A few institutions have unique missions that require their facilities to be located outside of the United States: for example, the Smithsonian Tropical Research Institute in Panama, the Bermuda Biological Station for Research, and the National Science Foundation's (NSF's) Palmer and McMurdo Antarctic Stations.

Small institutions tend to focus their research, exploration and monitoring activities on local and regional coastal and ocean processes. For example, the U.S. Environmental Protection Agency's (EPA's) National Health and Environmental Effects Research Gulf Ecology Division Laboratory in Gulf Breeze, Florida, focuses on researching the Gulf of Mexico coastal ecosystem. In contrast, large academic institutions, such as the University of California's Scripps Institution of Oceanography (SIO), have multiple laboratory facilities that support both local and global coastal and ocean research, exploration and monitoring projects.

The number of people conducting coastal and ocean research, education, and monitoring activities at these institutions is unknown. At a minimum, the National Association of Marine Laboratories estimates that over 10,000 professionals are employed by its more than 120 members institutions.[1]

The inventory of marine laboratories' capabilities in this chapter is organized by academic institutions; independent, nonprofit marine research institutions; and federal and state laboratories. Examples are provided for major or unique facilities within each category. The information presented in this chapter is not comprehensive, as not all government agencies reported on the capabilities of their facilities.

## 4.1.1 Academic Laboratories

Academic laboratories are research facilities that belong to an academic institution. A list of 64 academic laboratory facilities compiled primarily from a survey conducted for the Commission by the Consortium of Oceanographic Research and Education (CORE) is provided in Supplement 5-1. This list does not include all existing academic laboratories.

Some academic institutions have multiple laboratory facilities, including remotely located field stations (e.g., University of Washington's Friday Harbor Laboratories) to support their work. Other academic institutions cannot afford to own dedicated laboratory facilities to conduct research. To overcome this, academic institutions frequently develop partnerships with other institutions to establish and share facilities. These partnerships increase academic interactions, promote multidisciplinary collaboration and help promote the cost-effective use of facilities. Examples of partnerships are the Shoals Marine Lab, operated by Cornell University in cooperation with the University of New Hampshire, and the Marine Science Consortium at Wallops Island, Virginia, which serves 16 member universities and colleges from 4 Mid-Atlantic states.

Partnerships increase academic interactions, promote multidisciplinary collaboration and help promote the cost-effective use of facilities.

Some state governments establish state-owned laboratory facilities to be used by state academic institutions. These facilities not only promote academic research but also provide the states with facilities that develop the knowledge required to adequately manage ocean and coastal resources. An example of such a facility is the Dauphin Island Sea Lab (DISL) which Alabama founded in 1971 as a marine and educational research center.[2] The DISL serves an academic community of 22 member university programs, including 9 universities with graduate programs. Over 40 graduate students use the DISL each year as the base for their graduate education and research. DISL has a faculty of 14 principal investigators that conduct research on oceanography and ecology of estuaries and near-coastal waters.

Academic laboratories range from major research institutions, such as SIO at the University of California, to smaller facilities, such as the Bowdoin Coastal Studies Center in Orr Island, Maine. For example, SIO, established in 1903, is one of the oldest and largest marine science research institutions in the world. SIO has a staff of approximately 1,300, including approximately 90 general faculty, 300 scientists, and 200 graduate students. The institution's annual expenditures total more than $140 million. Research at SIO encompasses physical, chemical, biological, geological, and geophysical studies of the ocean, with more than 300 programs underway at any time. The institute operates a fleet of four University-National Oceanographic Laboratory System (UNOLS) research vessels (two Global Class, one Intermediate Class, and one Regional Class). The Bowdoin Coastal Studies Center is a five-year-old program at a liberal arts university that offers courses on and supports student and faculty research in coastal issues. The center also supports multidisciplinary studies, including humanities, arts, social, natural and behavioral sciences, and mathematics.

The Virginia Institute of Marine Science (VIMS) at the College of William and Mary in Williamsburg, Virginia, represents a cross-section of existing academic laboratory facilities. VIMS was established in 1940 and serves as the Graduate School of Marine Science for the College of William & Mary.[3] The institute has two major facilities: Gloucester Point, Virginia, located at the mouth of the York River, a tributary of the Chesapeake Bay, and the Eastern

Shore Laboratory in Wachapreague, Virginia. A third facility, the Kauffman Aquaculture Center on the Rappahannock River, has been proposed.

VIMS has more than 50 faculty members who teach more than 100 graduate students. Approximately half of the students are enrolled in a doctoral program, while the other half are pursuing master's degrees. International students comprise approximately 12 percent of the student body.

The Gloucester Point facilities include Chesapeake Bay Hall, Nunnaly Hall, Aquaculture Genetics and Breeding Technology Center, and a finfish aquaculture facility. Chesapeake Bay Hall includes laboratories dedicated to advanced research in genetics, immunology, toxicology, environmental chemistry, geology, and aquatic-disease studies. Nunnaly Hall includes a necropsy laboratory, teaching laboratory, and a sample-processing facility. The Aquaculture Genetics and Breeding Technology Center, established in 1997 by the Virginia General Assembly, is dedicated to the breeding and genetic research of declining populations of ecologically and commercially important marine species. The center is currently focused on the Chesapeake Bay native oyster *Crassostrea virginica*.

The Eastern Shore Laboratory, a 10-acre field station, has wet and dry laboratories, a shellfish hatchery, and a seawater flume. The lab has a large, flexible seawater system for husbandry of live marine and estuarine organisms. Approximately 50 flowing seawater tables, both indoor and outdoor, are located at the facility. Tanks of various sizes are available for use in either flow-through or recirculating modes. A seawater quarantine system provides the capability to conduct research on nonindigenous species. The Eastern Shore Laboratory has dormitory space for 40 people.

## 4.1.2 Independent, Nonprofit Marine Research Institution Laboratories

Independent, nonprofit marine research institutions have unique laboratory facilities that support coastal and ocean research. The research conducted at these facilities advances knowledge of coastal and ocean systems, and frequently compliments the research, exploration and monitoring activities conducted by government and academic institutions. Most of these institutions, in addition to their research missions, have active educational and training programs that include internships, graduate research assistantship positions, postdoctoral research appointments, and summer courses. In many instances, the classes offered are university-approved undergraduate and graduate courses. Ten independent, nonprofit marine research institutions (not including aquariums) were selected from the members of the National Association of Marine Laboratories. These institutions have very specific missions which require dedicated facilities.

Three nonprofit institutions are located in the Northeast, and two of them are the nation's oldest. The Marine Biological Laboratory (MBL), established in 1888 in Woods Hole, Massachusetts, hosts year-round research programs in cell and developmental biology, ecosystem studies, molecular evolution, neurobiology, and sensory physiology. MBL is also host to the Boston University Marine Program and the University of Pennsylvania's Laboratory for Aquatic Animal Medicine and Pathology. MBL currently supports a year-round staff of more than 275 scientists and support staff. In addition, every summer over 1,400 investigators and advanced students from the United States and abroad use the MBL facilities for research.

The Mount Desert Island Biological Laboratory, established in 1898 in Salisbury Cove, Maine, supports the following areas of research: marine biomedicine and physiology, marine molecular biology and functional genomics, bioinformatics, environmental toxicology and toxicogenomics, transgenic species, and neuroscience. The laboratory has 10 buildings with a total of 32 laboratory units, and employs 26 principal investigators. During the summer the number of people, including visiting researchers and students using the facilities, can exceed 200.

The third independent research institution in the Northeast is the Bigelow Laboratory, established in 1971 in West Boothbay, Maine. This laboratory focuses on research related to primary productivity of the oceans. The laboratory has diverse facilities, including a dedicated-flow cytometry facility. The laboratory's Provasoli-Guillard National Center for Culture of Marine Phytoplankton, supported by the NSF and by revenues derived from the sale of cultures, holds the largest collection of marine phytoplankton in the world (over 1,450 strains). The laboratory maintains formal affiliation with the University of New England and provides university-accredited marine science summer courses. The Bigelow Laboratory employs 16 principal investigators.

The Bermuda Biological Station for Research, located in St. George, Bermuda, was established in 1926 and incorporated in New York. The station supports tropical marine ecology, open ocean, and climate research. The station has three research initiatives: the Center for Integrated Ocean Observations, the International Center for Ocean and Human Health, and the Risk Prediction Initiative. The station provides university-accredited marine science graduate and undergraduate courses. The station also operates a UNOLS vessel, and manages the Hydrostation S, which is the longest oceanographic time-series station.

The South Atlantic region has two nonprofit institutions. The Harbor Branch Oceanographic Institution (HBOI) in Fort Pierce, Florida, has six major divisions: aquaculture, biomedical marine research, engineering, marine mammal research and conservation, marine operation, and marine sciences. HBOI operates three manned submersibles and two UNOLS vessels. This institution is considered an integral leader in the use of manned submersible technology. HBOI has a staff of approximately 250 employees.

The Mote Marine Laboratory (MML) in Sarasota, Florida, is on the state's Gulf of Mexico coast. MML, established in 1955, focuses its investigation on the marine ecology and ocean process of the southwest Florida coastal region. MML has 100,000 square feet of laboratory and public aquarium facilities. Experimental facilities include environmentally controlled rooms with recirculating seawater systems for maintaining marine organisms ranging from phytoplankton and invertebrates to fish. MML has a staff of approximately 55 employees.

One institution, the Monterey Bay Aquarium Research Institute (MBARI), was identified for the West Coast. MBARI, established in 1987 by the Lucille and David Packard Foundation in Moss Landing, California, is dedicated to the development and transfer of technology that supports ocean sciences, exploration of the marine environment, and dissemination of information to the marine science and educational community worldwide. MBARI is one of the nation's leaders in the use of remotely operated vehicle technology for research and exploration. The institute maintains close collaboration with other oceanographic institutions of Monterey Bay, including the University of California-Santa Cruz, Moss Landing Marine Lab, Hopkins Marine Station, and the Naval Postgraduate School. MBARI has a staff of approximately 225 employees, including engineers, ocean scientists, and support personnel.

The Prince William Sound Science Center, established in 1989 in Cordova, Alaska, is dedicated to promoting and maintaining the study of Alaska's biodiverse ecology and educating the public. The center's programs take an ecosystem approach to research, monitoring and management of natural resources. Major areas of research include physical oceanography; hydroacoustic studies of plankton, fish and marine mammals; food web analysis; and nearshore ecology. The center has a staff of 16 employees.

Two of these nonprofit institutions are located in the Western Pacific region: the Oceanic Institute (OI) and the Coral Reef Research Foundation. OI, established in 1960 in Oahu, Hawaii, is dedicated to the development and transfer of practical oceanographic and aquaculture technologies. OI coordinates the Gulf Coast Research Laboratory Consortium, which administers the U.S. Marine Shrimp Farming Program. OI also co-manages the Center for Tropical and Subtropical Aquaculture, one of five regional aquaculture centers established by the U.S. Department of Agriculture. OI also has a five-acre remote facility located in Kona, Hawaii, dedicated to training, education and shrimp research, with a staff of 75 employees.

The Coral Reef Research Foundation (CRRF), established in 1991 in the Republic of Palau and incorporated in California, conducts research and education on coral reefs and other tropical marine environments. A new laboratory building in Palau was completed in early 1996. Currently, CRRF's major activity is the collection and identification of marine organisms for anti-cancer and anti-AIDS screening tests by the U.S. National Cancer Institute. Information was not available on the number of employees.

## 4.1.3 Federal Agency Laboratories

Various federal agencies have laboratory facilities dedicated to coastal and ocean research. The extent of their laboratory facilities is related to the agencies' missions. Some agencies, such as the National Oceanic and Atmospheric Administration (NOAA), the U.S. Navy and the U.S. Army Corps of Engineers (USACE), have missions that require direct coastal or ocean activities and tend to have large laboratory facilities that support marine activities. Other agencies with missions not directly related to the coastal or ocean environment, such as the U.S. Department of Energy, do not have extensive facilities, but may provide unique and important capabilities.

### 4.1.3.1 National Oceanic and Atmospheric Administration Laboratories

NOAA's mission is to describe and predict changes in the environment and to conserve and wisely manage the nation's coastal and marine resources. To support this mission, NOAA has extensive laboratories that support coastal and ocean research, exploration and monitoring.

NOAA conducts ocean and coastal research activities mainly through the Office of Oceanic and Atmospheric Research. In addition, NOAA's National Ocean Service (NOS) and National Marine Fisheries Service (NMFS) have laboratories used for coastal and ocean research.

The Office of Oceanic and Atmospheric Research conducts research in NOAA laboratories and through extramural programs. In addition, it sponsors extramural research at 30 Sea Grant universities and research programs, 6 undersea research centers, and through the Office of Ocean Exploration. The National Sea Grant Program is further described later in this chapter.

NOAA's extensive laboratories support coastal and ocean research, exploration and monitoring.

There are five NOAA Office of Oceanic and Atmospheric Research laboratories that conduct coastal and ocean research: the Great Lakes Environmental Research Laboratory, the Geophysical Fluid Dynamics Laboratory, the Atlantic Oceanographic and Meteorological Laboratory, the Pacific Marine Environmental Laboratory, and the Environmental Technology Laboratory. Each is described in brief below.

The Great Lakes Environmental Research Laboratory, in Ann Arbor, Michigan, supports field, analytical, and laboratory investigations to improve understanding and prediction of biological and physical processes in estuaries and coastal areas. The laboratory also studies the interdependencies of the aquatic systems with the atmosphere and sediments. Investigations emphasize the Great Lakes ecosystem and the development of environmental service tools that support resource management and environmental services. The laboratory operates a field facility in Muskegon, Michigan. In 2002, the laboratory obtained a 15-year lease on the research vessel LAURENTIAN from the University of Michigan. The Great Lakes Environmental Research Laboratory has a staff of 53 federal employees and 20 non-federal employees.

The Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, supports research on weather and hurricane forecasts, El Niño prediction, stratospheric ozone depletion, and global warming. The research goal is to understand and predict trends in the earth's climate and weather patterns, including the impact of human activities. The laboratory has 84 federal employees and 50 non-federal employees.

The Atlantic Oceanographic and Meteorological Laboratory in Miami, Florida, supports basic and applied research in oceanography, tropical meteorology, atmospheric and oceanic chemistry, and acoustics (e.g., hurricanes, ocean current and temperature structures, ocean and atmosphere chemical exchanges, coral reefs, and coastal ocean) with emphasis on the Atlantic Ocean. Investigations seek to understand physical and biological characteristics and processes of the ocean and the atmosphere. This laboratory has 96 federal employees and 59 non-federal employees.

The Pacific Marine Environmental Laboratory in Seattle, Washington, supports interdisciplinary research in oceanography and marine meteorology, with a focus on coastal and open ocean observations and modeling. Research is focused on the ocean's physical, biological, and geochemical processes and supporting services for marine commerce and fisheries (e.g., environmental forecasting capabilities), with emphasis on the Pacific Ocean. The laboratory supports an undersea observation and research program in Newport, Oregon, and has a staff of 92 federal employees and 85 non-federal employees.

The Environmental Technology Laboratory in Boulder, Colorado, supports NOAA's environmental monitoring and stewardship charter by performing oceanic and atmospheric research and developing new remote-sensing systems. Atmospheric and oceanic processes are studied to probe regions that are not readily accessible by direct measurement. Research ranges from basic physics of electromagnetic and acoustic wave interactions in air and water, to development and transfer of oceans and atmosphere monitoring technologies, including remote-sensing systems. The laboratory has 62 federal employees and 64 non-federal employees.

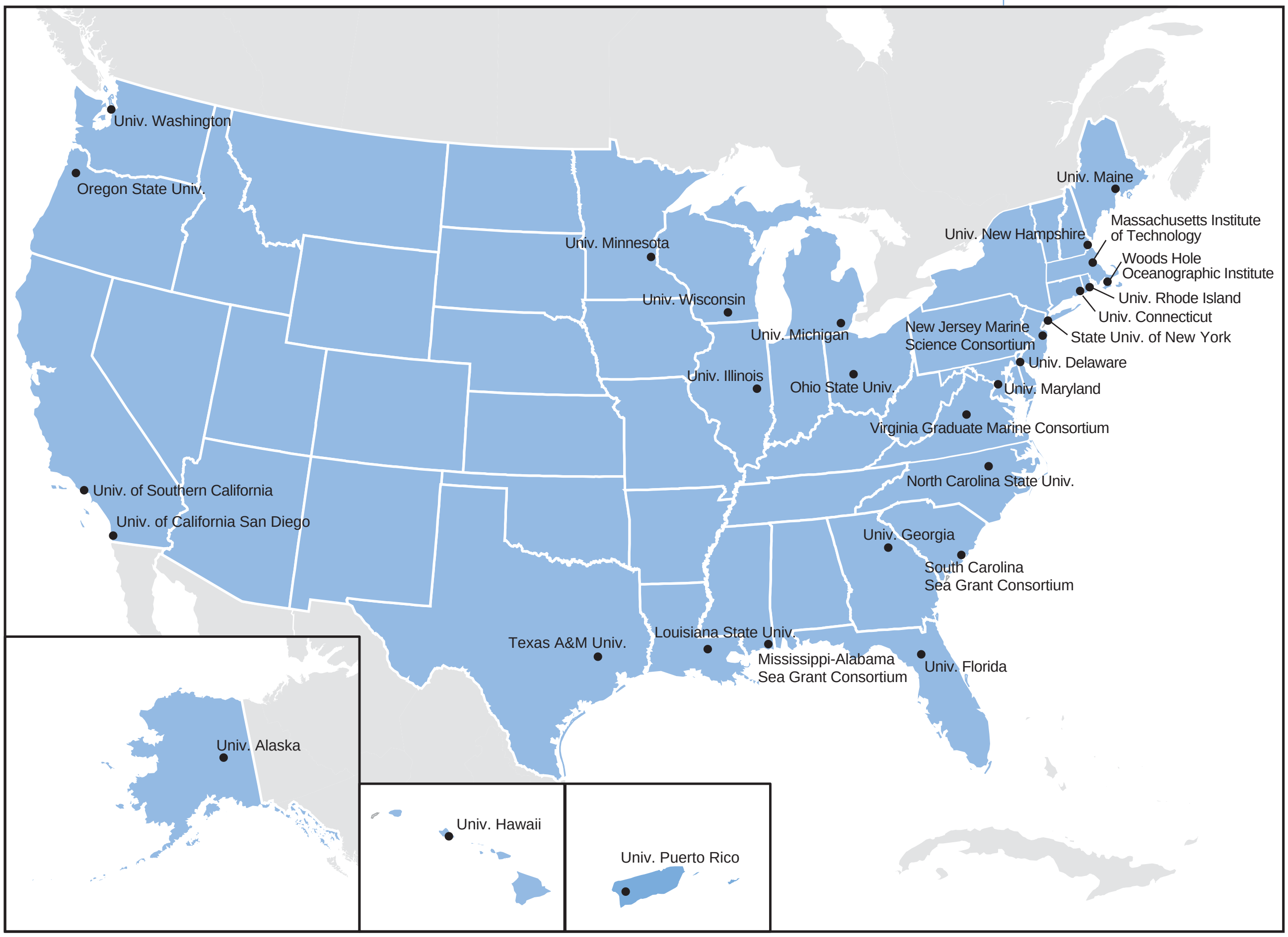
In addition to these laboratories, NOAA's Office of Oceanic and Atmospheric Research maintains eight joint cooperative institutes with significant ocean-related activities that provide opportunities for collaboration with academic investigators:

- In the Great Lakes, the Cooperative Institute for Limnology and Ecosystems Research in Ann Arbor supports research on climate and large lake dynamics, coastal and nearshore processes, large lake ecosystem structure and function, remote sensing of large lake and coastal ocean dynamics, and marine environmental engineering. The institute supports approximately 35 university researchers, postdoctoral investigators, and students at the University of Michigan and 14 other Great Lakes universities.

- The Cooperative Institute of Climate and Ocean Research in Woods Hole, Massachusetts, is a joint partnership between WHOI and NOAA that supports research on coastal ocean and nearshore processes, the ocean's roles in climate and climate variability, and marine ecosystem processes analysis.
- The Cooperative Institute for Marine and Atmospheric Studies in Miami, Florida, is a joint partnership with the University of Miami's Rosenstiel School of Marine and Atmospheric Sciences that supports research on climate variability, fisheries dynamics, and coastal ocean ecosystem processes. The institute collaborates with NOAA's Environmental Research Laboratory and NMFS. It supports 45 university researchers, postdoctoral investigators, graduate students, and staff.
- Two joint programs are located in the West Coast region — the Joint Institute for Marine Observations in La Jolla, California, and the Joint Institute for the Study of the Atmosphere and Ocean in Seattle, Washington. The joint program in La Jolla is a partnership with SIO. The program supports research on coupled ocean-atmosphere climate, blue water and littoral oceanography, marine biology and biological oceanography, marine geology and geophysics, and ocean technology. The institute is co-located with the NOAA Southwest Fisheries Center.
- The program in Seattle is a partnership with the University of Washington. The program supports research on climate variability, environmental chemistry, estuarine processes and interannual variability of fisheries recruitment (complementing the Pacific Marine Environmental Laboratory's research). It supports 35 university researchers, postdoctoral investigators, and students.
- The Cooperative Institute for Arctic Research in Fairbanks, Alaska, is a partnership with the University of Alaska. The institute supports Arctic research with a focus on fisheries oceanography, hydrographic studies and sea ice dynamics, atmospheric research, climate dynamics and variability, tsunami research and prediction, environmental assessment, monitoring, and numerical modeling. Currently, this institute supports 15 researchers and staff.
- The Joint Institute for Marine and Atmospheric Research in Honolulu, Hawaii, is a partnership with the University of Hawaii. It supports research on equatorial oceanography, climate and tropical meteorology, tsunamis, and fisheries oceanography (complimenting research conducted by the Environmental Research Laboratory). It supports 40 university researchers, postdoctoral investigators, students and staff.

NOAA also closely collaborates with the academic community's research through the National Sea Grant Program (Sea Grant). Sea Grant consists of 30 programs (Figure 4-1) that serve a national network of more than 300 participating institutions, involving more than 3,000 scientists, engineers, outreach experts, educators and students. Sea Grant addresses key issues and opportunities in areas such as aquaculture, aquatic nuisance species, coastal community development, estuarine research, fisheries management, coastal hazards, marine biotechnology, marine engineering, seafood safety, and water quality.

**Figure 4-1: Distribution of Sea Grant Program Offices**




*Sea Grant has program offices in each of the nation's nine coastal regions. Most of the offices are located in the Northeast.*

Sea Grant is a national program that sponsors research that addresses the ocean policy and management needs identified by coastal residents and businesses, and local, regional, state and federal agencies. The program conveys scientific research results to user groups such as natural resource managers and coastal business people. The program also conducts and sponsors marine education and outreach activities.

Another NOAA research program is the National Undersea Research Program (NURP). This program has six regional National Undersea Research Centers (NURCs) (Table 4-1) and provides funds annually for more than 200 research projects that support NOAA's mission. Examples of areas of research include causes behind depletion of fisheries, impacts of commercial fishing activity on critical habitats, effects of climate change on the health of coral reefs, and undersea volcanism and its role in coastal hazards. The program also supports research at a long-term ecosystem observatory off the coast of New Jersey. The program's NURCs support many of the nation's underwater vehicle operations.

**Table 4-1: NOAA Undersea Research Centers**

| NOAA Region | NURP Center |
| --- | --- |
| North Atlantic and Great Lakes | NOAA's Undersea Research Center, University of Connecticut, Avery Point |
| Mid-Atlantic Bight | NOAA's Undersea Research Center, Rutgers University |
| Southeast and Gulf of Mexico | NOAA's Undersea Research Center, University of North Carolina, Wilmington |
| Caribbean | National Undersea Research Center, Perry Institute of Marine Science, Caribbean Marine Research Center |
| West Coast and Polar Regions | NOAA's Undersea Research Center, University of Alaska, Fairbanks |
| Hawaii and the Pacific | NOAA's Undersea Research Center, University of Hawaii, Manoa, Hawaii Undersea Research Laboratory |

*NOAA's NURCs are a collaboration of the federal government and academic and research institutions that foster the exploration of the underwater regions of the nation's coasts.*

NOAA's most unique laboratory is the Aquarius, an underwater laboratory 60 feet down and adjacent to a coral reef off Key Largo, Florida, within the Florida Keys National Marine Sanctuary. The laboratory is used as a platform for the study of coral reef processes. It can accommodate 4 scientists and 2 technicians during missions that average 10 days. Owned by NOAA, the facility is administered by the NURC at the University of North Carolina at Wilmington.

The National Centers for Coastal Ocean Science, a program within NOAA's Ocean Service Office, has five laboratories dedicated to ocean and coastal science. These five centers conduct research, monitoring, and assessments on ocean and coastal environments, including the influences of human activities. Information on the staff employed at these centers was not available. The five centers in brief:

- The Center for Sponsored Coastal Ocean Research in Silver Spring, Maryland, hosts the Coastal Ocean Program, which gives scientific information to coastal managers to support policy decisions. The Coastal Ocean Program supports research on coastal ecosystem oceanography, cumulative coastal impacts, and harmful algal blooms and eutrophication.
- The Center for Coastal Monitoring and Assessment in Silver Spring, Maryland, provides long-term measurements at a network of core index sites (including NOAA's Marine Protected Areas). A network of marine laboratories and universities augment the information. The Center's Biogeography Program collects, synthesizes and analyzes data on marine biota distribution and life history. This program maintains local, national

and regional databases on the distribution of species and habitats. It is developing thematic, regional, watershed, and national assessments.

- The Center for Coastal Environmental Health and Biomolecular Research in Charleston, South Carolina, provides scientific information related to the health of coastal ecosystems. Major research activities include development of marine toxin and harmful algal bloom detection methods; development of techniques for field assessment of environmental quality and coastal ecosystem health; examining the relationship between land use and presence of chemical contaminants in the marine environment; and molecular genetics characterization of fish and shellfish to improve species and stock differentiation.
- The Center for Coastal Fisheries and Habitat Research in Beaufort, North Carolina, supports research on the biological productivity of estuaries and ocean ecosystems for the purpose of enhancing recreational and commercial fishery resources. Major research activities include habitat restoration, analyses of Atlantic and Gulf fisheries' responses to fishing efforts, and characterization of Southeast and Gulf biological productivity and contaminants cycling.
- The Hollings Marine Laboratory in Charleston, South Carolina, is a multi-institutional, multidisciplinary laboratory that provides science and biotechnology applications to sustain, protect, and restore coastal ecosystems, emphasizing linkages between the environment and human health. Major research areas include environmental and analytical chemistry, marine genomics, contemporary use of pesticides, ecotoxicology, and aquaculture production and disease.

NOAA's NMFS maintains more than 20 facilities that conduct fisheries research, including laboratories, science centers, and field stations (NMFS facilities are listed in Supplement 4-1). To support these facilities, NMFS employs 875 fisheries biologists, 188 general biologists, 109 biological scientific technicians, 43 oceanographers, and 39 chemists. Some of the NMFS facilities maintain close coordination with academic institutions, such as the Narragansett Laboratory, which is located on the Bay Campus of the University of Rhode Island. Of these NMFS facilities, two — the National Marine Mammal Lab and the National Systematic Laboratory — are described here in some detail because of their unique nature.

The National Marine Mammal Laboratory in Seattle, Washington, conducts research on marine mammals worldwide, with emphasis on the species native to coastal California, Oregon, Washington, and Alaska. The laboratory conducts censuses of marine mammals to evaluate the health and size of the populations. It relies on vessels, aircraft, and telemetry (including satellite tracking) to conduct its research.

The National Systematics Laboratory, administered by the Northeast Fisheries Science Center and co-located with the Smithsonian Institution in Washington, D.C., serves as the taxonomic research arm of the NOAA fisheries. The laboratory's mission is to describe and name new species, and to revise existing descriptions and names based on new information about the fishes, squids, crustaceans, and corals of economic or ecological importance.

Because some important species are highly migratory and many exotic species are introduced into U.S. waters or markets, the laboratory's research is worldwide. Major products of this research are worldwide and regional taxonomic publications and identification guides.

### 4.1.3.2 U.S. Department of Defense Laboratories

Within the U.S. Department of Defense (DoD), only the U.S. Navy and USACE have laboratory facilities that support coastal and ocean research.

The Naval Research Laboratory (NRL) has a number of major laboratory facilities that have some application to oceanography or involve ocean or shipboard research. The largest laboratory facility is located in Washington, D.C. The other facilities are located at the Patuxent River and Chesapeake Bay detachments in Maryland; at the Marine Corrosion Facility in Key West, Florida; at the Stennis Space Center in Mississippi; and at the Naval Postgraduate School complex in California. In terms of staffing, the NRL has approximately 430 full-time equivalents (FTEs) who conduct and support oceanographic research. Details on the six NRL facilities follow:

- NRL — Washington, D.C., conducts most of NRL's research and serves as the operational and administrative focal point for all research efforts. NRL's Acoustic and Remote Sensing Division offices and primary research facilities are located here.
- NRL — Flight Support Detachment (NRL FSD) is located at the Patuxent River Naval Air Station in Lexington Park, Maryland. NRL FSD operates and maintains five uniquely modified P-3 Orion turboprop aircraft that are used as airborne research platforms (see Section 4.4). NRL FSD's aircraft operate worldwide on extended deployment and annually log more than 2,500 flight hours. These aircraft are the sole airborne platforms for numerous projects, such as bathymetry, electronic countermeasures, gravity mapping, and radar development research.
- NRL — Chesapeake Bay Detachment (CBD) occupies a 168-acre site near Chesapeake Beach, Maryland, and provides facilities and support services for research in radar, electronic warfare, optical devices, materials, communications, and fire research. Because of its location high above the Chesapeake Bay on the western shore, unique experiments can be performed in conjunction with the Tilghman Island site 16 kilometers across the bay from CBD. Some of these experiments include low clutter and generally low background radar measurements. By using CBD's support vessels, experiments are performed that involve dispensing chaff over water and radar target characterizations of aircraft and ships. Basic research is also conducted in radar antenna properties, testing radar remote sensing concepts, use of radar to sensor ocean waves, and laser propagation.
- NRL — Marine Corrosion Test Facility in Key West, Florida, offers a flowing clean ocean-air environment suitable for studies of environmental effects on materials. Equipment is available for experiments involving weathering,

general corrosion, fouling, and electrochemical phenomena, as well as coatings, cathodic protection devices, and other means to combat environmental degradation.

- NRL — Stennis Space Center is a tenant at the National Aeronautics and Space Administration's (NASA's) Stennis Space Center (SSC) in Mississippi. Other Navy tenants include the Naval Meteorology and Oceanography Command and the Naval Oceanographic Office, which are major operational users of the oceanographic and atmospheric research and development performed by NRL. This unique concentration of operational and research oceanographers makes SSC the center of naval oceanography and the largest grouping of oceanographers in the world. The Oceanography Division, the Marine Geosciences Division, and one branch of the Acoustics Division are also located at NRL-SSC.
- NRL — Marine Meteorology Division (NRL-MRY) in Monterey, California, is a tenant at the Naval Postgraduate School. This facility is co-located with the Fleet Numerical Meteorology and Oceanography Center (FNMOC) to support development and upgrades of numerical atmospheric forecast systems and related user products. NRL-MRY's mission has broadened considerably to include basic research and support to other customers. Proximity to FNMOC allows NRL-MRY access to the Navy's largest vector supercomputer mainframe and workstation resources. This access provides real-time as well as archived global atmospheric and oceanographic databases for research on-site and at other NRL locations. There are interfaces to the Defense Research and Engineering Network at FNMOC and Defense Simulation Internet at NPS.

USACE conducts coastal research at the Coastal and Hydraulics Laboratory (CHL) of the Engineer Research and Development Center located at the Waterways Experiment Station in Vicksburg, Mississippi. Research conducted at CHL focuses on coastal and nearshore physical processes, including but not limited to waves, currents, tides, tsunamis, morphological response, and sediment transport. This research is applied to a variety of coastal and ocean engineering areas, including breakwaters, beach fills, navigation channels, vessel response, tidal inlets, and dredged material disposal.

CHL has a permanent staff of 250 people (approximately half are engineers and scientists). At any given time, approximately half of the permanent staff is engaged in activities directly related to coastal and nearshore physical processes. (The CHL research mission also includes non-ocean water environments such as rivers, estuaries, lakes, reservoirs, and groundwater.) Computational facilities available to the CHL staff include the Major Shared Resource Center. The major types of CHL facilities used for coastal research are various large-sized basins (some more than 300 feet long) used to simulate waves and current.

USACE also has the Field Research Facility in Duck, North Carolina, on the Outer Banks. It operates as a branch of the CHL. The Field Research Facility has a concrete and steel research pier. The research facility also operates the Coastal Research Amphibious Buggy, a motorized tripod equipped with a centimeter-level global positioning system (GPS) surveying system. It is used for precision mapping, and also serves as a stable work platform for instrument deployments and other activities. A 12-person staff of technicians, oceanographers and computer specialists operates the facility. This site also supports a coastal observing system (see Section 4.6).

### 4.1.3.3 U.S. Coast Guard Laboratories

The U.S. Coast Guard (USCG) operates the Marine Safety Laboratory in Groton, Connecticut. This laboratory provides forensic oil analysis and expert testimony in support of oil pollution law enforcement efforts for field investigators, districts, hearing officers, the National Pollution Funds Center, the U.S. Department of Justice, and other federal agencies. The Marine Safety Laboratory also investigates ways to enhance sampling oil spills and improve the forensic process. The Marine Safety Laboratory is at the Research and Development Center, which USCG leases from the University of Connecticut. The laboratory employs 10 people.

### 4.1.3.4 National Aeronautics and Space Administration Laboratories

NASA has only one land-based laboratory, located on Virginia's Eastern Shore. The air-sea interaction research facility at the Wallops Flight Facility has two wave tanks and engineering laboratories to study air-sea interaction and to test and design sensors. The annual cost of the air-sea interaction laboratory is between $50,000 and $80,000, funded through peer-reviewed research projects.

### 4.1.3.5 U.S. Department of the Interior Laboratories

An accurate inventory of the U.S. Department of the Interior's (DOI's) laboratories was not possible because, with the exception of the Minerals Management Service (MMS), DOI's agencies did not provide a report of their facilities. Through Internet searches, some laboratories were identified for the U.S. Geological Survey (USGS).

MMS operates the Ohmsett (Oil and Hazardous Material Simulated Test Tank) test facility in Leonard, New Jersey. This facility is the largest oil spill response test facility in the world.[4] The main facility at Ohmsett is a large, outdoor, aboveground, 230-meter long concrete test tank filled with salt water. Water clarity is maintained by filtration and chlorinating systems to enhance underwater video of equipment being tested. This unique facility provides a simulated marine environment with reproducible test conditions for oil spill response equipment testing and evaluation. Ohmsett serves as a test bed facility that bridges the gap between laboratory scale and open-ocean testing. The facility is available for use year-round by both government agencies and the private sector.

Movable tow bridges at the facility are capable of towing full-scale oil spill cleanup equipment at speeds up to 6.5 knots. The tow tank also has a wave maker that is able to produce a variety of wave forms up to one meter in height. The on-site storage tanks hold up to 60,000 gallons of test oils that can be distributed on the surface of the tank water in varying amounts and thicknesses. A wide variety of crude and refined petroleum products have been used in tests at Ohmsett. Including the facility manager, there are a total of 13 staff positions at Ohmsett.

USCG's Coastal and Marine Geology Program conducts scientific research along U.S. coastlines, in adjoining ocean waters, and in other waterways. The broad goals of this program are to collect information, monitor conditions, and distribute findings about geologic hazards, environmental conditions, habitats, geologic processes, and energy and mineral resources. Its activities help DOI and other government managers to make informed decisions about the use and protection of our coastal and marine resources. The program includes three field centers: Menlo Park/Santa Cruz, California; Woods Hole, Massachusetts; and St. Petersburg, Florida.[5]

A staff of about 150 people, most of them located in Menlo Park, conducts the work of the USGS Coastal and Marine Geology Program on the West Coast. The Menlo Park office is expanding to include an office near the University of California, Santa Cruz campus, to facilitate collaboration with several dozen marine research institutions in the Monterey Bay area.

The St. Petersburg center investigates scientific processes related to societal problems arising in coastal and marine environments, including natural hazards, resources, and environmental change. The scientific staff has grown from a core group of geologists to include biologists, hydrologists, remote sensing specialists, biogeochemists, microbiologists, coral reef experts, and fish ecologists. In 1996, the center had about 60 employees; current employment numbers are unknown.

The Woods Hole Coastal and Marine Geology team is located on WHOI's Quissett Campus. The team has a staff of about 100, including 24 research scientists and 75 scientific and administrative support staff. USGS scientists explore and study many aspects of the underwater areas between shorelines and the deep ocean off the East Coast, the Gulf of Mexico, and in parts of the Caribbean and Great Lakes.

The USGS's Great Lakes Science Center is located on the North Campus of the University of Michigan in Ann Arbor.[6] The Center has five field stations, one vessel base, and three field station/vessel base combinations dispersed throughout the Great Lakes Basin. Strategic placement of the center's field operations facilitates research conducted over this large geographic area. Field stations are located at Cortland, New York (Tunison Laboratory of Aquatic Sciences); Millersburg, Michigan (Hammond Bay Biological Station); Munising, Michigan; and Porter, Indiana (Lake Michigan Ecological Station). A mid-lake vessel base is located in Cheboygan, Michigan. Combined field stations and vessel bases are located in Ashland, Wisconsin (Lake Superior Biological Station); Oswego, New York (Lake Ontario Biological Station); and Sandusky, Ohio (Lake Erie Biological Station). Approximately half of the center's 107 staff is in Ann Arbor and the other half is distributed across the center's field stations. The center operates four research vessels.

The National Wetlands Research Center (NWRC) is a USGS facility that serves as a clearinghouse for scientific information about the nation's wetlands.[5] NWRC, located in Lafayette, Louisiana, has three scientific branches (Forest Ecology, Spatial Analysis, and Wetlands Ecology) and a technology branch (Technology and Informatics). It operates two field stations and three project offices. The scientific branches employ 41 scientists (13 at Forest Ecology, 15 at Spatial Analysis, and 13 at Wetland Ecology), while Technology and Informatics has 5 technical staff employees.[6] NWRC's wetland information products include peer-reviewed journal articles, databases, synthesis reports, workshops, conferences, technical assistance, training, and information and library services. Examples of NWRC's coastal research topics include accretion, subsidence, sea-level rise, aquatic ecosystem stressors, submerged aquatic vegetation, and assessment of hurricanes' environmental effects. Users of the products include federal and state government agencies, private entities, academia, and the public.

#### 4.1.3.6 U.S. Environmental Protection Agency Laboratories

EPA's Office of Research and Development has four laboratories that target ocean, estuarine, and coastal research, including the Great Lakes. To help support the agency's mission, these four laboratories maintain close collaboration with academic institutions and other government agencies. The Mid-Continent Ecology Division at Duluth, Minnesota, identifies impaired watersheds, diagnoses causes of degradation, and establishes risk-based assessments to support restoration and remediation decisions. It also develops approaches for monitoring trends in ecological conditions within the Great Lakes. The division has 145 federal employees. This division operates the research vessel LAKE EXPLORER.

The Atlantic Ecology Division in Narragansett, Rhode Island, operates a laboratory that develops and evaluates theory, methods, and data to better understand and quantify the environmental effects of anthropogenic stressors on the coastal waters and watersheds of the Atlantic seaboard. EPA's Narragansett laboratory is located adjacent to the University of Rhode Island Graduate School of Oceanography and a NMFS laboratory. This facility, with a fiscal year 2002 (FY2002) operating budget of approximately $13.5 million, employs 81 federal employees, including 65 scientists.

The Gulf Ecology Division in Gulf Breeze, Florida, operates a laboratory that focuses on Gulf of Mexico ecosystems, including assessing the ecological condition of estuaries, coastal wetlands, submerged aquatic vegetation, and coral reefs. Located within this facility is the Gulf Breeze Project Office of the USGS NWRC. The EPA Gulf Breeze laboratory, with a FY2002 operating budget of approximately $15.3 million, employs 70 federal employees, including 64 scientists.

The Western Ecology Division has facilities in Corvallis, Oregon, and Newport, Oregon. It is responsible for developing an understanding of the structure and function of ecological systems, and conducting holistic analysis of ecological phenomena at the ecosystem, landscape, and regional scales.

These facilities, with an FY2002 operating budget of approximately $17.0 million, employ 83 federal employees, including 71 scientists.

### 4.1.3.7 National Science Foundation Laboratories

NSF is in charge of the nation's Antarctic Program. In support of the program, they own and operate the McMurdo and Palmer Antarctic Research Stations. McMurdo is the largest Antarctic station, which provides for Antarctic marine organism and climate studies. During the summer about 1,100 people occupy the station, and during the winter the number is reduced to approximately 250.

Palmer Station, located on a protected harbor on the southwestern coast of Anvers Island off the Antarctica Peninsula, is well situated for biological and marine ecosystem research. It has a large and extensively equipped laboratory and seawater aquaria. In 1990, NSF designated the station as a long-term ecological site. The station operates in conjunction with the research ship LAURENCE M. GOULD. During the summer about 40 scientists occupy the station, while in winter only about 10 occupy the facility.

In addition to the Antarctic stations, NSF owns the National Ocean Sciences Accelerator Mass Spectrometry Facility at WHOI. This facility is used for radiocarbon analysis of environmental samples, mainly oceanographic. The cost of the facility or plans for its replacement are unknown.

### 4.1.3.8 U.S. Department of Energy Laboratories

The U.S. Department of Energy (DOE) has seven laboratories that conduct ocean-related research. Researchers at the Lawrence Livermore National Laboratory in California are developing ocean models with the goal of producing high-quality simulations and predictions of ocean circulation and bio-geochemistry. Of special interest is modeling sequestration of carbon in the oceans by direct injection of carbon dioxide or by iron fertilization.

The Earth Sciences Division at Lawrence Berkeley National Laboratory in California supports research on bio-geochemical cycles in the ocean; in particular, the vertical transport and sequestration of carbon. The laboratory evaluates the feasibility, effectiveness and environmental consequences of purposeful ocean carbon sequestration as a strategy for managing atmospheric carbon dioxide levels. The research is multidisciplinary and includes mathematics, chemistry, physics, biology, computer science and engineering.

The Oak Ridge National Laboratory in Utah has a Seafloor Process Simulator. The Simulator is a 72-liter, high-pressure, temperature- and pressure-controlled chamber. It is being used to study the formation of carbon dioxide hydrates in the deep sea. Understanding of hydrates dynamics is important for climate change research.

The Climate, Ocean and Sea-Ice Modeling Group at Los Alamos National

Laboratory in New Mexico develops and applies state-of-the-science global ocean general circulation models and sea-ice models as part of the DOE Climate Change Prediction Program. These models are a component of the multi-institutional Community Climate System Model program supported by DOE and NSF. The Earth and Environmental Sciences group uses advanced ocean-circulation models to investigate the interactions of oceans circulation and the ecology of the ocean's surface layers, including the distribution of phytoplankton and zooplankton.

The Pacific Northwest National Marine Sciences Laboratory is located in Sequim, Washington. Scientists at this laboratory perform both basic and applied research in support of the management of marine and estuarine ecosystems, the impacts of human activity on ecosystems, and the development of marine resources and biotechnology. Expertise includes marine chemistry, ocean modeling, measurement technology, ecological system processes and restoration research, fisheries research, and marine ecotoxicology.

The DOE Joint Genome Institute is a state-of-the-art genomics laboratory in Walnut Creek, California. Recent projects include a number of marine organisms such as the tunicate *Ciona intestinalis*, the zebrafish, and numerous marine bacteria and phytoplankton (e.g., cyanobacteria *Prochlorococcus* and *Synechococcus*). Data from these projects offer the potential to provide a whole new level of understanding of marine systems and to greatly enhance our ability to develop fundamental, mechanistically based models of ocean bio-geochemical cycles.

### 4.1.3.9 Smithsonian Institution Laboratories

The Smithsonian Institution has a tropical research institute, an environmental research center, and a marine field station that conduct coastal and ocean research. In addition, the Smithsonian is the repository for multiple collections of marine organisms used regularly by the scientific community for research.

In the Republic of Panama, The Smithsonian Tropical Research Institute (STRI) maintains a series of facilities dedicated to tropical research and education.[7] STRI has a marine field station on the Caribbean coast of Panama in the Bocas del Toro province. In addition, STRI is also constructing a new educational research center in the same region. The new center will host a comprehensive education and research program, which is focused on both marine and terrestrial environments. Also on the Caribbean coast is the Galeta Marine Laboratory, where the long-term effects of an oil spill are studied. On the Pacific coast, near the entrance of the Panama Canal, STRI has the Naos Island Laboratories. The laboratory facilities include modern molecular biology labs, tanks with running seawater for experimentation, and research diving facilities. STRI was bequeathed a 242-hectacre island on the Pacific Coast of Panama in an area with the highest density of coral reefs in the eastern Pacific Ocean. STRI is considering establishing an Eastern Pacific Marine Research and Educational Center on this donated island. STRI also operates the research vessel URRACA, a UNOLS vessel (Section 4.2).

The Smithsonian Environmental Research Center, on the western shore of the Chesapeake Bay, provides facilities for interdisciplinary research and educational outreach. An important feature of the center is its relatively large size.[8] With 2,600 acres of land and 12 miles of undeveloped shoreline, the center serves as a natural laboratory for long-term ecological research. The center is a leading national and international institution for research in the area of non-native species invasion, and hosts the National Ballast Water Information Clearinghouse.

The Smithsonian Marine Station is a field station facility of the Smithsonian National Museum of Natural History. The Marine Station, located in Ft. Pierce, Florida, specializes in the study of marine biodiversity and ecosystems of Florida. In 1999, the station was moved from a small floating facility to a new eight-acre campus equipped with general-use laboratories that include electron microscopy capabilities. The station has various small boats, including the 39-foot research vessel SUNBURST, which is equipped for coastal research and benthic sampling.

An example of the Smithsonian's repository role is the National Collection of Foraminifera (and other microfossils), which is the largest collection of foraminifera in the world. The study of foraminifera provides relevant information for multiple areas of research including the elucidation of long-term climatic fluctuations.

### 4.1.3.10 U.S. Food and Drug Administration Laboratories

FDA's Seafood Safety Laboratory has an ongoing research program in marine biotoxins, in particular those produced by harmful algal blooms. This program provides guidance to FDA's regulatory program. An important component of the program is to improve the characterization of the various seafood toxins, the development of detection methods, and the culture of the organisms that produce biotoxins. FDA also routinely supplies reference standards for two types of biotoxins to other laboratories for regulatory and research purposes. The Administration's research program also provides technical support to state and other regulatory agencies when there are management questions. Information about FDA's laboratory facilities or the number of staff was not available.

## 4.1.4 State Marine Laboratories

State marine laboratory facilities fall into two general categories: state-owned laboratory facilities designed to support universities, and state-owned laboratory facilities that support the state's resource management or environmental monitoring and assessment activities. State laboratory facilities that support academic institutions were discussed earlier in this chapter. This section discusses state laboratory facilities that support state resource management or environmental monitoring and assessment activities.

The protection and conservation of the coastal zone of any state requires programs that adequately monitor the environmental characteristics of each particular system. Each state has a different governmental organization, so the monitoring programs fall under different agencies depending on the state. For example, some states may have an agency with a laboratory used for fisheries and water quality, while other states may have the same responsibilities distributed among separate agencies with independent facilities. This variability in state facilities, combined with the relatively low response to the request for information received from the states (about a third of the states responded), limits discussion about these facilities.

Two example state laboratory facilities are described here to illustrate the existing degree of capabilities and diversity of programs the states have to conduct coastal and ocean research, monitoring, and exploration activities. The state facilities selected are the Marine Resources Division of South Carolina's Department of Natural Resources, and the Florida Marine Research Institute of Florida's Fish and Wildlife Commission.

The South Carolina Marine Resources Division has multiple responsibilities for the protection and sustainable use of fisheries resources.[9] For example, the division conducts studies on marine resources and aquaculture research, sets the seasons for saltwater fishing and shell fishing, manages the shellfish grounds artificial reefs, and conducts outreach and education activities. The division's facilities conducting research are the Marine Resources Research Institute and the South Carolina Algal Ecology Laboratory.

The Marine Resources Research Institute, established in 1973 in James Island across the harbor from the City of Charleston, is South Carolina's only seaside research facility not directly administered by an academic institution. The institute provides scientific expertise and technical capabilities needed to develop and conduct the research programs required to protect, restore, and enhance estuarine and marine resources. In addition, the institute identifies suitable species, develops culture methods, and provides advisory services for the growing shrimp, mollusk, and fish aquaculture industries.

The institute also provides a research facility for the academic community. It occupies a modern cooperative research facility with wet and dry laboratories, and in association with the College of Charleston, houses a research library with more than 14,400 monographic titles, 7,800 bound journals, 25,600 reprints and 400 current serial subscriptions. Other features of the facility include culture systems supplied with flow-through and recirculating seawater, a graphics center, photographic darkrooms, and a geographic information processing laboratory. The institute operates 4 research vessels ranging from 51 to 110 feet in length and 18 outboard motor boats ranging from 13 to 23 feet in length.

The institute also operates the James M. Waddell Research and Development Center, one of the country's largest facilities for aquaculture research. The Waddell Center maintains a system of 35 ponds that range in size from 0.5 to 1.25 acres, hatcheries, spawning facilities, and support laboratories. The aquaculture facilities at the Waddell Center are used by institute staff as well as researchers and students associated with the state's academic institutions.

The South Carolina Algal Ecology Laboratory is a partnership between the University of South Carolina's Baruch Institute, and the Marine Resources Division of the South Carolina Department of Natural Resources. The laboratory personnel work at three facilities. Most of the personnel work at the Marine Resources Research Institute. Additional personnel work at the nearby Hollings Marine Laboratory and at the Baruch Marine Field Laboratory, located approximately 80 miles northeast of Charleston. The Baruch Marine Field Laboratory is a facility of the University of South Carolina Belle Baruch Institute for Marine Ecology and Coastal Science.

The Florida Marine Research Institute (FMRI) conducts applied research that supports the management of Florida's marine resources.[10] It has 12 laboratories distributed along the Florida coastline. Some of the laboratories, like the Marine Mammal Pathological Laboratory, have very specialized missions. The Institute has four main technical areas of work: fisheries assessment, ecosystem assessment and restoration, endangered and threatened species, and information science and management.

FMRI's Fisheries Assessment Section conducts monitoring of commercial and recreational marine fisheries. Typical areas of studies include life histories, genetic characteristics, population structure and dynamics, ecology, and stock enhancement potential of important recreational and commercial fish and invertebrate species. Information collected helps to assess and predict fisheries harvest trends. This section employs approximately 103 FTEs.

The Ecosystem Assessment and Restoration Section addresses many different issues, including assessment of marine habitats; plant and animal communities associated with Florida's coastal fisheries; studies of fish kills and seagrass die-off; and monitoring of red tides. This section employs 27 FTEs.

The Endangered and Threatened Species Section's priority is conservation research designed to provide managers with timely information for protecting the North Atlantic right whale, sea turtles, and Florida manatees. Frequent techniques use for research and monitoring include aerial surveys, radio and satellite telemetry, photo identification of manatees, and geographic information systems. This section employs 21 FTEs.

The Information Science and Management Section ensures the timely delivery of marine-related information collected by FMRI staff. This section includes a program in coastal and marine resources assessment, information access, and computer management. This section employs 29 FTEs and more than 18 other personnel. FMRI also employs another 35 FTEs and 18 other personnel in support of operation tasks. FMRI's annual operating budget is approximately $33 million.

# 4.2 Research, Exploration, and Monitoring Vessels

This section addresses surface vessels (i.e., any boat, craft, or ship) that support ocean and coastal research, exploration, and monitoring activities. It does not include underwater vehicles, which are covered in Section 4.3; commercial vessels (e.g., cruise or cargo ships); and military ships that, outside of their normal operations, may deploy oceanographic instrumentation or collect samples as part of a volunteer program. This inventory does not include boats under 25 feet in length, as these assets are too dynamic to be accurately evaluated.

The U.S. research, exploration, and monitoring fleet consists of more than 400 vessels ranging in size from the 470-foot JOIDES RESOLUTION ocean drilling ship, to small boats that support coastal and inshore water activities. Vessels in this inventory have an average length of 92 feet and are 23 years old. Approximately 21 percent of the vessels are large ocean-going vessels (over 130 feet).

The U.S. research, exploration, and monitoring fleet has more than 400 vessels.

The inventory of vessels is sorted into five organizational categories: UNOLS, academic, federal, state, and commercial (Table 4-2). UNOLS vessels include U.S. Navy and NSF-owned vessels in operation with various universities. Academic vessels are non-UNOLS vessels operated by academic institutions and nonprofit, private oceanographic research institutions such as Harbor Branch Oceanographic Institutions and Monterey Bay Aquarium Research Institute. Federal vessels are those owned and operated by federal agencies, including the Navy and USCG. Commercial vessels are vessels owned by for-profit organizations, including vessels chartered or leased by federal, state or academic institutions. In addition, vessels are also sorted by their homeport, according to the nine regions defined in Chapter 1. For smaller vessels with a limited operational range, the homeport region approximates the vessel's operational region. For some large oceangoing vessels, the operational region surpasses their homeport region. These larger vessels have a global reach, and occasionally operate for significant periods of time conducting missions through multiple regions.

The missions supported by these vessels range from water-quality monitoring in the Great Lakes to deep-ocean drilling for geophysical research. The type of deployment mission dictates the vessel's characteristics. Some vessels have a unique role that cannot be replicated by any other vessel in the fleet. For example, the 360-foot FLIP is designed to be towed to a station and "flipped" into a vertical position to act as a research platform. Other vessels frequently support multidisciplinary investigations and cannot be classified within a defined mission (e.g., fisheries, geophysics survey).

## 4.2.1 UNOLS Vessels

UNOLS was created in 1972 with the objective of coordinating and reviewing access to and use of facilities for academic oceanographic research.

**Table 4-2: Vessel Distribution by Region**

| Region | UNOLS | Academic | Federal | State | Commercial | Total |
|---|---|---|---|---|---|---|
| Great Lakes (GL) | 1 | 12 | 9 | 31 | 2 | 55 |
| Northeast Atlantic (NE) | 4 | 26 | 3 | 2 | 49 | 84 |
| Mid Atlantic (MA) | 3 | 34 | 10 | 7 | 5 | 59 |
| Southeast Atlantic (SE) | 5 | 16 | 6 | 5 | 10 | 42 |
| Caribbean (C) | 1* | 4 | 0 | 0 | 0 | 4 |
| Gulf of Mexico (GOM) | 3 | 16 | 7 | 0 | 56 | 82 |
| West Coast (WC) | 8 | 27 | 8 | 3 | 12 | 58 |
| Alaska (AK) | 1 | 1 | 7 | 2 | 7 | 18 |
| Western Pacific (WP) | 1 | 3 | 3 | 0 | 0 | 7 |
| TOTAL | 27 | 139 | 53** | 50 | 141 | 410 |

*Summary table of the number of research vessel sorted by type of organization and homeport region.*

** The URRACA, a vessel of the Smithsonian Tropical Research Institute, operates mostly on the Pacific coast of Panama, although it occasionally operates in the Caribbean.*
*** Total does not include eight Navy survey vessels that are forwardly deployed, and two NSF operated vessel that support Antarctic missions.*

The UNOLS vessels compose the National Academic Research Fleet, made up of federal, state, and privately owned vessels. In December 2001, the Federal Oceanographic Facilities Committee of the National Oceanographic Partnership prepared a report to the National Ocean Research Leadership Council titled *Charting the Future of the National Academic Research Fleet: A Long-Range Plan for Renewal*.[11] The information in this section relies largely on that report, as it is the most current document about the status and future plans for the National Academic Research Fleet.

The UNOLS fleet consists of 27 vessels with an average length of 163 feet, and ranging in size from 66 to 279 feet (Supplement 4-2 lists the UNOLS vessels). NSF is the primary supporter of the UNOLS's National Academic Research Fleet, owning eight of the vessels. The U.S. Navy owns 6 vessels, and various academic and research institutions own the other 13 vessels. As of 2003, the average age of the fleet is 17 years. The oldest vessel is the CLIFFORD BARNES, built in 1966, and the newest addition is the SWATH (Small Waterplane Area Twin Hull) design vessel KILO MOANA, built in 2002. With the exception of the Caribbean, there is at least one UNOLS vessel with a homeport in each coastal region, with the largest number in the West Coast region. UNOLS currently groups the vessels into five classes based on vessel length (Table 4-3).

A few of the UNOLS vessels have very specific missions. For example, the ATLANTIS, a 274-foot Global Class vessel owned by the U.S. Navy and operated by WHOI, provides support to the manned submersible ALVIN. Another vessel with a unique role is the 239-foot MAURICE EWING, operated by the Lamont-Doherty Earth Observatory, which has extensive geophysical capabilities. Other UNOLS vessels such as the POINT SUR or the CAPE HATTERAS, both 135 feet long, are general oceanographic vessels.

**Table 4-3: UNOLS Vessel Classes**

| Class | Class Name | Length (ft) | Number of Vessels Per Region | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GL | NE | MA | SE | C | GM | WC | AK | WP | Total |
| I and II | Global Class | 230 – 280 | — | 4 | 1 | — | — | — | 3 | — | — | 6 |
| III | Intermediate | 168 – 204 | — | — | — | 1 | — | 1 | 2 | — | — | 7 |
| IV | Regional | 105 – 135 | — | — | 2 | 2 | 1* | 2 | 2 | 1 | 1 | 9 |
| V | Local | < 100 | 1 | — | — | 2 | — | — | 1 | — | — | 5 |
| | | TOTAL | 1 | 4 | 3 | 5 | 1 | 3 | 8 | 1 | 1 | 27 |

*Summary table of the number of UNOLS research vessel sorted by class designation and homeport region.*

** The URRACA, a vessel of the Smithsonian Tropical Research Institute, operates mostly on the Pacific coast of Panama, although it occasionally operates in the Caribbean.*

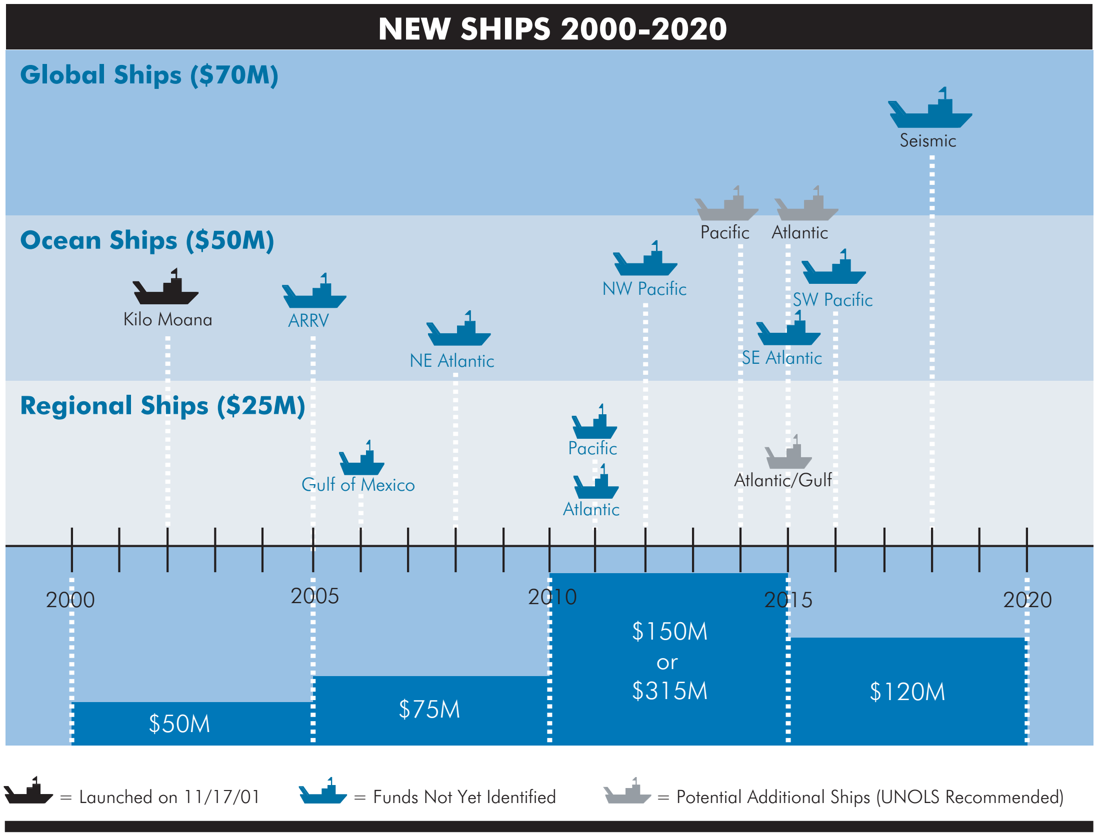
*Regions: GL - Great Lakes; NE - Northeast; MA - Mid-Atlantic; SE - Southeast; C - Caribbean; GM - Gulf of Mexico; WC - West Coast; AK - Alaska; WP - Western Pacific*

UNOLS plans to reorganize the five categories of vessels into four new classes based roughly on length and capabilities: Global, Ocean, Regional, and Local (Figure 4-2). The Global Class will include vessels longer than 230 feet that are able to work worldwide in ice-free waters. These vessels carry more than 30 scientists and can conduct missions longer than 50 days. The Ocean Class is a new class of vessels for interdisciplinary research, similar in design to the Global Class, but without the global range. These vessels are expected to be from 180 to 230 feet in length and will have greater capabilities than the currently existing Intermediate Class vessels. Regional Class is the smallest class, which is expected to depend primarily on federal funding for their construction. These vessels are expected to range from 130 to 150 feet. Regional Class vessels will carry about 20 scientists for up to a month and have laboratory space for multidisciplinary research. Local vessels are vessels under 130 feet, and their characteristics and number will reflect the research priorities of the sponsoring institutions with input from the UNOLS community. The main factor for the new vessel classification will be the operational capabilities of the vessels and not the length.

Five of the UNOLS vessels are expected to be decommissioned within five years. Plans for the replacement of one of those vessels, the CAPE HENLOPEN (a 120-foot Local Class vessel), are being developed by the University of Delaware.[12] The plans call for a 138-foot vessel that may fit the description of a UNOLS Regional Class vessel. This new vessel, to be built with state funds, is expected to be in service by early 2006.

The NSF Division of Ocean Sciences expects to provide funds to construct three Regional Class ships over a six-year period, beginning in FY2006. Another vessel that will be retired within the next six years is the ALPHA HELIX,

**Figure 4-2: Proposed Schedule for Construction of New UNOLS Vessels**




*Schedule proposed for the construction of new UNOLS vessels during the next two decades. Figure from* Charting the Future of the National Academic Research Fleet: A Long Range Plan for Renewal *by the National Oceanographic Partnership Program.*

a 133-foot ice-strengthened vessel that operates in Alaska. The design for a high-latitude Ocean Class ship, the Alaska Region Research Vessel (ARRV), is near completion. The ARRV is a potential candidate for funding from NSF's Major Research Equipment-Facilities Construction account. The U.S. Navy is in the process of identifying a single-hull form for Ocean Class vessels and is contemplating construction of four vessels starting in FY2006, depending on overall Navy program priorities and hull selection. Estimated replacement cost per vessel ranges from $70 million for a Global Class vessel to $25 million for a Regional Class vessel.

## 4.2.2 Academic Vessels

Academic vessels are not included in the UNOLS National Academic Fleet, even though many belong to institutions that are members of UNOLS. Academic institutions and nonprofit, private oceanographic research institutions, such as Harbor Branch Oceanographic Institute and Monterey Bay Aquarium Research Institute, own and operate the academic vessels. A total of 139 vessels over 25 feet in length were identified using the CORE Report, Internet searches, professional contacts, and technical references. (Supplement 4-3 provides a list of academic vessels.)

With 34 vessels, the Mid-Atlantic region has the highest inventory of academic vessels, which reflects the high number of academic institutions in the area (Supplement 5-1 provides a list of academic institutions). The Western Pacific and the Caribbean regions have three and four vessels respectively, the lowest numbers. The Western Pacific is a region of oceanic islands characterized by extensive open ocean environments close to shore that require larger-size ships as compared to the mainland, which has both an extensive coastline and a continental shelf. Even though the Western Pacific has the lowest number of vessels, it has the 186-foot KILO MOANA, the newest UNOLS vessel. In contrast, the four academic vessels in the Caribbean belong to the University of Puerto Rico, with the largest vessel being the 127-foot CHAPMAN, a former NOAA fisheries vessel. This vessel supports the monthly sampling at the Caribbean Time Series ocean-observing system (see Section 4.6.1) and is well suited to support oceanography activities in the Caribbean basin; however, funding for its full utilization and maintenance has not been secured.

The type of vessels used by academic institutions varies from multipurpose coastal research and education vessels to geophysical survey and research vessels. The type of vessel used reflects the mission of each academic institution, which in turn is linked to the economy and surrounding environment of the institution location. For example, academic vessels operating in the Great Lakes region tend to be equipped for fisheries, water quality, and benthic chemistry studies as these are the typical research priorities for the area. In contrast, many vessels in the Gulf of Mexico support geophysical research work, which relates to the region's oil and gas exploration industry.

The average vessel used by academic institutions is 60 feet long and 22 years old. Only 16 vessels (less than 12 percent of the inventory) exceed 100 feet in length, with the largest vessel being the 470-foot ocean drilling JOIDES RESOLUTION (see Section 4.2.3.4). Most of the academic vessels (approximately 66 percent) do not exceed 60 feet. These numbers indicate that relatively small-sized vessels comprise a significant portion of the academic vessels used for research and education purposes.

The ACADIANA, operated by the Louisiana Universities Marine Consortium, is a typical example of an academic vessel and serves as a representative academic vessel to illustrate the capabilities of this category.[13] The aluminum-hulled ACADIANA is a 58-foot, shallow-draft research vessel built in 1985. When it is used only for research purposes, the vessel carries a crew of two and about four scientists. For educational purposes, it can carry up to 25 people for day trips.

Twin Caterpillar 3406 engines provide 650 total horsepower for the ACADIANA. The vessel has a moderate cruise speed of 10 knots and an endurance of 5 days, and is equipped with a generator. For communication, the vessel relies on one SSB and two VHF radios, and one inshore and one offshore cellular phone. Navigation equipment includes a magnetic compass, two GPS Chartplotter/sounders, and autopilot. The vessel has a small 144 square-foot laboratory equipped with running seawater, 12 volts direct current, and 110/220 volts alternating current. To support the collection of hydrographic, biological, and benthic samples, the ACADIANA has on-deck a trawl winch with 500 feet of quarter-inch cable, one hydro winch with 500 feet of three sixteenth-inch cable, and one electromechanical winch with 500 feet of three sixteenth-inch single conductor cable. Vessels like the ACADIANA, even though not suitable for long oceanographic cruises or deep-water operations, are versatile enough that they can be customized to support many different coastal research projects.

Exact figures were not available, but many vessels in the academic fleet were not acquired as new vessels designed for ocean and coastal research. In many instances, institutions receive, as a donation or at a minimal cost, decommissioned USGS or Navy vessels (e.g., the MATTHEW F. MAURY, a 1960s former Navy patrol craft transferred in 1996 to Virginia's Tidewater Community College). Former fishing vessels are also sometimes acquired and modified for coastal and ocean research. On occasion, private individuals or foundations donate private vessels to academic institutions. This process ameliorates the high cost of acquiring a new research vessel. For example, WHOI is replacing its 46-foot coastal research vessel ASTERIAS with a new 60-foot vessel that will be delivered in 2004 at a cost of $1.6 million.[14] Few institutions can afford or justify such expenditure. The transfer of vessels between organizations also occurs between federal agencies.

Some institutions have been forced to retire aging, but still useful vessels due to a lack of funding to ensure the vessel's overhaul and safe operation. An example of this situation is the recent retirement of the 53-foot RV ORION by the University of Maryland Center for Environmental Science.[15]

Some academic institutions have devised partnerships with other organizations, such as federal or state agencies, to allow them to retain vessels when they can no longer afford their operating and maintenance costs. An example of this situation is the 80-foot LAURENTIAN at the University of Michigan. In 2002, through a partnership agreement, NOAA's Great Lakes Environmental Research Laboratories leased the LAURENTIAN for 15 years and assumed responsibilities for its operation maintenance and scheduling.[16,17] This agreement augmented the facilities available at the NOAA lab, and still provides the university's research and educational community with access to the vessel.

### 4.2.3 Federal Vessels

Six federal agencies own vessels used for coastal and ocean activities. The respective mission of each agency helps determine the size of fleet they operate and the design and characteristics of their vessels. The vessels range in size from 420-foot icebreakers to small vessels used to conduct work in coastal and estuarine waters. NOAA has the largest number of vessels, with more than 25 vessels over 50 feet.

### 4.2.3.1 National Oceanic and Atmospheric Administration Vessels

The Office of Marine and Aviation Operations (OMAO) maintains and operates NOAA's fleet of ships and aircraft and manages the NOAA Corps. NOAA's vessels collect hydrographic, fisheries and coastal data for NOAA programs and have capabilities largely unavailable in commercial vessels. The types of missions and annual average operating days per vessel for FY2002 are listed in Table 4-4. "Operating days" are defined as days when a ship is not at its homeport and is available for service.

The cost for operation, maintenance, shoreside facilities and support, and management of all NOAA vessels in FY2002 was $63 million. The NOAA fleet consists of 18 vessels (15 of them active) longer than 90 feet, with an average vessel age close to 25 years (Supplement 4-4 provides a list of federal vessels). NOAA's vessels currently operate well beyond the normal service life of comparable research vessels.

**Table 4-4: NOAA Ships Operating Days**

| Mission Supported | Annual Average Operating Days Per Vessel |
|---|---|
| Fisheries Stock Management and Marine Mammal Protection | 236 |
| Nautical Charting | 233 |
| Oceanography | 242 |
| Coastal Research and Assessment | 304 |

*NOAA vessels are heavily used, spending more than 60 percent of the year in operation.*

A noticeable exception to these statistics in the NOAA fleet is the RONALD H. BROWN, the newest vessel in NOAA's fleet. This vessel was built in 1996 and was designed as a sister ship of the Navy AGOR 23-class vessels that include the THOMAS G. THOMPSON, ATLANTIS, and ROGER REVELLE. It is considered to be a state-of-the-art vessel with deep-water and atmospheric research capabilities. Equipment that supports these capabilities includes a c-band Doppler radar, dynamic positioning system, wind profiler, radiosondes, Seabeam 2112 (12 Khz) swath bathymetric sonar system, Acoustic Doppler Current Profiler (ADCP) (150 kHz NB), and attitude sensor. The vessel has approximately 4,000 square feet of lab space, and space on deck for four additional labs or accommodation vans.[18] This vessel operates worldwide, has an at-sea endurance of 60 days, and can carry a maximum of 34 scientists in addition to the crew. This vessel has an expected service life of 30 years.

A recent report by the NOAA Office of Marine and Aviation Operations addresses NOAA vessel requirements for the period of 2003 to 2012.[19] The following discussion on NOAA vessel requirements is based on this report.

For FY2003, NOAA projects it will require more than 12,000 operating days for all missions, but only about 30 percent of the operating days can be completed with the NOAA fleet.  Outsourcing will provide 38 percent of the requirements, and the other 32 percent probably will go unmet.

The report identifies nine active NOAA ships to be retired during the next decade, with NOAA recommending nine vessels as replacements.  NOAA recommends that four of the replacements be new construction vessels (three fisheries survey vessels, one SWATH hydrographic survey vessel), and three replacements be met by the acquisition and conversion of decommissioned Navy survey ships.  Two additional fisheries survey ships are also recommended for construction.  Even if NOAA can reach the goal of having a fleet of 19 active vessels by 2012, it will still require outsourcing of approximately 56 percent of the required operating days to fulfill its mission.

An example of a NOAA fisheries vessel expected to remain as an operational asset for more than a decade is the 224-foot GORDON GUNTER.  This vessel normally operates in the Gulf of Mexico and Caribbean Sea in support of NOAA's NMFS Pascagoula Laboratory, Mississippi.  The ship uses trawls and benthic longlines to collects fish and crustaceans.  It also collects fish larvae, fish eggs, and plankton using plankton nets and surface- and mid-water larval nets.  The GUNTER is a former Navy AGOS 1-Class ship, constructed in 1989 for quiet operations with a low acoustic signature.  The Navy transferred the vessel to NOAA in 1993.  NOAA commissioned it in 1998 after converting it for fisheries research.  A stern trawl ramp and handling gear and nine deck and oceanographic winches were added during conversion.[18]  The vessel has equipment capable of supporting all of the NOAA line offices.  It has a wet lab, dry lab, chemistry/hydrology lab, computer lab, and an electronics lab.  The vessel has an endurance of 30 days, carries a crew of 22, and can support up to 15 scientists.

In addition, NOAA operates nearly 150 small boats.  The majority of NOAA's small boats are less than 50 feet in length, but detailed information on their size and capabilities was not available.  NOAA Line Offices own and are responsible for the maintenance and operation of NOAA's small boats. These boats provide an important service.  For example, during a period of 12 months, boats that support the 13 National Marine Sanctuaries undertook approximately 3,200 trips.  Of these trips, approximately 40 percent were in support of research and monitoring activities.[19]

#### 4.2.3.2 U.S. Navy Vessels

The U.S. Navy provides six oceanographic vessels to the UNOLS fleet to support civilian research and exploration activities.  In addition, the Navy maintains a fleet of eight T-AGS 60-Class ocean-surveying vessels to support military operations.  These vessels, operated by the Navy Military Sealift Command, collect oceanographic information that is not for public use (see Section 3.2.3.2).  The commercial vessel CAROLYN CHOUEST, in addition to supporting the Navy's nuclear submersible craft NR-1, often supports oceanographic and ocean engineering activities for the Navy.

### 4.2.3.3 U.S. Coast Guard Vessels

USCG has three multimission icebreakers that support polar research activities in addition to its icebreaking duties (Section 3.3.1.2 provides more information on these vessels). Two of the vessels are 399-foot POLAR-Class vessels built in 1976. These POLAR-Class vessels can carry up to 30 scientists in addition to the vessel crew. The third is the HEALY, a 420-foot vessel built in 1998 and assigned to support operations in the Arctic. The HEALY has five laboratories totaling close to 4,000 square feet. The vessel has diesel-electric power with the main engines located in the main deck, which provide very low acoustic signature for a vessel of its size.[18] The HEALY can carry 50 scientists in addition to its crew, and has an endurance of 180 days.

### 4.2.3.4 National Science Foundation Vessels

NSF owns or supports some of the most important research vessels, including 8 of the 27 UNOLS vessels. In addition, NSF charters the operation of the Polar vessels NATHANIEL B. PALMER and LAWRENCE M. GOULD, and provides support for the research activities of the USCG icebreakers HEALY, POLAR STAR, and POLAR SEA and for the ocean drilling ship JOIDES RESOLUTION.

Both the 308-foot NATHANIEL B. PALMER and 230-foot LAWRENCE M. GOULD, built in Louisiana by Edison Chouest Offshore, support the nation's Antarctic mission. The NATHANIEL B. PALMER, built in 1992, can break up to three feet of ice at three knots. It accommodates 37 scientists and has a crew of 22. The LAWRENCE M. GOULD is an ice-strengthened vessel built in 1997 that replaced the research vessel POLAR DUKE. The LAWRENCE M. GOULD conducts year-round polar operations and can accommodate 26 research scientists. Both, the PALMER and the GOULD have endurance of 75 days.

NSF has the unique role of supporting the U.S. component of the International Ocean Drilling Program. The 470-foot JOIDES RESOLUTION ocean drilling ship, a chartered vessel homeported at Texas A&M University, is the main facility of the Ocean Drilling Program. The ship, built in 1978 as a conventional ocean drilling ship, was refitted for research in 1984. The ship is capable of drilling in water deeper than 26,000 feet. The ship accommodates approximately 30 scientists, 20 engineers and technicians, and a crew (including drilling personnel) of 52 during each 2-month cruise.[20] The three repositories for cores collected by the Ocean Drilling Program are the East Coast Repository at Lamont-Doherty Earth Observatory, the Gulf Coast Repository at Texas A&M University, and the West Coast Repository at SIO.

NSF released a request for proposal in March 2003 to provide support for the U.S. facility contribution to the new international drilling program (i.e., Integrated Ocean Drilling Program). Funds will be provided to convert a commercial drill-ship into a state-of-the-art scientific facility, possibly as early as FY2005. The plans for the replacement of the JOIDES RESOLUTION call for a similar class non-riser drilling vessel, but with significantly enhanced coring and drilling capabilities at an estimated cost of $100 million.

The Integrated Ocean Drilling Program, which is scheduled to begin in October 2003, is a 10-year program that will be co-led by NSF and Japan's Ministry of Education, Culture, Sport, Science and Technology, with significant scientific and financial participation from European and other Asian nations.[21] In support of this program, Japan is completing construction of a heavy drill ship. The Japanese vessel, the CHIKYU, will undergo outfitting and testing from 2003 to 2006, and will be available for operations in 2007.

### 4.2.3.5 U.S. Department of the Interior Vessels

An accurate inventory of DOI vessels was not possible because, with the exception of MMS, DOI agencies did not provide a report for this inventory. With that in mind, the inventory of DOI vessels over 25 feet consists of at least 11 vessels: one with FWS, two with MMS and eight with USGS. Five of the vessels operate in the Great Lakes, two in Alaska, two in the Gulf of Mexico, one in the Northeast, and one in the West Coast. USGS may have two other vessels, the STURGEON and the SISCOWET, but information about these vessels was conflicting and their status could not be ascertained.

The 85-foot TOGUE, operated by the Jordan River National Fish Hatcheries, Michigan, is the FWS Great Lakes fish stocking vessel and is the only vessel in the Great Lakes specially modified for lake trout stocking.[22] The TOGUE transports lake trout in tanks located in the aft of the vessel to designated stocking locations, which occurs from April to June. During this period, the vessel is not available for any other use. The TOGUE carries a crew of two, and one or more biologists while conducting stocking activities.[23] The 2004 FWS budget includes $4.3 million for the replacement of the TOGUE.

MMS owns the 42-foot THE NINA and the 37-foot LAUNCH 1273. THE NINA is a former fishing vessel built in 1962 for NOAA, and transferred to MMS in 2001. The Center for Marine Resources and Environmental Technology of the University of Mississippi use THE NINA as a support vessel for its Marine Minerals Research program. The vessel is moored in Biloxi, Mississippi.

The LAUNCH 1273 is a research vessel constructed in 1983 along the design of a Bristol Bay gill-netter. The vessel, designed to operate in northern, nearshore waters, has operated in Alaska's southeast Bering Sea, Cook Inlet, Glacier Bay and most recently the Beaufort Sea. MMS Alaska OCS Region, Environmental Studies Section manages the LAUNCH 1273. Depending on priority commitments to MMS-sponsored studies and related cruise plans, the vessel is used cooperatively with other agencies and academic institutions in Alaska. Currently the vessel is in drydock undergoing renovations, to be returned to the central Alaska Beaufort Sea to support additional MMS-sponsored research efforts. The LAUNCH 1273 is expected to continue in service at least through 2008.

MMS also owns the RELENTLESS II, a less than 25-foot boat, but with a unique role that deserves mention. This boat is a deep-V aluminum hull surrounded by a modular closed-cell foam sponson designed and built for whale research. The RELENTLESS II, launched from the NOAA RV GUNTER, is used in the Gulf of Mexico for close approaches to whales for tag attachment, biopsy samples, and identification.

The USGS Great Lakes Science Center operates four research vessels: KIYI, GRAYLING, KAHO, and MUSKY II. The 107-foot KIYI, acquired in 1999 at a cost of $3.3 million to replace the SICOWET, is the newest vessel in the Center's fleet.[23-25] The vessel conducts fish research primarily in Lake Superior, including trawling, gill netting, and plankton collections. The vessel carries a crew of four and one biologist or technician. The vessel also collaborates with Canada's Ontario Ministry of Natural Resources to conduct fish assessments in Ontario waters of Lake Superior.[23,25]

The 77-foot GRAYLING, built in 1977, conducts fish population and habitat assessment primarily at Lake Huron using bottom and midwater trawls, gill nets and acoustics. The vessel is also used in Lake Michigan for similar purposes. The vessel carries a crew of two and one biologist or a technician. There are no plans for the replacement of the GRAYLING, and it is expected to have 20 to 25 years of service life remaining.[23]

The 65-foot KAHO, built in 1961, conducts fish population research on Lake Ontario in close coordination with the New York State Department of Environmental Conservation.[25] The vessel frequently operates in eastern Lake Ontario, but also collaborates with Canadian authorities in research conducted in Canadian waters of Lakes Ontario, Huron, and Superior. Currently there are no plans for replacing or refitting the KAHO.

The 45-foot MUSKY II, built in 1960 and overhauled in 1986, is the smallest of the larger than 25-foot vessels operated by the USGS Great Lakes Science Center. The vessel conducts fish habitat surveys in the western basin of Lake Erie.[25]

The USGS Coastal Marine Geology Program at the Woods Hole Center operates the 25-foot research vessel RAFAEL.[26] The RAFAEL has nearshore geophysical surveys capabilities, including high-resolution sub-bottom profiling, sidescan sonar, and multibeam echo-sounding. A commercial-grade trailer permits the transport of the RAFAEL to remote locations.

The 50-foot G.K. GILBERT, built in 1993, is a shallow-draft vessel equipped with Hamilton jets capable of conducting seismic surveys in shallow water with little noise interference.[27] The vessel is kept at the waterfront facilities of Eckerd College in St. Petersburg, Florida.

The oldest vessel in the USGS inventory, and probably one of the oldest research vessels in operation in the nation, is the 96-foot POLARIS. USGS acquired this 1927-built former yacht in 1966 and uses it primarily for water quality studies.[28] The POLARIS completes several water and sediment sampling cruises per month on San Francisco Bay. The samples collected are analyzed at USGS labs in Menlo Park, California.

The 42-foot KARLUK, an ice-strengthened vessel, provides USGS with light Arctic-survey capabilities.[29] The vessel has an endurance of 14 days to a month and an operating range of about 900 nautical miles. The USGS Western Region Coastal and Marine Geology program operates the KARLUK.[30]

## 4.2.3.6 U.S. Environmental Protection Agency Vessels

EPA's fleet consists of five research vessels that range in length from 32 to 180 feet. Three of the vessels (LAKE GUARDIAN, LAKE EXPLORER, and MUDPUPPY) operate in the Great Lakes. The other two vessels (PETER W. ANDERSON and LEAR) are based in the Mid-Atlantic region. This small fleet provides the agency with platforms from which to conduct monitoring and investigation in support of the agency's mission in the Great Lakes and Atlantic region. EPA does not have similar facilities on the West Coast.

The 180-foot LAKE GUARDIAN is the largest EPA vessel, and is the only self-contained, nonpolluting research ship on the Great Lakes. EPA's Great Lakes National Program Office operates this vessel. The vessel spends approximately 120 days per year away from its homeport of Bay City, Michigan. The LAKE GUARDIAN has an operating range of 8,650 nautical miles, is capable of staying at sea up to 30 days, and can accommodate up to 27 scientists. The vessel is 20 years old, and its replacement is not anticipated for 30 years. There is no replacement plan, but the cost to replace the vessel would be approximately $35 million.

The second largest EPA vessel in the Great Lakes is the LAKE EXPLORER.[31] This 82-foot vessel is a former USCG POINT-Class Cutter built in 1963 and operated by the EPA Mid-Continent Ecology Division. The vessel complements the mission of the LAKE GUARDIAN, and has been used in Lake Superior to support EPA's Environmental Monitoring and Assessment Program (EMAP). The vessel can accommodate 10 crew and scientists. With a cruise speed of 18 knots, and capability of 24 knots during short periods, the LAKE EXPLORER is one of the fastest research vessels in the Great Lakes.

The third EPA vessel in the Great Lakes is the MUDPUPPY, a 32-foot flat-bottom boat built in 1985 specifically designed for sediment sampling in shallow rivers and harbors in and around the Great Lakes. It is equipped with a vibro coring unit for the collection of cores up to 15 feet. Each year the MUDPUPPY is deployed an average of 50 days from mid-April until early-November. The vessel has an expected remaining service life of more than 10 years, and its current replacement cost is approximately $200,000.

The 165-foot PETER W. ANDERSON is an ocean survey vessel owned by EPA headquarters, and used by several EPA region offices. The vessel is a former Navy ASHEVILLE-Class patrol combatant built during the 1960s. Its homeport is Baltimore, Maryland, and it operates approximately 120 days a year along the Atlantic coast, although on occasion it conducts missions in the Caribbean and the Gulf of Mexico. The vessel has an endurance of 6 to 10 days depending on speed, and can carry 15 crew members and 17 scientists. Replacement plans for the vessel are under development. The cost of replacement is estimated to be $10 to 15 million.

The second EPA vessel in the Mid-Atlantic region, and smallest, is the 35-foot LEAR.[32] This vessel is a twin-engine Bertram boat owned and maintained by the EPA Region 3. The vessel is used for water and benthic sampling, fish studies, and diving along the Atlantic coast from New Jersey to Virginia.

## 4.2.4 State Vessels

State government agencies own and operate at least 50 vessels (Supplement 4-5 provides a list of state vessels). More vessels likely exist, but only about a third of the states provided data. The Great Lakes has the highest number of vessels (31 vessels), including 13 Canadian vessels that frequently participate in joint U.S.-Canada research and monitoring programs. Even without the Canadian vessels, the Great Lakes region has about twice as many vessels as the Mid-Atlantic region, which has seven vessels. No vessels were identified for the Caribbean, Gulf of Mexico, or Western Pacific regions, but this is expected to be an undercount. Some state-owned vessels operate under the jurisdiction of state universities and are tabulated as academic vessels.

The average vessel used by state government agencies is 51 feet long and 29 years old. Not including a 147-foot Canadian vessel, only two state vessels were greater than 100 feet. These vessels were the 110-foot MEDEIA, operated by the Alaska Department of Fish and Game, and the 110-foot PALMETTO, operated by the Marine Resources Research Institute, South Carolina Department of Natural Resources.

The usual role of state vessels is protection and monitoring of the state's natural resources. They are typically equipped with water quality and sediment sampling instrumentation, and also conduct fisheries studies including, but not limited to, plankton sampling and bottom and midwater trawling.

The newest known state agency vessel is the 62-foot FIRST STATE, built in 2002, and operated by the Delaware Division of Fish and Wildlife. This aluminum vessel accommodates a crew of five fisheries scientists, and operates in shallow waters at relative high speeds (more than 20 knots).

A typical state vessel is the 51-foot KERHIM operated by the Maryland Department of Natural Resources. The vessel, built in 1980, collects water and sediment samples in the Chesapeake Bay, supports fisheries investigations, and conducts geological mapping of estuaries and the continental shelf outside of Ocean City, Maryland. The vessel has a range of 220 nautical miles and is equipped to deploy instrumentation. The vessel has two diesel generators: a 15 KW with 220/100 VAC single phase and a 21.5 KW 110 VAC three-phase. USGS and U.S. Navy NRL researchers frequently charter the KERHIM for investigations in the Chesapeake Bay region.

### 4.2.5 Commercial Vessels

A total of 141 commercial vessels were identified that support ocean and coastal research monitoring and exploration activities (see Supplement 4-6 for a list of commercial vessels). This group of vessels range from those based in the Gulf of Mexico region that conduct geophysical survey activities in support of offshore oil and gas industry, to fishing vessels available for lease or charter that have been modified to support oceanographic investigations. The Gulf region has almost 40 percent of the commercial vessels identified, with all of them supporting oil and gas industry. Another third of the vessels are located in the Northeast region. In the Northeast, the vessels are mostly former fishing vessels. The value provided by the commercial vessel fleet is that they provide an opportunity for institutions that cannot afford the capital investment and maintenance cost of a research vessel to access a facility for the purpose of conducting research work.

Some commercial vessels have unique capabilities. For example, the 86-foot MARITIME MAID, built in 1971 as a fishing vessel, has a helicopter deck and has been used by federal and state agencies in the Alaska region to support monitoring activities.[33]

The 52-foot SHANA RAE is a typical example of a fishing vessel converted for use as a commercial coastal research vessel. This vessel was a former salmon tender built in 1980 that has been used as a commercial research vessel since 1986.[34] The vessel operates along the central California coast and is frequently chartered by academic and federal agencies. The vessel navigation equipment includes aircraft VHF, Weatherfax, 48-mile radar, and differential GPS plotter. The SHANA RAE has a mini-dry lab to help process samples. The vessel has a 1,500 nautical mile range and an endurance of 10 days.

## 4.3 Underwater Vehicles

During the last two decades, the nation's inventory of underwater vehicles used for research, exploration, and monitoring has changed considerably in composition and capabilities. For the purpose of this Appendix, underwater vehicles include manned submersibles, remotely operated vehicles (ROVs), towed vehicles (TOVs), and autonomous underwater vehicles (AUVs). Underwater vehicles do not include atmospheric diving suits used to conduct deep-water dives, nor do they include U.S. Navy deep submergence rescue vehicles and submersibles used for tourism.

### 4.3.1 Manned Submersibles

Since the early 1980s, the number of manned submersibles that operates in U.S. waters has slightly decreased. In 1981, in a report titled *Technology and Oceanography: An Assessment of Federal Technologies for Oceanographic Research and Monitoring*, the former U.S. Office of Technology Assessment identified 23 manned submersibles in operation in the nation's waters.[35] The federal government owned 5 of these submersibles, academic institutions owned 4, and the commercial sector owned the other 14.

Today, approximately 20 manned submersibles are available for operation in the nation's waters. Two are owned by the federal government, six are owned by academic institutions, and the commercial sector owns the rest (Table 4-5). The commercial inventory includes seven submersibles owned and operated by Nuytco™ Research Ltd., a company based in Vancouver, Canada. These Canadian manned submersibles regularly operate in the nation's water under contract with the federal government, local jurisdictions, commercial firms, and academic institutions.[36]

To facilitate the discussion of the submersible capability, the inventory was sorted by operation depth as shallow waters (less than 500 feet), mid-waters (up to 10,000 feet), and deep waters (greater than 10,000 feet). When the U.S. Navy decommissioned the deep submergence vehicle 4 (DSV 4) SEACLIFF submersible in the late 1990s, the nation lost its capability to reach a 20,000-foot depth with manned submersibles, which represents access to 98 percent of the ocean floor. In contrast, Japan, Russia, and France have manned submersibles with 20,000-foot depth operational capabilities.

### 4.3.1.1 Shallow-Water Manned Submersibles

The two shallow-water manned submersibles identified in Table 4-5 are the Carolyn and the Dual Deep Worker. The Texas A&M Institute of Nautical Archaeology (INA) owns and operates the Carolyn. The Carolyn is a Seamobileä model submersible built by SEAmagine Hydrospace Corporation, a California-based company. INA acquired the two-person Carolyn in 2000 to conduct surveys of archaeological sites. The submersible has been successfully used during various expeditions in the Mediterranean Sea. The Dual DeepWorker is a recently developed manned submersible by Nuytco™. The submersible was built by joining, with a center collar, two sections of single-manned DeepWorker submersibles. The Dual DeepWorker has four penetration plates to interface electrical or hydraulic components and an external digital camera housing controlled by the pilot.[37]

### 4.3.1.2 Mid-Water Manned Submersibles

Most of the manned submersibles identified in this inventory are capable of working at mid-water depths, with 4 of them rated for depths up to 3,000 feet and 2 rated for depths up to 6,580 feet. The commercial sector owns more than half of the mid-water submersibles.

HBOI owns and operates three mid-water depth capable submersibles: Clelia, Johnson-Sea-Link I (JSL I) and Johnson-Sea-Link II (JSL II).[38] The Clelia is a PC 1204 submersible built by Perry Oceanographics in 1976 and refitted in 1992. It is equipped with a hydraulic manipulator, video and still cameras, and various sampling devices, and has logged over 1,800 dive hours.[39] The JSL I was acquired in 1971 and the JSL II in 1975. Both JSL submersibles are equipped with a forward five-inch-thick acrylic sphere that accommodates a

**Table 4-5: Manned Submersibles**

| Operation Depth Region | Submersible | Owner | Number of Submersibles | Depth Rating (ft) | Crew | Scientist | Payload (lb) |
|---|---|---|---|---|---|---|---|
| Shallow Waters | Carolyn | Texas A&M INA | 1 | 150 | 1 | 1 | 1,000 |
| | Dual DeepWorker | Nuytco | 1 | 300 | 1 | — | 250 |
| Mid-Water | Clelia | HBOI | 1 | 1,000 | 1 | 2 | 750 |
| | RS | Kokes Marine Technology | 2 | 1,000 | 2 | 4 | NA |
| | Aquarius | Nuytco | 1 | 1,200 | 1 | 3 | 100 |
| | Delta | Delta Ocenographics | 1 | 1,200 | 1 | 1 | 550 |
| | DeepWorker | Nuytco | 4 | 2,000 | 1 | — | 250 |
| | DeepWorker | DMT | 2 | 2,000 | 1 | — | 250 |
| | Deep Rover | Nuytco | 1 | 3,000 | 1 | — | 250 |
| | Johnson-Sea-Link | HBOI | 2 | 3,000 | 2 | 2 | 1,000 |
| | NR-1 | Navy | 1 | 3,000 | 11 | 2 | NA |
| | Pisces | University of Hawaii SOEST | 2 | 6,580 | 1 | 2 | 600 |
| Deep Water | ALVIN | Navy Owned; WHOI Operated | 1 | 14,764 | 1 | 2 | 1,500 |

*Most of the manned submersibles are capable of operating at mid-water depths. The only deep-water submersible, the ALVIN, cannot operate at depths of 20,000 feet, which limits its range to about 50 percent of the ocean's bottom.*

pilot and a scientist. Another scientist and a crew occupy the aft observation chamber, which is equipped with observation ports and a video monitor. Both submersibles are equipped with xenon arc lights developed by HBOI that simulate the sunlight spectrum and near daylight conditions.[38] The JSL I has logged over 11,000 dive hours and the JSL II over 8,500 dive hours.[39] The three submersibles are typically used for mid-water and benthic surveys, sampling, search-and-recovery, and environmental impact studies.

Delta Oceanographics, a Ventura, California-based company, owns and operates the Delta, a mid-water depth submersible. This submersible has logged over 5,900 dives and 7,300 dive hours during the approximately 17 years it has been in service.[39,40] The Delta has 19 view-ports, which facilitate its use as a survey platform. The Delta has been used in multiple government-sponsored projects, including NOAA's National Underwater Research Center North Atlantic and Great Lakes mission.[41]

Nuytco,™ Ltd. owns and operates six manned submersibles capable of operating at mid-water depths: four DeepWorkers, one Deep Rover, and one Aquarius.[36] The DeepWorker and Deep Rover are single-manned submersibles that have been used in multiple projects, including the NOAA/

National Geographic five-year Sustainable Sea Expedition. The Aquarius is a 1971 submersible with multiple capabilities, including a five-function, jettisonable manipulator, articulated grapple, hydraulic cutters/tools, sampling equipment, and jetting/dredging pumps. The Aquarius has conducted multiple missions, participating in a USCG survey of the JACOB LUCKENBACH wreck, which is one of the historic shipwrecks managed and protected by NOAA's Gulf of the Farallones National Marine Sanctuary. [36]

Deep Marine Technology (DMT), a Houston-based company founded in 2000, owns and operates two DeepWorker manned submersibles, one of them acquired in May 2003. The company recently used a DeepWorker, in conjunction with an ROV, to support archaeological investigations conducted in the Gulf of Mexico by Texas A&M researchers. In addition, DMT uses the DeepWorker to conduct inspections and surveys of offshore oil and gas facilities.

The only manned submersibles capable of operating independently of surface support for a relatively extended period are the privately owned U.S. Corsair RS-1 and U.S. Constellation RS-2, and the U.S. Navy-owned NR-1. Kokes™ Marine Technology, LLC, a company based in Lakewood, New Jersey, owns and operates the U.S. Corsair RS-1 and the U.S. Constellation RS-2 manned submersibles.[42] These are the nation's only two diesel electric submersibles used for research and survey work. Both 48-foot submersibles have an operational range of 400 nautical miles. They navigate at eight knots and can remain submerged for up to five days. They are made of zinc galvanized high-tensile strength steel and are equipped with two manipulator arms, two high-resolution digital video cameras, and a forward hemispherical panoramic view-port.[41]

The Navy's NR-1 craft is a one-of-a-kind, 150-foot nuclear-powered submersible.[43] Submarine Squadron TWO (Submarine Force Atlantic, U.S. Atlantic Fleet) in Groton, Connecticut, operates the NR-1. The NR-1 came into service in 1969 and is expected to be in service until 2012. In 2001, a RAND study tried to define the missions and the capabilities needed for NR-2, a putative replacement of NR-1; however, no replacement plans are known at this time.[44] The NR-1 provides a platform to conduct deep-ocean exploration, survey, and ocean engineering activities primarily in support of military operations. It also conducts special scientific missions in cooperation with academic research institutions.

The NR-1 is capable of up to 30 days of continuous submerged operations and speeds of up to 4 knots. Forty U.S. Navy personnel support the direct operations and maintenance of NR-1. At sea, the Navy Military Sealift Command-leased vessel CAROLYN CHOUEST provides towing and logistic support, in addition to laboratory facilities. The CAROLYN CHOUEST can tow the NR-1 at speeds of up to 11 knots, for operations throughout the Atlantic, Gulf of Mexico and Mediterranean Sea. In conjunction with the CAROLYN CHOUEST, the NR-1 is capable of up to 6-month extended deployments away from homeport.

In addition to its ability to maneuver precisely in the water column, the NR-1 has the unique capability of landing on the ocean bottom and rolling along the bottom using two tires mounted fore and aft. The submersible is equipped with advanced sonar systems for forward search-and-survey and side-looking bottom mapping. An extensive array of lights and cameras (still, digital, and video) provide full near-bottom electro-optical investigation capabilities. The NR-1 can recover objects using various installed systems, including a heavy capacity manipulator arm. Full recording and data storage capabilities of all camera, sonar system outputs, continuous conductivity, temperature, and sound velocity measurements allow for post mission analysis and dissemination. The NR-1 is capable of through-hull water sampling, and can install mission-specific sensors using existing through-hull penetrators for power and data, including fiber optics. Navigation capabilities are supported by fore and aft depth sounders for accurate altitude reference; GPS while on surface, and Doppler velocity log while operating near the bottom. Additional navigation reference is provided by a short baseline navigation transponder system between Submarine NR-1 and the CAROLYN CHOUEST.[42]

Examples of ocean research activities supported by the NR-1 include mapping deep-water coral reefs and archeological sites using video and sonar surveys. In addition, the NR-1 played a key role in recovery activities for the Space Shuttle Challenger and Egypt Air Flight 990 accidents.

The University of Hawaii School of Ocean and Earth Science and Technology owns and operates the 25-year-old manned submersibles Pisces IV and Pisces V.[39] Pisces V has logged over 3,150 dive hours and Pisces IV over 450 dive hours during dives that last 7 to 10 hours each. Both manned submersibles, made by International Hydrodynamics of Vancouver, Canada, are equipped with three view-ports and hull penetrators for electrical, hydraulic air, and oxygen supplies. The main difference between them is related to some of the equipment carried (e.g., type of cameras). The R/V KA'IMIKAI-O-KANALOA supports the operation of both submersibles.

### 4.3.1.3 Deep-Water Manned Submersibles

The nation's only manned submersible capable of operating in deep-water regions is the U.S. Navy-owned ALVIN. The WHOI National Deep Submergence Facility (NDSF) operates the ALVIN with support from NSF-OCE. The ALVIN submersible has a maximum operational depth of 14,764 feet with a maximum range of 5 kilometers. It has logged close to 26,000 dive hours during more than 3,700 dives that normally last between 6 to 10 hours. Its operational capabilities provide access to approximately 50 percent of the ocean floor (compared to the retired DSV 4 SEACLIFF which provided access to 98 percent of the ocean floor). The ALVIN's maximum operational depth limits research and exploration of much of the ocean's abyssal plains.

The ALVIN is equipped with a titanium pressure hull and has two hydraulic robotic arms that provide sampling and experimental gear manipulation capabilities.  A sample basket mounted on the front of the submersible can carry a variety of instruments.  Scientists can load up to 1,000 pounds of gear that may include sediment corers, temperature probes, water samplers and biological sample pumps.  The U.S. Navy-owned UNOLS R/V ATLANTIS supports the operation of ALVIN.

At the request of NSF, the Ocean Studies Board of the National Academy of Sciences  is conducting a study of the feasibility of replacing the ALVIN with a new, deeper-diving, manned submersible.  Initial replacement cost for the ALVIN is estimated at about $25 million.

## 4.3.2 Remotely Operated Vehicles

In contrast to the manned submersibles, the number of ROVs has significantly increased since the early 1980s.  The Office of Technology Assessment's 1981 report described ROVs as a "burgeoning technology… used primarily by the industrial sector… their utilization in ocean projects as practical, economic, work stations has only recently been accepted."

Today, the ROV is a well-established technology for ocean research activities. In 2002, more than 100 "work class" ROVs were in operation just within the Gulf of Mexico, not including ROVs used for research.[39]  The offshore oil and gas industry and DoD led the development of ROVs in the 1960s and 1970s.[39]  In 1980 a scientific investigation employed a commercially operated ROV for the first time to study fish in the Gulf of Mexico.[40]  Now, ROVs routinely support tasks such as surveys and inspections of offshore oil and gas platforms and public treatment outflows, and enumeration of pelagic planktonic communities.  ROVs are used frequently to complement manned submersible operations.  For example, some small ROVs can be deployed from a manned submersible, allowing the close exploration of confined sites outside of the maneuverability envelope of a larger manned submersible. ROVs provide a cost-effective research platform for many different types of ocean tasks with minimal risk to personnel.  In contrast, manned submersibles, even though they have an excellent safety record, have an inherent risk from placing a person inside an extreme environment.

A limitation of ROV technology is that the operator does not easily acquire all the information associated with the three-dimensional perception experienced by an observer inside a manned submersible.  Equipment such as sonar and specialized lasers can provide depth and size information that can partially overcome the loss associated with the two-dimensional video signal.  Another limitation of ROV technology is that with an increase in operational depth, technical problems arise, such as increase in weight and drag of the ROV tether line, that pose significant operational challenges and augment systems cost.  For example, of the 476 work-class ROVs identified, only 7 vehicles were rated for depth greater than 10,000 feet.

ROVs range from very small units with a few cubic feet of volume, to large units the size of an automobile. ROV technology has benefited from recent advances in many different fields, including increased computational capabilities, fiber optics, robotic miniaturization, and video. ROVs are designed for gathering detailed information within a relatively small area during missions that last a few hours. ROVs can be acquired as ready-to-use commercial off-the-shelf units (COTS); customized by vendors according to clients needs. In many instances they are developed in-house without major engineering capital investment. A measure of the maturity of the field is that for the last two years, private industry, professional societies, government, and academia have sponsored a very successful national ROV design-and-build competition for high school and college students.[45]

The main types of instruments in ROVs are video cameras supported by light systems that provide real-time images to operators in the support vessel. In addition to video cameras, ROVs frequently carry other instruments, such as still cameras; sonar; devices for collection of biological, chemical, and geological samples; and manipulators to conduct underwater work. Most of the new ROVs have modular designs that permit the interchange of instruments according to mission requirements and the payload capabilities of each system. In general, smaller systems are designed for shallow-water operations and are more limited in the size and number of instruments they can carry. Deep-water systems tend to be larger because they require larger motors to enable them to overcome the increase in tether drag and weight. Larger systems have greater payload capacity and can accommodate diverse sets of instrumentation.

NOAA's NURCs are an example of a major operator of ROV technology for research and exploration. For example, the North Atlantic and Great Lakes NURC started using a leased ROV in 1985 to conduct biological surveys in the Gulf of Maine.[41] The surveys' success led to the acquisition of its first ROV unit in 1988. During the last two decades, the center has leased or procured about eight different systems, including MiniRovers (Eastern Oceanics), various Phantom models (Deep Ocean Engineering) and the Kraken (Deep Sea Systems International). These ROVs have proven to be very useful for benthic and mid-water surveys. The demand for ROV use required the hiring of a full-time pilot. The center has successfully used these ROVs for research off the coast of New England and Alaska, the Great Lakes, and multiple missions abroad.

Due to their pervasive use, it is difficult to provide a detailed account of all the ROVs in operation. Instead, a few examples of ROV systems used by some major research institutions are described to provide a picture of existing capabilities. Table 4-6 provides a partial list of ROVs currently in use.

**Table 4-6: Examples of Existing ROV Systems**

| Operation Depth Region | ROV Model | Owner | Depth Rating (ft) | Weight (lbs) | Payload (lb) |
|---|---|---|---|---|---|
| Shallow-Water | Phantom 300 | North Atlantic & Great Lakes NURC | 300 | 70 | 20 |
| Mid-Water | MiniRover Mk-II | North Atlantic & Great Lakes NURC | 1,000 | 77 | 12 |
| | Phantom III S2+2 | North Atlantic & Great Lakes NURC | 1,000 | 319 | 30 |
| | RCV-150 | University of Hawaii SOEST | 3,000 | NA | NA |
| | Kraken (MaxRover MK-I) | North Atlantic & Great Lakes NURC | 3,300 | 1,750 | 50 |
| | Ventana | MBARI | 5,250 | 5,150 | 700 |
| | Deep Drone (Navy) | Navy SUPSALV | 7,200 | NA | 300 |
| | Magnum (Navy) | Navy SUPSALV | 8,200 | 3,500 | 300 |
| Deep-Water | Tiburon | MBARI | 13,123 | 7,400 | 1,100 |
| | ROPOS | Canadian Scientific Submersible Facility | 16,400 | 17,000 | NA |
| | CURV III (Navy) | Navy SUPSALV | 20,000 | 13,000 | 300 |
| | Jason II/Medea | WHOI | 21,325 | 7,260 | NA |

*The nation has a robust ROV fleet that is capable of operating anywhere from shallow- to deep-water environments.*

## 4.3.2.1 Shallow-Water Remotely Operated Vehicles

Shallow-water ROVs are mostly low-cost, lightweight ROVs of about 100 pounds with operational capabilities limited to depths of a few hundred feet. These shallow-water ROVs can be acquired as COTS items, and frequently they can be customized by the vendor according to user requirements. The small size and power capabilities of these ROVs limit the number and type of instruments they can carry, but facilitate their deployment from small vessels with minimal equipment and personnel support. An example of a shallow-water ROV is the Phantom 300. This ROV, the smallest available at the North Atlantic and Great Lakes NURC, provides an ideal platform for relatively shallow water (under 300 feet).[46]

## 4.3.2.2 Mid-Water Remotely Operated Vehicles

Three other ROVs used at the North Atlantic and Great Lakes NURC are the MiniRover MKII, Phantom III S2+2 (P3S2), and the Kraken.[47] The MiniRover MKII has custom skid and framework around the vehicle that can accommodate a variety of sampling systems. This ROV can operate in currents up to one knot. The P3S2 is a larger ROV that is very adaptable due to its open frame design and high output thrusters. The P3S2 has similar operational depth as the MiniRover MK II, but can operate in currents up to two knots. The Kraken is a commercial Max ROVER Mk-I ROV. The Kraken has an open-frame design, which facilitates the installation of additional science equipment, and can conduct multiple types of sampling on a mission. This vehicle can maneuver in currents up to two knots. This combination of ROVs provide the North Atlantic and Great Lakes NURC with research flexibility.

The University of Hawaii School of Ocean Science and Technology operates the RCV-150. This ROV is approximately 20 years old, making it one of the oldest ROVs in service. Color video and a single manipulator is standard equipment on the RCV-150. This ROV is frequently used in joint missions with the Pisces manned submersibles.

On the West Coast, MBARI probably has the most sustained research ROV operations in the nation. The institute operates two ROVs: the Ventana and the Tiburon. The Ventana ROV logged over 1,500 dives by 1998, 10 years after it arrived in MBARI, at a rate of about 3 dives per week.[48] By June 2001, the Ventana reached the 2,000-dive mark, accumulating 8,920 hours of exploration.[49] The Ventana has been used for many purposes, including mid-water and benthic water surveys; collection of biological, chemical, and geological samples; and deployment and retrieval of scientific instrumentation.

The U.S. Navy operates various ROVs under the Office of the Director of Ocean Engineering, Supervisor of Salvage and Diving (SUPSALV).[50] These ROVs support Navy's salvage operations. The U.S. Navy's standard mission does not include research, exploration or monitoring activities. Some of the SUPSALV ROVs are standard COTS units; however, the Deep Drone, Magnum and CURV III provide some important capabilities. The Deep Drone is designed for deep-ocean recovery. It has a 3,200-pound lift capacity and can carry 300 pounds of payload. The Deep Drone is equipped with two manipulators and multiple still and video cameras. The Magnum is an ROV designed to operate in high current systems and capable of a depth of 8,200 feet. It is deployed within a protective cage. Once the ROV reaches the target area, the Magnum is released from the cage and stays connected with a tether line. The Magnum has 8,000-pound lift capacity and can carry a 300-pound payload.

### 4.3.2.3 Deep-Water Remotely Operated Vehicles

Deep-water ROVs are larger and heavier than shallow-water and mid-water ROVs, sometimes exceeding 10,000 pounds. Their larger size requires more complex and heavier support operations, but provide greater flexibility for instrumentation integration. Only four systems were identified: Tiburon, ROPOS, CURV III, and Jason II/Medea.

In 1996, MBARI built the Tiburon, a 13,123-foot depth-capable ROV as a complete in-house project. The ROV operates from the swath RV WESTERN FLYER. Tiburon is a mission-flexible platform with a variable buoyancy system capable of conducting deep-water surveys; deploying, servicing and retrieving instruments and tools; and collecting biological, chemical and geological samples.[51]

ROPOS (Remotely Operated Platform for Ocean Science) is a Canadian deep-water-capable ROV, built by International Submarine Engineering and operated by the Canadian Scientific Submersible Facility that has supported multiple NOAA and academic missions.[52] For deep-water operations, the vehicle is lowered as a caged ROV system. Once it reaches target depth, the ROV is released from the cage using a 1,000-foot tether. For deep-water missions, the ROV's large size requires a support vessel with on-deck equipment capable of lifting 14 tons or more.

The CURV (Cable-controlled Undersea Recovery Vehicle) III provides deep-water ROV capabilities to the U.S. Navy SUPSALV office. The CURV III is rated for 20,000-foot depths and weighs 13,000 pounds. This ROV has a 2,500-pound lift capacity, can carry 300 pounds of payload, and is equipped with multiple video and still cameras and two manipulators.

The WHOI Deep Submerge Laboratory, a leading center for the development of underwater vehicle technology, developed the Jason II/Medea system in 2002.[53] NSF has provided support for Medea and for the development of Jason II, a replacement of Jason I. The Jason II/Medea is a 21,325-foot depth, dual ROV system that is lowered as a single unit to target depth, where Jason II is decoupled from Medea. The system has multiple optical sensors, sonars, and manipulators, and can support additional scientific instrumentation.

In addition to the institutions mentioned above, other institutions known to have well-established ROV systems include Harbor Branch Oceanographic Institute, the University of Southern Mississippi, and the Massachusetts Institute of Technology (MIT).

## 4.3.3 Towed Vehicles

TOVs include any submerged or surface vehicle that can be towed from a moving vessel and that is used to acquire data. TOVs cover large areas, sometimes hundreds of nautical miles, during missions that can last days. Some TOV vehicles, like many COTS, tow side-scan sonar systems and have very specific missions. Others have a modular design and allow customization with different instruments according to mission needs. Some TOVs are equipped with video cameras and optical sensors used to collect information on plankton communities and ocean colors. Others can collect water samples or record information on the ocean's chemical (e.g., dissolved oxygen) and physical parameters (e.g., temperature and salinity). TOVs' depth of operation can range from near surface waters to 20,000 feet.

As with ROVs, it would be impractical to try to list all TOV systems in place. Instead, examples of TOVs used by the U.S. Navy and at two major academic institutions (WHOI and University of Hawaii's School of Ocean and Earth Science and Technology, or SOEST) are described to provide a picture of existing capabilities. Because information was not available on the depth capabilities of all TOV systems discussed, this information is not presented.

The U.S. Navy's Naval Oceanographic Office (NAVOCEANO) tows specialized sampling equipment from its eight deep-draft, ocean-going survey ships. This equipment includes the TOWed Defined EXcitation (TOWDEX) bioluminescence system; the Towed Ocean Survey System (TOSS); and various COTS towed side-scan sonar (i.e., Seamap, Klein 5500, Klein 2000, Klein 3000, and Benthos 1502). The TOWDEX is a shallow-water towed photometer sensor that continuously measures bioluminescence at speeds up to 10 knots, while computer-operated movable wings control operational depth.[54] Auxiliary instruments include an in-situ fluorometer, transmissometer, a spectral absorption attenuation meter, and sensors for temperature, conductivity, dissolved oxygen, and pH. TOSS is a submersible for general ocean exploration and bottom mapping used for high-resolution optical and acoustic surveys at multiple depths.[55] This TOV, developed by WHOI Oceanographic Systems Laboratory, can be towed very close to the bottom.

The Argos II and the DSL-120A are both deep-water-capable TOVs operated by WHOI NDSF with financial support from NSF OCE. Argos II is a 9-year-old, near-bottom towed imaging and mapping vehicle. It carries cameras and several acoustic sensors. The DSL-120A is a two-year-old TOV equipped with two side-scan sonars used to measure ocean bathymetry.

The Hawaii Mapping Research group of the University of Hawaii SOEST operates the MR1, a shallow-towed side-scan sonar system that collects bathymetry and imaging data.[56] The system is capable of producing up to a 25-kilometer-wide swath at 9 knots. An improved version, the IM12, is in the final stages of development. The IM12 has a modular design, new electronics, and a new tow-body. In 2002, NSF provided funds to build and operate the IMI-30, a deep-towed 30 kHz phase-difference bathymetric side-scan sonar. The system will acquire side-scan sonar images, phase difference bathymetry, and multibeam sub-bottom data. The system is designed to be portable, with the capacity to operate from UNOLS Class I or II vessels.

### 4.3.4 Autonomous Underwater Vehicles

AUVs include unmanned vehicles designed to operate without being tethered to a support vessel. AUVs can be navigated by pre-programmed instruction or by remote telemetry (e.g., radio signals). In 1981, Office of Technology Assessment identified only five untethered vehicles: two of them with the U.S. Navy and the other three (in development stages) with two academic institutions. By 1999, at least 12 AUVs were operational and 21 more were in various stages of research and development.[57] Today, the exact number of AUV units is unknown, but it is expected to have significantly increased since

1999, since COTS units are available from commercial enterprises dedicated to AUV technology. Table 4-7 lists some examples of AUVs currently in use.

Examples of academic institutions with well-established AUV research and development programs are MIT, Florida Atlantic University, the University of Washington, and WHOI. Work at some academic institutions has fostered the development of AUV private-sector enterprises, including Bluefin Robotics, Hydroid Inc., and the Autonomous Undersea System Institute (AUSI).[a]

**Table 4-7: Examples of Existing AUV Systems**

| Operation Depth Region | AUV Model | Owner | Depth Rating (ft) | Weight (lbs) |
|---|---|---|---|---|
| **Shallow-Water** | AutoCat | MIT | Surface | NA |
| | REMUS | Hydroid Inc | 330 | < 80 |
| | Fetch[2] | Sias Patterson | 500 | 160 |
| **Mid-Water** | Seahorse | Navy | 1,000 | 9,858 |
| | Ocean Voyager II | Florida Atlantic University | 1,968 | NA |
| | Ocean Explorer | Florida Atlantic University | 1,968 | NA |
| | Seaglider | University of Washington | 3,300 | 115 |
| | Solar AUV | AUSI | 3,300 | 880 |
| | Slocum | Rutgers University | 5,000 | NA |
| | Hugin 300 | C&C Technologies | 10,000 | NA |
| **Deep-Water** | Caribou (Odyssey III) | Bluefin Robotics | 14,760 | 881 |
| | ABE | WHOI | 20,000 | NA |

*The number and type of AUV systems has increase dramatically in the last several decades. The current inventory is capable of operating anywhere from shallow- to deep-water environments.*

Bluefin Robotics, established in 1997 by a core team from the MIT AUV Lab, manufactures AUVs for shallow- to deep-water environments.[58] Bluefin AUVs are modular and can range in size from 3 to 16 feet in length and 12 to 21 inches in diameter, depending on the payload configuration. Hydroid Inc. builds AUVs developed by WHOI under a license agreement, while AUSI is a nonprofit AUV research institute established in 1996 that originated from the Marine Systems Engineering Lab at the University of New Hampshire.[59] AUSI developed a new solar-powered AUV design that recharges its batteries during the day while afloat. A private contractor is building two of these solar AUVs for the U.S. Navy.

[a] *Wernli (2002) provides a more detailed review of the commercialization of AUV technology.*

### 4.3.4.1 Shallow-Water Autonomous Underwater Vehicles

Shallow-water AUVs tend to be light-weight vehicles designed to operate near coastal systems. Their light weight and smaller size place some constraints on the instrumentation they can carry and the length of their missions. Of the three AUVs identified in this section, one is the product of an academic institution, and two are currently available as COTS units.

The MIT AUV Lab, in collaboration with Sea Grant, developed the Autonomous Surface Craft line of AUVs. The MIT Sea Grant started its AUV collaboration during the early 1990s.[60] The latest Autonomous Surface Craft is the AutoCat, a catamaran craft designed to perform shallow hydrographic surveys. In late 1997 this AUV completed a survey of Boston Harbor.

Two commercially available shallow-water AUVs are REMUS and Fetch[2]. REMUS is a low-cost, small AUV developed by the WHOI Oceanographic Systems Laboratory for coastal monitoring.[61] Hydroid Inc. is producing the REMUS AUV through a licensing agreement with WHOI, building more than a dozen units to support WHOI's Very Shallow Water Mine Counter Measures activities. Because of its small size, a two-person team operating from a small boat can hand-deploy a REMUS AUV.

Fetch[2] is a patented AUV built by Sias Patterson Inc. In 2002 Sias Patterson delivered its first AUV to be used on a U.S. Navy NLR research cruise in the Gulf of Mexico.[62] This AUV has an endurance of 8 to 12 hours, depending on speed, and an approximate range of 50 nautical miles.

### 4.3.4.2 Mid-Water Autonomous Underwater Vehicles

Midwater AUVs typically are larger and have a longer endurance and range than shallow-water AUVs. Some systems have operating ranges in the thousands of miles and can conduct missions that last months. These AUVs are especially well suited for investigations of ocean areas outside of the operational range of most surface vessels or manned submersibles, such as the polar regions.

The U.S. Navy leads the federal government in the use of AUV technology. Currently the U.S. Navy is using the mid-water-capable Seahorse AUVs, which are fully autonomous, for the collection of high-quality data in the littoral regions of the world. These AUVs are intended to operate primarily from the U.S. Navy's T-AGS 60-class ships, but can operate from shore or other platforms. The Seahorse AUVs have 72 hours of endurance and a range of 300 nautical miles.

The Department of Ocean Engineering at Florida Atlantic University has two lines of midwater AUVs: Ocean Voyager II and Ocean Explorer.[63] The Ocean Voyager II is an AUV that started as a 1992 project by a group of senior students and became operational in 1994. The Ocean Explorer is a line of AUVs with modular construction to facilitate interchange of instruments according to mission.

The University of Washington's Applied Physics Laboratory (APL) began its AUV research during the 1950s.[64] In collaboration with its School of Oceanography, it developed the Seaglider line of AUVs. The Seaglider collects ocean profile information (e.g., CTD and oxygen concentration) during dives and transmits it to shore in near-real-time using satellite communication from the surface. On the surface, the Seaglider also can receive new operational instructions via satellite communications. At slightly over 100 pounds, the Seaglider is a relatively light AUV that can be deployed from small vessels with minimal support equipment. The Seaglider can operate for up to 6 months, conduct about 500 vertical profiles to depths of more than 3,000 feet, and cover over 6,000 kilometers.

Three other examples of mid-water commercial AUVs are the Solar AUSI, Slocum, and Hugin 3000. Falmouth Scientific Inc., a subcontractor of AUSI, is currently building two Solar AUSI AUVs for the U.S. Navy Office of Naval Research. These solar-powered AUVs are expected to be operational by the end of the summer of 2003.[65] The Rutgers Coastal Ocean Observatory Lab (COOL) operates a Slocum Glider AUV, built by Webb Research Corporation.[66] The Slocum has an estimated operational range of 1,500 kilometers. Rutgers University and Webb Research have plans for an operating fleet of four Slocum Glider AUVs supporting COOL. In late 1999, C&C Technologies acquired a Hugin 3000 AUV to support world-wide surveys.[67]

#### 4.3.4.3 Deep-Water Autonomous Underwater Vehicles

The MIT lab developed the Odyssey line of AUVs that included the Caribou model, or Odyssey III (built by Bluefin Technologies). The Caribou, the latest Odyssey AUV, is a modular AUV that has an operational depth of 10,000 feet and 20 hours of endurance at 3 knots. Other previous models in the Odyssey line include the Xanthos (Odyssey IId), which has over 500 successful dives.

The Autonomous Benthic Explorer (ABE), developed in 1993 by WHOI, is considered a true robot capable of moving at predetermined depths, performing specific maneuvers, taking photographs and collecting various samples.[68] Collected data are downloaded at the end of each mission after the AUV is recovered. There are plans for the development of sleep modes that will allow ABE to dock to a submerged station to download information and stay in standby mode between missions. The ABE AUV can conduct dives that last from 6 hours up to a year with 4 to 100 active hours.

# 4.4 Research, Exploration, and Monitoring Aircraft

NOAA, NASA, DoD, NSF and DOE own and operate most of the aircraft used for ocean and coastal research, exploration, and monitoring activities. The DOI Office of Aircraft Services manages aircraft use and contracting to support its natural resources mission, including research and monitoring of coastal assets.[69] Data from DOI's MMS indicate that MMS leases 1 fixed-wing aircraft for 59 days a year to conduct bowhead whale surveys, and leases16 helicopters for 365 days a year to conduct oil and gas platform inspections.

Some states own or operate aircraft for assessment, management, and protection of natural resources including coastal and ocean areas, but information on these assets was not available. The private sector provides aircraft contracting services to federal and state agencies in support of ocean and coastal activities. Most of these commercial aircraft are not included in this report because they are not considered facilities dedicated to the direct support of ocean and coastal activities. An exception is the US LTA 138S airship owned by US-LTA Corporation. This aircraft is included because of its unique design. This non-rigid, 160-foot airship provides a slow-moving platform that has been used to conduct detailed vertical and horizontal profiling of the marine boundary layer.[70]

Aircraft that support ocean and coastal activities frequently serve as platforms for atmospheric research and monitoring purposes. The multidisciplinary use of aircraft tends to ameliorate their relatively high acquisition and maintenance costs. Recent advances in the field of unmanned aerial vehicles (UAV) may, in the near future, reduce the cost and expand the use of aircraft as platforms for research and monitoring activities.[71] A significant advantage provided by UAV over piloted aircraft is the extended mission time, which in some current systems can exceed 24 hours of continuous flying.

The sensors installed in aircraft depend on the aircraft payload capabilities, operational limitation, and mission requirements. Missions can range from a visual survey for marine biota to high-altitude remote-sensing measurements. A partial list of sensors used on aircraft is provided in Table 4-8.

## 4.4.1 National Oceanic and Atmospheric Administration Aircraft

NOAA's Aircraft Operation Center of the Office of Marine and Aviation Operation maintains and operates the NOAA aircraft fleet (11 fixed-wing and 2 rotary-wing aircraft) (Table 4-9). The fleet, based at MacDill Air Force Base in Tampa, Florida, conducts missions in support of NOAA's research and monitoring activities and other federal and academic programs.

### Table 4-8: Examples of Sensors Installed in Aircraft

| Sensors | Type | Aircraft | Mission |
|---|---|---|---|
| **AOCI Airborne Ocean Color Imager** | High altitude multispectral scanner | NASA ER-2 | Mapping of chlorophyll, suspended sediments and sea surface temperature |
| **AOL3 Airborne Ocean LIDAR** | Visible and infrared imaging spectrometer (Primary sensor) | NOAA Twin Otter<br>NASA P-3B | Ocean and coastal color studies |
| **ATM Airborne Topographic Mapper** | Combined airborne laser altimeter and GPS | NASA P3<br>NASA Twin Otters | Topography measurements (10 to 20 cm); recent investigations include measurement of sea-ice thickness, sea-surface elevations, coastal beach dynamics |
| **AVIRIS Airborne Visible and Infrared Imaging Spectrometer** | Visible and infrared imaging spectrometer | NASA ER-2<br>NASA Twin Otter | Identify, measure, and monitor constituents of the Earth's surface and atmosphere based on molecular absorption and particle scattering signatures |
| **FLOE Fish LIDAR Oceanic, Experimental** | LIDAR | NOAA Twin Otter | Experimental sensor for measurements of epipelagic fish |
| **EAARL Experimental Airborne Advanced Research LIDAR** | LIDAR | NASA Cessna 310 | New airborne LIDAR that provides capabilities to survey coral reefs, nearshore benthic habitats, coastal vegetation, and sandy beaches |
| **MAS MODIS Airborne** | Airborne scanning spectrometer | NASA ER-2 | Acquires digital imagery to help refine, develop and test algorithms for the Moderate Resolution Imaging Spectroradiometer (MODIS) |
| **ROWS Radar Ocean Wave Spectrometer** | High-range-resolution radar | NASA P3 | Airborne remote sensor used to support the development and refinement of satellite radars that measure the ocean surface |
| **SHOAL Scanning Hydrographic Operational Airborne LIDAR Survey** | LIDAR | JALBTCX Twin Otter | Coastal bathymetric mapping |
| **SRA Scanning Radar Altimeter** | Raster scanning pulsed narrow-beam radar altimeter | NASA P3 | Remote measurements of hurricane driven ocean directional wave spectra and hurricane storm surge |
| **TMS Thematic Mapper Simulator** | Digital multispectral scanner | NASA ER-2 | Simulates performance of Thematic Mappers on Landsat 4 and 5 satellites |

*Multiple sensors can be used in aircraft for remote sensing purposes. Some of the sensors are used for research, while others support operational tasks such as bathymetry mapping.*

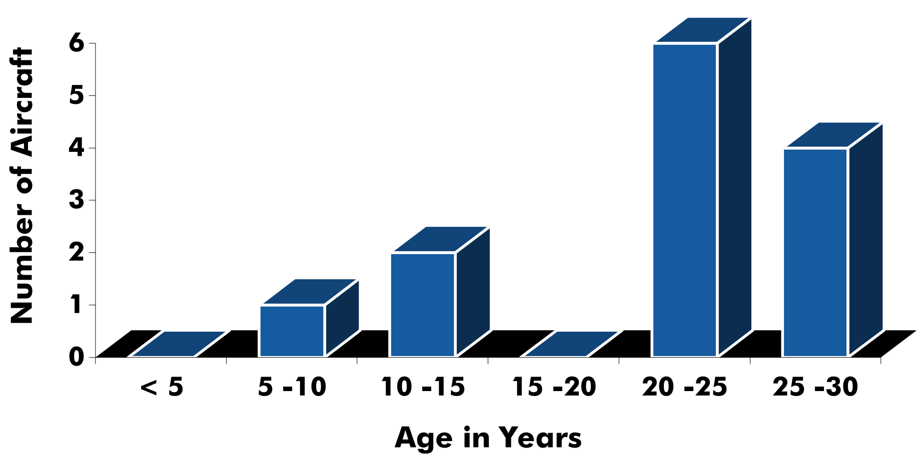
The NOAA aircraft fleet is relatively old, with an average age of 21 years (Figure 4-3), and some of the aircraft reaching the end of their service life.[72] Currently NOAA is developing a report to address its airborne platform requirements for the 10-year period of FY2003 to FY2012.

## Table 4-9: NOAA Aircraft

| Aircraft Model | Number of Aircraft | Type | Age | Ceiling (ft) | Maximum Endurance (hrs) | Mission |
|---|---|---|---|---|---|---|
| **BELL 212** | 1 | Twin engine helicopter | 23 | 12,500 | 3.5 | Costal research and assessment; homeland security |
| **Cessna Citation CE-550** | 1 | Twin engine jet | 24 | 43,000 | 5 | Mapping and charting |
| **Gulfstream IV-SP (G-IV)** | 1 | Twin engine turbo fan jet | 6 | 45,000 | 9 | Weather and climate research |
| **Rockwell Turbo Commander AC-690** | 1 | | 28 | 31,000 | 6.8 | Weather and climate research; mapping and charting; coastal research and assessment; snow surveys |
| **Lake Renegade Seawolf LA-27** | 2 | Single engine amphibious aircraft | 11 | 20,000 | 12 | Coastal research and assessment |
| **MD500** | 1 | Single engine helicopter | 23 | 16,000 | 2.8 | Coastal research and assessment; marine mammal survey, marine sanctuary overflights; ship grounding and oil spill investigations; hurricane and flood damage assessments |
| **Rockwell Aero Commander AC-500S** | 2 | Twin engine (piston) | 26 | 18,000 | 6 | Weather and climate research; mapping and charting research; coastal research and assessment |
| **Twin Otter DHC-6** | 2 | Twin engine turboprop | 22 | 25,000 | 7 | Coastal research and assessment; weather and climate research; marine mammal protection |
| **WP-3D Orion** | 2 | Four-engine turboprop | 27 | 27,000 | 11 | Weather and climate research; coastal research, ocean remote-sensing; fisheries studies |

*NOAA operates nine different aircraft models including two helicopters. These aircraft support a variety of missions that range from marine mammal surveys to atmospheric research.*

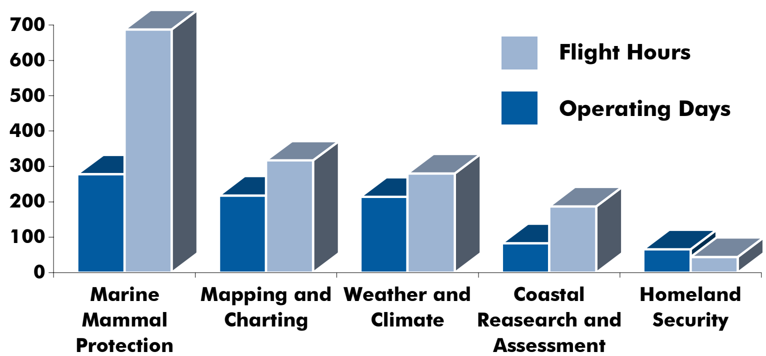
## Figure 4-3: Age Distribution of NOAA Aircraft




*More than half of NOAA's aircraft are over two decades old, with many of them reaching the end of their service life.*

During FY2002, marine mammal protection activities accounted for 278 operating days and 687 flight hours, which represent about 45 percent of NOAA's aircraft flight time (Figure 4-4). Mapping and charting, weather climate, and coastal and ocean research activities accounted for 21 percent, 18 percent, and 12 percent of the flight time, respectively. Homeland security activities required only about 3 percent of NOAA flight time. The cost of operation, maintenance (including ground facilities support) and management of all NOAA aircraft in FY2002 was $16.9 million, or approximately $11,000 per flight hour.

**Figure 4-4: FY 2002 NOAA Aircraft Allocation**




*Marine mammal protection activities account for almost half of NOAA's annual aircraft flight hours. These missions are frequently conducted from smaller aircraft, including helicopters, which fly at relative low speeds and altitudes.*

## 4.4.2 National Aeronautics and Space Administration Aircraft

NASA's fleet consists of more than 100 aircraft used primarily for aeronautical research. [73] Of these aircraft, about a dozen, including UAV, were identified through Internet searches as used to support ocean and coastal-related activities (Table 4-10). The exact number, conditions or plans for upgrades or new acquisition of NASA aircraft is unknown.

NASA operates aircraft dedicated to supporting ocean and coastal activities primarily from three centers. On the West Coast, Dryden Flight Research Center in Edwards, California, operates two ER-2, a DC 8, and various UAVs.[74] Johnson Space Center in Texas operates two WB-57 high-altitude research aircraft.[75] In the Mid-Atlantic region, Goddard Space Flight Center Wallops Flight Facility operates a P-3 Orion.[76] Wallops Flight Facility also has the AeroScience Lab, which is a facility dedicated to developing new technology in the area of UAV instrumentation and platforms, particularly within the area of atmospheric research.[71] Technology developed at this facility may be easily transferred to support ocean and coastal activities.

**Table 4-10: NASA Aircraft**

| Aircraft Model | Number of Aircraft | Type | Age | Ceiling (ft) | Maximum Endurance (hrs) | Mission |
|---|---|---|---|---|---|---|
| **DC-8** | 1 | Four-engine turbo fan jet | NA | 41,000 | 10 | Atmospheric research; remote sensing data collection; technology development |
| **P-3 Orion** | 1 | Four-engine turboprop | 25 | 27,000 | 11 | Ocean and coastal remote sensing |
| **WB-57** | 2 | Twin engine high altitude jet | NA | 60, 000 | 6.5 | Atmospheric and climate research |
| **ER-2** | 2 | Twin engine high altitude Jet | NA | 70,000 | 6.5 | Atmospheric, oceanographic, and earth sciences research |
| **Cessna 310** | 1 | Twin engine | NA | NA | NA | Coastal remote sensing |
| **Bronco OV-10** | 1 | Multipurpose twin engine | NA | NA | NA | Coastal remote sensing; technology development, Earth energy budget research |
| **Lear Jet** | 1 | Turbo fan jet | NA | 45,000 | NA | Atmospheric research |
| **Aerosonde** | | UAV | NA | 20,000 | 40 | Monitoring of coastal systems, atmospheric research |
| **Proteus** | NA | Twin engine Jet | NA | 60,000 | 18 | Earth sciences studies, weather and climate research; telecommunications relay platforms |
| **Pathfinder** | NA | UAV | NA | 71,500 | 16 | Earth sciences studies, habitat mapping (e.g., coastline and reefs), agriculture assessment; mammal movement studies |
| **Pathfinder Plus** | NA | UAV (under development) | NA | NA | NA | Earth sciences studies; weather and climate research, ocean wind vector imaging, habitat assessment |
| **Altus II** | NA | UAV Predator (civilian variation) | NA | 45,000 | 24 | Weather and climate research, including monitoring and forecasting |
| **ALTAIR** | NA | UAV Predator B (under development) | NA | 52,000 | 32 | Disaster-management; remote sensing |

*NASA uses a combination of manned and unmanned aircraft to support its research mission. These aircraft are owned or operated by NASA, under partnerships with the government or private sector.*

*NA: Information not available*

Of NASA's assets, the ER-2 aircraft provide unique capabilities, as they are civilian versions of the Air Force U2-S reconnaissance platform. The aircraft has a cruise altitude of 65,000 feet, which allows the sensors aboard to simulate sensors carried by orbiting satellites.[77] Other aircraft like the Lear jet based at Glenn Research Center in Ohio, or the OV-10 that operates from Langley, Virginia, have been used to support ocean and coastal research, but their predominant use is as a platform for aeronautical research. In addition, under the Earth Science Project Office, NASA maintains cooperative agreements with other federal agencies for the use of its aircraft.[78]

## 4.4.3 U.S. Department of Defense Aircraft

The U.S. Navy, USACE, U.S. Air Force, and New York Air National Guard use aircraft to support ocean and coastal research and monitoring activities. Frequently, activities conducted by these aircraft support ocean and coastal missions of other institutions, including federal agencies and academic research centers. The mechanism of collaboration varies, and can range from formal partnerships among institutions to providing access to instruments aboard the aircraft in support of specific research projects and sharing and exchanging data.

The U.S. Navy operates 11 aircraft (3 UAV and 8 piloted aircraft) to support ocean and coastal research activities (Table 4-11). These aircraft operate from two facilities: The Naval Research Laboratory (NRL) Flight Support Detachment at the Naval Air Station Patuxent River, Maryland, and the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) at the Naval Postgraduate School in Monterey, California. In addition, the U.S. Navy and USACE established the Joint Airborne LIDAR Bathymetry Technical Center of Expertise (JALBTCX). This center uses a contractor-supplied Twin Otter aircraft as an airborne platform for an advanced LIDAR system.

**Table 4-11: Navy Aircraft**

| Aircraft Model | Number of Aircraft | Type | Age | Ceiling (ft) | Maximum Endurance (hrs) | Mission |
|---|---|---|---|---|---|---|
| **WP-3D Orion** | 5 | Four-engine turboprop | 25 | 27,000 | 11 | Atmospheric, oceanographic, and Earth science research; technology development |
| **Pelican I Cessna 337/O-2A Skymaster** | 1 | Twin engine | NA | NA | NA | Long endurance, low altitude atmospheric and oceanographic research; technology development |
| **Pelican II Cessna 337/O-2A Skymaster** | 1 | Twin engine optionally-piloted | NA | NA | NA | Long endurance, low altitude atmospheric and oceanographic research; technology development |
| **UV-18A Twin Otter** | 1 | Twin engine turboprop | NA | 25,000 | 7 | Coastal and marine research; weather and climate research |
| **Altus ST UAV General Atomic ASI** | 1 | UAV | NA | 45,000 | 24+ | Atmospheric research; support a variety of payloads including expendable sensors |
| **Predator** | 2 | UAV | NA | 25,000 | 36 | Research and technology development platform |

*The Navy uses a combination of manned and unmanned aircraft to support its research mission.*

*NA: Information not available*

The NRL Flight Support Detachment operates five highly modified P-3 Orion turboprop airplanes. These aircraft are used for multiple research projects including mapping magnetic variation and conducting hydroacoustic measurements. These aircraft operate worldwide and annually log more than

2,500 hours of flight time supporting research conducted by the U.S. Navy and other federal and academic institutions.

The Office of Naval Research (ONR) established CIRPAS in 1996.[79] The CIRPAS facilities, located at the Marina Municipal Airport (formerly Fort Ord Frizsche Field) provide UAV flight services to the research and development community. CIRPAS operates one UAV, two manned twin-engine aircraft, and one optionally manned twin-engine aircraft (Table 4-10). CIRPAS is a unique institution because it provides a centralized repository of diverse UAV and support equipment to the ocean and coastal research community on a lease basis. CIRPAS's strategic location within the Monterey Bay area, a major center for oceanographic research, facilitates the logistic access to UAV by the research community. On September 27, 2002, UNOLS designated CIRPAS as a National Oceanographic Aircraft Facility under Annex II of the UNOLS charter.[80] This designation should further promote the use of this facility by the ocean and atmospheric research community.

JALBTCX is a partnership between USACE, the Naval Meteorology and Oceanography Command, and the NOAA National Ocean Service. The center's mission is to advance and exploit airborne LIDAR technology and to coordinate work and exchange information and expertise in this area. JALBTCX owns and operates the Scanning Hydrographic Operational Airborne LIDAR Survey (SHOALS) system. This is the most advanced airborne LIDAR bathymetric mapping system. The SHOALS system, installed on a DHC/300 Twin Otter contracted with Kenn Borek Air, Ltd., has completed over 400 project surveys worldwide. The system is planned to be replaced in FY2003 by CHART, an advanced topographic and bathymetric LIDAR system under development that will produce a high-resolution, seamless survey of the coastal zone. JALBTCX employs over 35 personnel from USACE, the U.S. Navy, NOAA, and contractors with expertise in physics, engineering, remote sensing, marine sciences, electronics, and other related professional disciplines.

The 53rd Weather Reconnaissance Squadron, a component of the 403rd Wing, located at Keesler Air Force Base in Biloxi, Mississippi, operates 10 WC-130s. The WC-130s are military transport aircraft modified for storm penetration. The squadron provides tropical disturbance and hurricane surveillance in the Atlantic, Caribbean, and Gulf of Mexico for the National Hurricane Center in Miami, Florida.[81] On occasion, the squadron conducts missions in the Pacific in support of the Central Pacific Hurricane Center in Honolulu, Hawaii. During winter, the squadron flies storm missions in both the Atlantic and Pacific in support of NOAA's National Center for Environmental Prediction. In addition to the weather reconnaissance missions, the squadron occasionally participates in ocean and atmospheric research missions, and has expertise with the deployment of drifting buoys.

The New York Air National Guard 109th Airlift Wing provides airlift support for U.S. science efforts in Antarctica under a 1998 DoD and NSF Memorandum of Agreement. The unit operates 10 ski-equipped LC-130 Hercules, and is the only unit with this capability in the world. In addition, the Air Force

Reserve Command's 4th Air Force is managing the strategic airlift missions to Antarctica for Operation Deep Freeze of the U.S. Antarctic Program until 2005. This unit currently operates C-141C aircrafts. By 2005, a new C-17 will replace the C-141C.

### 4.4.4 National Science Foundation Aircraft

NSF owns two aircraft operated by the Atmospheric Technology Division of the National Center for Atmospheric Research (NCAR): a former Air Force C-130, and a new Gulfstream V turbofan airframe currently undergoing modifications and expected to be in service by June 2005. The new Gulfstream is designated as the High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER). The HIAPER will be equipped with multiple oceanographic remote sensing instruments. NSF recently removed from service a LC-188 research aircraft that was in operation with NCAR. This aircraft had an ELDORA radar, an airborne, dual beam, meteorological research radar developed jointly by the United States and France. NSF recently transferred and installed the radar on a NRL P-3 Orion under a cooperative agreement with the U.S. Navy.

NSF supports two other smaller aircraft in operation with two academic institutions. The Donald L. Veal Research Flight Center of the University of Wyoming's Department of Atmospheric Science operates a King Air twin-engine aircraft to conduct in-situ atmospheric measurements.[82] The Institute of Atmospheric Sciences at the South Dakota School of Mines and Technology operates a T-28 under a cooperative agreement with NSF.[83] The T-28 is a single-engine, armored storm-penetrating aircraft equipped with optical sensors mounted on the wings. The T-28 is used for studies of hail formation, precipitation and storm forecasting. This unique aircraft has been used in many different national and international projects. Table 4-12 describes NSF's aircraft.

**Table 4-12: NSF Aircraft**

| Aircraft Model | Number of Aircraft | Type | Age | Ceiling (ft) | Maximum Endurance (hrs) | Mission |
|---|---|---|---|---|---|---|
| **HIAPER Gulfstream V** | 1 | Twin engine turbo fan jet | NA | 51,000 | NA | Atmospheric, oceanographic, and Earth science research; technology development |
| **EC-130Q** | 1 | Modified C-130 | NA | 27,000 | 10 | Atmospheric and oceanographic research; supports oceanographic droposonde dispensing |
| **KA B2000T** | 1 | Twin Engine turboprop | NA | 30,000 | 5 | Atmospheric research |
| **T-28** | 1 | Single engine armored | > 30 | 23,000 | 2 | Atmospheric research |

*Aircraft owned or operated by NSF under partnership with academic institutions and used to support ocean and coastal activities.*

*NA: Information not available*

### 4.4.5 U.S. Department of Energy Aircraft

DOE operates one Gulfstream (G1) twin-engine turboprop owned by Batelle. The aircraft, based at the DOE Pacific Northwest National Laboratory, has been used as an atmospheric research airborne platform during national and international multidisciplinary projects since 1988.[84] The aircraft has an operational ceiling of 45,000 feet and a maximum endurance of 9 hours. This aircraft recently participated in a New England air quality study conducted in coordination with NOAA RV RON BROWN.

## 4.5 Satellites and Space-Based Sensors

The use of satellites for ocean research, exploration, and monitoring is a relatively young discipline. Seasat-A, launched on June 26, 1978, was the first satellite dedicated to ocean research. The purpose of the mission was to demonstrate techniques for global monitoring of the oceans, to collect oceanographic data, and to determine needed features of an operational ocean-dynamics monitoring system.[85]

Today, the United States has satellites that support both ocean and coastal research and operational activities. NASA has responsibility for research satellites (e.g., measurements of ocean color as a proxy of biological activity) while NOAA, DoD, and USGS are in charge of operational satellites (e.g., weather prediction). The National Academy of Science is conducting a study of the opportunities to expedite the transition of remote-sensing technological advances to operational status.[86]

### 4.5.1 Research Satellites

Even though remote sensing has proven to be a powerful tool, NASA has just 10 satellite missions in operation dedicated to ocean research (Table 4-13). At least two of these missions may not continue beyond FY2003. Two new research satellites are expected to be launched by 2006. Some ocean remote-sensing research activities are actually conducted using data from sensors aboard operational satellites, including recent advances in the use of GPS signals to infer sea state and wind speed.[87] A few research missions rely on international partnerships either for instrumentation or spacecraft platform. In addition, the United States relies on European satellites (ERS-1 and ERS-2); a Japanese satellite (JERS-1), and a Canadian satellite (RADARSAT-1) for Synthetic Aperture Radar data.

TOPEX/Poseidon, the oldest satellite in operation used for ocean research, is a joint mission between NASA and the French Centre National d'Etudes Spatiales (CNES). The mission, launched in August 1992 with a planned service life of three years, continues to provide high-quality altimetry observations of the sea surface. The accurate measurement of ocean altimetry is fundamental to the study and understanding of ocean circulation. Each orbit repeats within 1 kilometer approximately every 10 days. The accuracy of TOPEX/Poseidon sea surface topography observations (7 by

7-kilometer resolution) is 2 to 3 centimeters. In August 2002 the TOPEX/Poseidon spacecraft was moved to a slightly different orbit to create, in association with the Jason spacecraft, the first wide-swath altimeter.

**Table 4-13: NASA Research Satellites in Service**

| Mission | Launch Date | EOL Date | Instruments | Ocean Color | SST | Ocean Circulation | Wave Hieghts | Surface Winds | Sea Ice | Land Cover Wetlands |
|---|---|---|---|---|---|---|---|---|---|---|
| **Topex/ Poseidon** | Aug 92 | Depends on Funding | POSEIDON 1 | | | • | | | | |
| | | | TOPEX | | | | • | • | | |
| **SeaStar** | Aug 97 | Depends on Funding | SeaWiFS | • | | | | | | |
| **QuikSCAT** | Jun 99 | Depends on Funding | Sea Winds | | | | | • | | |
| **TRMM** | Nov 97 | Dec 04 | TMI | | • | | | | | |
| **Terra** | Dec 99 | Dec 05 | MODIS | • | • | | | | | • |
| **Jason 1** | Dec 01 | Dec 04 | POSEIDON 2 | | | • | | | | |
| **GRACE** | Mar 02 | Mar 07 | GRACE | | | • | | | | |
| **Aqua** | May 02 | May 07 | MODIS | • | • | | | | | • |
| | | | AMSR E | | • | | | • | • | |
| **ADEOS-2** | Dec 02 | Dec 05 | SeaWinds | | | | | • | | |
| **ICESa** | Jan 03 | Dec 06 | GLAS | | | | | | • | |

*In addition to these 10 research missions, 2 other missions are expected to launch within the next 5 years.*

The Sea-viewing Wide Field-of-View Sensor (SeaWiFS), launched on the SeaStar/OrbView-2 satellite, is the first ocean color-measuring satellite in operation since the end of the Coastal Zone Color Scanner Mission in 1986. SeaWiFS provides estimates of oceanic chlorophyll-a concentrations and other bio-optical parameters used to quantify phytoplankton abundance and ocean productivity. SeaWiFS has a minimum horizontal resolution of 1 by 1-kilometer, with an accuracy for chlorophyll-a data of 30 percent. Clouds and rain can, however, degrade SeaWiFS measurements. SeaWIFS data are available at 1-kilometer local and 4-kilometer global resolution. The mission is to continue until 2003; continuation of the mission beyond then depends on funding.

The QuikSCAT mission was launched in June 1999 as a quick-recovery mission to fill the gap created by the 1997 loss of the NASA Scatterometer (NSCAT), a sensor designed to measure near-surface wind speed. The QuikSCAT satellite carries the SeaWinds, a specialized microwave radar that measures near-surface wind speed and direction over the ocean under all weather and cloud conditions, although its measurements can be degraded by rain. The SeaWinds instrument on QuikSCAT is the first conically scanning spaceborne scatterometer. The accuracies of SeaWinds speed and direction measurements are about 1 meter per second and 20 degrees, respectively.

Each day the SeaWinds instrument records 25 by 25-kilometer ocean vector winds over 96 percent of the ice-free oceans, repeating the ground tracks in an approximate 4-day cycle. NOAA uses real-time QuikSCAT observations to prepare the daily weather forecast.

The Tropical Rainfall Measuring Mission (TRMM) was launched in November 1997. In addition to measuring the diurnal cycle of tropical rainfall, the TRMM Microwave Imager sensor provides the first estimate (since SeaSat in 1978) of sea surface temperature in the presence of clouds. This sensor design is based on the highly successful Special Sensor Microwave Imagers used on the Defense Meteorological Satellites. TRMM rainfall data are combined with data from the Advanced Microwave Scanning Radiometer sensor in the Aqua (discussed below) and the Special Sensor Microwave Imager sensor on the Defense Meteorological Satellites to yield daily estimates of 100 by 100-kilometer global precipitation, which is a useful parameter for studying ocean salinity and density.

Terra, launched in December 1999, is the first Earth Observing System (EOS) spacecraft. The satellite carries the Moderate-resolution Imaging Spectroradiometer (MODIS), which measures 44 parameters including near-surface ocean chlorophyll-a and sea-surface temperature with a horizontal resolution of 1 kilometer. MODIS has a 2,330 kilometer-wide viewing swath, and covers every point of the world every 1 to 2 days. The accuracy of chlorophyll measurements made by MODIS is comparable to SeaWiFS. MODIS also measures chlorophyll fluorescence to provide a better estimate of phytoplankton abundance and productivity. MODIS sea-surface temperature uncertainties are lower than those of the Advance Very High Resolution Radiometer (AVHRR) sensor on the NOAA weather satellites.

Jason 1 is a joint NASA and CNES spacecraft launched in the TOPEX/Poseidon orbit in December 2001 to continue the high-precision ocean altimetry observations made by TOPEX/Poseidon. The combined Jason and TOPEX/Poseidon observations represent the minimum attribute of a wide-swath altimeter.

The Gravity Recovery and Climate Experiment (GRACE), launched in March 2002, is an international collaboration of the United States and Germany. The instrument consists of two satellites flying in formation with GPS and microwave ranging systems onboard. The GRACE satellites measure the altitude, acceleration and distance between the two, which are influenced by the Earth's gravity field. The gravity variations can be used to infer changes in the surface and deep ocean currents. The complete gravity field can be mapped every 30 days for the expected 5-year lifetime of the mission, with a resolution of 250 to 300 kilometers. The amount of data GRACE collected in 30 days exceeded the amount of information collected during the 30 years before the mission.[88] Combining GRACE and Jason data yields subsurface heat content.

The second EOS spacecraft, Aqua, was launched in May 2002. A MODIS instrument (an improved version of the one on Terra), Aqua provides various oceanic measurements. The advanced microwave scanning radiometer sensor measures sea ice extent and rainfall, in addition to providing sea-surface temperature through most cloud cover.

Advanced Earth Observation Satellite-2 (ADEOS-2), launched in December 2002, is a joint mission between NASA and the National Space Development Agency of Japan. The first ADEOS spacecraft carried the NSCAT sensor lost in 1997. ADEOS-2 carries an advanced SeaWinds instrument, which is the only all-weather microwave radar that measures near-surface wind velocity (both speed and direction) over Earth's ice-free oceans.

The Ice, Cloud and Land Elevation Satellite (ICESat), launched in January 2003, is the latest in a series of EOS spacecraft, following the Terra satellite launched in December 1999 and the Aqua satellite launched in May 2002. The primary role of ICESat is to quantify ice-sheet growth or retreat, and to improve understanding of global climate change and changes in sea level. The laser can measure the distance from the spacecraft to the ice with a precision better than 10 centimeters and a spot resolution of 66 meters.

Two new ocean research missions are planned for the near future: Aquarius and Ocean Surface Topographic Mission (OSTM). Aquarius, scheduled to fly in 2006, will measure sea-surface salinity averaged over a spatial scale of 200 by 200 kilometers during a one-week period.

OSTM, formerly called Jason 2, is a joint mission of NASA and CNES scheduled to fly in 2005. OSTM will measure ocean-surface elevation over a 200 kilometer-wide swath to enable the mapping of mesoscale surface currents. The mission will support physical oceanography, geodesy, gravity, climate monitoring, and marine meteorology research, and will transition the measurements into an operational mode to support science and industrial applications.

## 4.5.2 Operational Satellites

The National Academy of Science defined operational satellites as those that routinely and reliably generate services and products with specific accuracy, periodicity, and format, and that make their product available to a variety of users including public, private, and academic sectors.[77] In the United States, NOAA has primary responsibility for operational satellites for ocean and coastal activities. DoD and USGS also have some ocean and coastal operational satellite capabilities.

### 4.5.2.1 National Oceanic and Atmospheric Administration Satellites

NOAA's National Environmental Satellite Data and Information Service (NESDIS) operates geostationary and polar-orbiting operational environmental satellites. These satellite systems are Geostationary Operational Environmental Satellites (GOES) for short-range warning and forecasting, and the Polar-Orbiting Environmental Satellite (POES) for long-term weather forecasting. Together, both sets of satellites provide a complete global monitoring system. NESDIS also manages the largest collection of atmospheric, geophysical, and oceanographic data in the world through the NOAA National Data Centers. In addition to the GOES and POES satellites, NOAA, NASA and DoD are engaged in a multi-billion dollar, 24-year program (1995-2018) to develop the National Polar-Orbiting Operational Environmental Satellite System (NPOESS). NPOESS satellites will replace POES and DoD's Defense Meteorological Satellite Program. Nearly a third of the NPOESS data products will support ocean-observing activities, including surface vector winds, ocean color, sea-ice edge motion and sea-ice age, sea-surface stress, sea-surface heights and topography, and wave heights at a higher resolution and decreased data latency than are currently available. The United States is in partnership with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and the National Space Development Agency of Japan to complement the NPOESS mission of providing long-term continuity of observations from polar-orbiting satellites.

GOES satellites circle the Earth in a geosynchronous orbit, which allows them to hover continuously over one position on the surface and have a full-disc view of the planet. Their position above a fixed spot on the surface permits the ability to monitor the development of severe weather conditions, such as hurricanes. The primary instruments are the Imager and the Sounder. The Imager is a multi-channel instrument that detects radiant energy and reflected solar energy from the Earth's surface and atmosphere. The Sounder provides data to determine the vertical temperature and moisture profile of the atmosphere, surface and cloud-top temperatures, and ozone distribution. The satellite sensors also detect ice fields and can be used to map the movements of ice on the sea and on lakes.

GOES satellites transmit high-resolution Imager and Sounder data signals via the GOES I-M variable data transmission format, which requires complex receiving hardware. GOES satellites also transmit low-resolution satellite images using the Weather Facsimile system, which requires low-cost hardware, and is available for users who want to establish their own direct readout receiving station. The first GOES was launched in 1975. Currently, NOAA is operating GOES-8 and GOES-10. GOES-11, launched on May 3, 2000, and GOES-12, launched on July 23, 2001, are being stored in orbit as fully functioning replacements for GOES-8 or GOES-10.

Currently, NOAA has five POES satellites: NOAA-12, and NOAA-14 through NOAA-17. NOAA-12, launched May 14, 1991, continues transmitting high resolution picture transmission data as a standby satellite. NOAA-14, launched in December 1994, is in standby mode. With the launch of NOAA-15 in May 1998 and NOAA-16 on September 21, 2000, a new series of polar orbiters with improved sensors were put in service. NOAA-15 and NOAA-16 are in operational status. The newest satellite, NOAA-17, was launched June 24, 2002.

The two POES in operational status are Advance TIROS-N satellites constantly circling the Earth in an almost north-south orbit, passing close to both poles. Operating as a pair, these satellites ensure that data for any region of the

Earth are no more than six hours old. The orbits are circular, with one satellite crossing the equator at 7:30 a.m. local time, the other at 1:40 p.m. local time. The circular orbit permits uniform data acquisition and efficient control of the satellite by the NOAA Command and Data Acquisition stations located near Fairbanks, Alaska, and Wallops Island, Virginia. Instruments onboard are able to measure many atmospheric and surface parameters. The primary instrument aboard the satellite is the Advanced Very High Resolution Radiometer (AVHRR), which is used to measure sea-surface temperature.

The POES satellite sensors transmit data to the ground via high-resolution picture transmission. A second data transmission, called automatic picture transmission, allows users who want to establish their own direct readout receiving station to receive low-resolution imagery data. It can be received with inexpensive equipment, while the high-resolution data utilizes a more complex receiver. These satellites send more than 16,000 global measurements daily via NOAA's Command and Data Acquisition station to NOAA computers, adding valuable information for forecasting models, especially for remote ocean areas, where conventional data are lacking.

### 4.5.2.2 U.S. Department of Defense Satellites

The Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC) uses data from the Defense Meteorological Satellite Program (DMSP) in order to run its atmospheric forecast models. The DMSP satellites support DoD's long-term meteorological program to collect and disseminate worldwide atmospheric, oceanographic, solar geophysical, and cloud cover data on a daily basis. The Special Sensor Microwave Imager sensor carried in these satellites is useful for investigation of sea-surface winds, rain rates, cloud vapor, precipitation, soil moisture, and ice edge and age.

### 4.5.2.3 U.S. Geological Survey Satellites

USGS and NASA operate the Landsat 5 and Landsat 7 satellites.[89] The primary sensor in both satellites is the Thematic Mapper, although Landsat 7 has an improved version called the Enhanced Thematic Mapper. The Thematic Mapper, is a multispectral scanning radiometer used for environmental monitoring, including land surface, agriculture and forestry, ice and snow cover, and disaster monitoring and assessment. Landsat 5, launched in 1984, and Landsat 7, launched in June 1999, should remain in operation at least until 2004. The Landsat series satellites, even though designed for remote sensing of land surfaces, provide valuable information on coastal systems such as estuarine wetlands. Information from these satellites help elucidate the hydrology processes occurring in estuarine systems. NASA and USGS are collaborating on a new mission called the Landsat Data Continuity Mission. This mission is expected to be launched by 2006 and will extend the 35-year Landsat data record available that started with the launch of Landsat 1 in 1972.[89]

# 4.6 Ocean-Observing Systems

The United States does not have an integrated ocean-observing system comparable to the other systems that monitor, study, and forecast weather. The infrastructure and standardized methods required for the continuous collection, analysis, and timely dissemination of ocean and coastal information to the public, policy decision makers, and research community does not exist. Independent programs, most of them still in research and development stages, provide the existing ocean-observing systems inventory. Some ocean-observing systems (e.g. Chesapeake Bay Mouth Survey Monthly) are limited to collecting periodic oceanographic samples at a few selected stations. Other systems, such as the MBARI Ocean Observing System (MOOS), encompass a combination of diverse facilities, including moorings and drifters with real-time data telemetry, satellite images, and periodic oceanographic sampling, which are supplemented with data from ROV and AUV technologies.

The federal government recognizes the need for an Integrated Ocean Observing System (IOOS) and has expressed support for establishing such a system (Senate Committee on Appropriations Report 107-218, S. 2778 and the House Armed Services Committed Report 107-436).[90] To address this need, the National Oceanographic Partnership Program (NOPP) created Ocean.US in late 2000 to coordinate the efforts for the development of IOOS.[91] IOOS has three components: global ocean systems, coastal systems, and nested regional systems. The global ocean component is part of an international effort to develop the Global Ocean Observing System (GOOS). In support of IOOS, NSF recently approved an Ocean Observatories Initiative to be funded through the Major Research Equipment and Facilities Construction (MRE-FC) account. NSF's Ocean Observatories Initiative will support the development of a network of ocean observatories. To support the IOOS effort, in January 2003 the UNOLS council formed a working group to address ocean observatory facility needs, composed of experts in the development and use of ocean-observing systems.[92]

IOOS includes both coastal and global observing systems, and defines the coastal observing systems as those systems designed to acquire data from inside the 200 nautical-mile exclusive economic zone, Great Lakes, and estuaries.[90] Global observing systems are those systems designed to collect data outside the exclusive economic zone.

## 4.6.1 Coastal Observing Systems

A total of 41 coastal observing systems were identified, primarily through the Coastal Observation Technology program web site, part of NOAA's National Ocean Service Office (Table 4-14 and Supplement 4-7).[93] This program provides grants for the development of coastal observing systems. Table 4-14 does not include all existing systems, as many new, independent systems are in various stages of research and development or implementation. For example, the development of a coastal observing system for the Great Lakes has been suggested as a fundamental need for monitoring the region.[94]

## Table 4-14: Coastal Observing Systems by Region

| Coastal Observing System | Great Lakes | Northeast | Mid Atlantic | South Atlantic | Gulf of Mexico | West Coast | Alaska | Western Pacific | Caribbean |
|---|---|---|---|---|---|---|---|---|---|
| Alliance Citizen Monitoring Program (ACMP) | | | ✓ | | | | | | |
| Gulf of Alaska Global Ocean Ecosystem Dynamics Monitoring Program Alaska (GLOBEC) | | | | | | | ✓ | | |
| Acoustic Monitoring Hydrophones (AMH) | | | | | | ✓ | ✓ | | |
| California Cooperative Oceanic Fisheries Investigations (CalCOFI) | | | | | | ✓ | | | |
| Caribbean Time Series (CaTS) | | | | | | | | | ✓ |
| Chesapeake Bay Mouth Survey Monthly CBMSM | | | ✓ | | | | | | |
| Chesapeake Bay Observing System (CBOS) | | | ✓ | | | | | | |
| Coastal Data Information Program (CDIP) | ✓ | | ✓ | ✓ | | ✓ | | ✓ | |
| West Florida Coastal Ocean Monitoring and Prediction System (COMPS) | | | | ✓ | ✓ | | | | |
| Coastal Ocean Observation Laboratory/Long term Ecosystem Observatory (COOL/LEO-15) | | | ✓ | | | | | | |
| Columbia River Estuary Real-time Observation and Forecasting System (CORIE) | | | | | | ✓ | | | |
| Deep Ocean Assessment and Reporting of Tsunamis (DART) | | | | | | ✓ | ✓ | | |
| Fisheries Oceanography Coordination Investigations (FOCI) | | | | | | | ✓ | | |
| Gulf of Alaska Ecosystem Monitoring and Research (GEM) | | | | | | | ✓ | | |
| Gulf of Maine Ocean Observing System (GOMOOS) | | ✓ | | | | | | | |
| Hawaii Ocean Time series Program (HOT) | | | | | | | | ✓ | |
| Innovative Coastal Ocean Observing Network (ICON) | | | | | | ✓ | | | |
| Indiana Coastal Information System (ICIS) | ✓ | | | | | | | | |
| Indiana Shoreline Erosion Observation System (ISEOS) | ✓ | | | | | | | | |
| Louisiana Universities Marine Consortium Environmental Monitoring (LUMCON) | | | | | ✓ | | | | |
| MBARI Observing System (MOOS) | | | | | | ✓ | | | |
| Martha's Vineyard Coastal Observatory (MVCO) | | ✓ | | | | | | | |
| National Data Buoy Center (NDBC) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Neuse Estuary Monitoring Project (NEMP) | | | | ✓ | | | | | |
| National Estuarine Research Reserve (NERR) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Northern Gulf of Mexico Littoral Initiative (NGLI) | | | | | ✓ | | | | |
| New Jersey Coastal Monitoring Network (NJ CMN) | | | ✓ | | | | | | |
| National Water Level Observing Network (NWLON) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Physical Oceanographic Real-time System (PORTS) | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | |
| South Atlantic Bight Synoptic Offshore Observational Network (SABSOON) | | | | ✓ | | | | | |
| Sea-Air-Land Modeling and observation Network (SALMON) | | | | | | | ✓ | | |
| Santa Barbara Channel- Santa Maria Basin Circulation Study (SBCSMB) | | | | | | ✓ | | | |
| Southern California Coastal Water Research Project Authority (SCCWRP) | | | | | | ✓ | | | |
| Sustainable Ecological Research Related to Management of the Florida Keys Seascape (SEAKEYS) | | | | ✓ | ✓ | | | | |
| South Florida Ocean Measurement Center (SFOMC) | | | | ✓ | | | | | |
| Texas Automated Buoy System (TABS) | | | | | ✓ | | | | |
| Texas Coastal Ocean Observation Network (TCOON) | | | | | ✓ | | | | |
| U.S. Army Corps of Engineers Field Research Facility (USACE FRF) | | | | ✓ | | | | | |
| U.S. Army Corps of Engineers Wave Gauges (USACE Waves) | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| U.S. Geological Survey Streamflow and Stage Data (USGS Stream) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Wave Current Surge Information System (WAVCIS) | | | | | ✓ | | | | |

*This table depicts the distribution of coastal observing systems in the nation's nine coastal regions. Some observing systems are located in more than one coastal region.*

The coastal observing systems identified in this Appendix, vary in size, design, and complexity. The systems range from those where trained volunteers collect samples manually to large-scale multidisciplinary partnership programs, with multiple mooring arrays and real-time data telemetry, integrated with remote sensing technology. Some programs have deployed coastal observing systems in multiple regions. For example, USACE's Waves program has coastal observing systems in seven of the nine coastal regions. Collecting measurements of the same parameter with a standardized method in many different regions allows for the development of large-scale spatial and trend analyses.

Many coastal observing systems rely on existing facilities to serve as platforms for oceanographic instrumentation (e.g., NDBC buoys and the onshore/nearshore platforms offered by the C-MAN stations of the National Weather Service). This approach reduces the cost of the observing system by decreasing the number of new mooring installations required and maintenance costs. In addition, it links information about climate and ocean features by allowing atmospheric and oceanographic data collection at similar spatial and temporal scales.

Abandoned or under-utilized submarine cables also can serve as facilities of opportunity for coastal observing systems. Submarine cables can provide power for instruments and transmit a large amount of data across multiple spatial scales.[95] Examples of systems in development that rely on submarine cables include the NSF-funded projects ALOHA Observatory and Monterey Accelerated Research System (MARS). The ALOHA observatory involves the re-commission of a cable near Hawaii. This project provides funding for one employee and instrumentation to be attached to the junction box in addition to a mooring for water-column investigations. MARS is a MBARI project under development for Monterey Bay. MARS will serve as a proof-of-concept for the NEPTUNE underwater observatory project.[96] The NEPTUNE observatory will include 30 seafloor nodes over a 500 by 1,000-kilometer area in the Juan de Fuca tectonic plate on the Pacific Northwest coast.[97]

Coastal observing systems are highly variable in design (including equipment) and data collection, analysis, and distribution methods used. This variability has resulted in a need for integration and coordination that has fostered the development of regional "umbrella" organizations that bring together independent coastal observing systems into a more cohesive functional network. Examples of some of these organizations include NEOS (NorthEast Observing System), SEA-COOP (Southeast Atlantic Coastal Observing System), and SCOOP (SURA Coastal Ocean Observing). NEOS focuses on the Northeast and encompasses observing systems from Maine to North Carolina. SEA-COOP focuses on the Southeast, and includes systems from North Carolina to Florida. SCOOP is a program of the Southeastern Universities Research Association, and focuses on coastal observing systems from the Chesapeake Bay to the Gulf of Mexico. The Gulf Coastal Ocean Observing System was recently proposed as another regional organization for the Gulf of Mexico.

These organizations have various degrees of geographic overlap. To assist with the development of these umbrella organizations, a national federation with regional associations for observing systems is under development in accordance with guidelines promulgated by Ocean.US. The goal of the federation is to develop a national observing network that will facilitate the communication and sharing of information among all users. In addition, the NOAA Coastal Observation Technology System program has funded seven new programs for the development of coastal observing systems on a regional basis (Table 4-15). These programs have agreed to form a federation that may serve as a model for the larger IOOS efforts.[93]

**Table 4-15:**
**NOAA Coastal Observation Technology System-Funded Programs**

| Program | Region | Institution |
|---|---|---|
| **ACT**<br>**Alliance for Coastal Technologies** | MA | Center for Environmental Science<br>University of Maryland |
| **CI-CORE**<br>**California Center for Integrative Coastal Ocean Research** | WC | Moss Landing Marine Laboratory<br>California State University |
| **Caro-COOPS**<br>**Carolinas Coastal Ocean Observing and Prediction System** | SA | Baruch Institute<br>University of South Carolina |
| **CIMT**<br>**Center for Integrated Marine Technologies** | WC | Institute of Marine Sciences<br>University of California Santa Cruz |
| **COOA**<br>**Coastal Ocean Observing and Analysis** | NE | University of New Hampshire |
| **CORMP**<br>**Coastal Ocean Research and Monitoring Program** | SE | University of North Carolina Wilmington |
| **WAVCIS**<br>**Wave Current Information System** | GM | Coastal Studies Institute<br>Louisiana State University |

*These seven programs will form a federation of coastal observing systems that will provide the basis for a nationwide network of ocean observatories.*

## 4.6.2 Global Observing Systems

The United States operates or is a significant partner in at least 19 global observing systems (Table 4-16 and Supplement 4-8). An accurate account of all systems is difficult because some are only pilot projects that may transition to long-term programs if they prove viable and funding is available.

Global observing systems are by nature supported by international oceanographic and atmospheric programs. In the United States, NOAA has the lead for the operation component of the global observatories. The U.S.

**Table 4-16: Global Observing Systems**

| Global Observing Systems | Atlantic Ocean | Pacific Ocean | Indian Ocean | Southern Ocean | Arctic Ocean |
|---|---|---|---|---|---|
| Acoustic monitoring hydrophones (AMH) | ✓ | ✓ | | | |
| Argo Floats | ✓ | ✓ | ✓ | ✓ | |
| Bermuda Atlantic Time-series Study (BATS) | ✓ | | | | |
| Bermuda Hydrostation S | ✓ | | | | |
| Bermuda Test-bed Mooring (BTM) | ✓ | | | | |
| Carbon Retention in a Colored Ocean (CARIACO) | ✓ | | | | |
| Carbon Dioxide Measuring Systems (CO2) | | ✓ | | | |
| Expendable Bathy Thermograph Global Array (XBT) | ✓ | ✓ | ✓ | | |
| Global Drifter Array (GDA) | ✓ | ✓ | ✓ | | |
| Hawaiian-2 Observatory (H2O) | | ✓ | | | |
| High-Density Expendable Bathy Thermograph Global Array (HD XBT) | ✓ | ✓ | | | |
| Oceanic Flux Program (OFP) | ✓ | | | | |
| Ocean Reference Stations (ORS) | ✓ | | | | |
| Pilot Research Moored Array in the Tropical Atlantic (PIRATA) | ✓ | | | | |
| Tropical Atmosphere-Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON) | | ✓ | | | |
| The Oleander Section (TOS) | ✓ | | | | |
| Trans-Pacific Profiler Network (TTPN) | | ✓ | | | |
| U.S. Inter-Agency Arctic Buoy Program (USIABP) | | | | | ✓ |
| Voluntary Observing System (VOS) | ✓ | ✓ | ✓ | | |

*This table depicts the distribution of global observing systems. Some systems are deployed in more than one ocean basin.*

Navy and NSF support NOAA's efforts by providing funding and equipment. The National Ocean Partnership Program, through Ocean.US, is coordinating activities to facilitate broad user-access to ocean knowledge, data, tools and products.

Within NOAA, the Office of Ocean and Atmospheric Research maintains a network of global observing systems. Some of the systems, even though designed primarily for climate research, such as the Tropical Atmospheric Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON), are core facilities of ocean observatories. The Atlantic Oceanographic and Meteorological Laboratory (AOML), in Miami, Florida, and the Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington, oversee most of NOAA's global ocean-observing activities. Global observing facilities managed by these labs include, but are not limited to, mooring arrays across the Pacific and Atlantic oceans, drifters, submarine cables, and voluntary observing ship programs (Table 4-16 and Supplement 4-8).

Academic research institutions also operate global observing systems (e.g., H20 at the University of Hawaii). These systems, because of their relatively high capital and maintenance costs, rely on federal funds and close partnership with government laboratories. An example is the Argo floats program, which operates as a consortium consisting of SIO, WHOI, University of Washington, and NOAA AOML and PMEL.

Global observing systems, even though they measure similar parameters as coastal observing systems, cover greater surface areas and deeper waters. As a result, they require the use of larger oceanographic ships, extended cruise time, and a greater use of drifters than coastal observatories. Frequently the information gathered is transmitted to shore using the Argos satellite communication network. The sensors installed on global observing systems vary depending on the mission of each system. As an example, Table 4-17 lists the types of sensors used on TAO/TRITON moorings.[98]

**Table 4-17: Sensors Used on the TAO/TRITON Array**

| Measurement | Sensor Type |
|---|---|
| **Wind speed** | Propeller |
| **Wind direction** | Vane |
| **Wind direction** | Fluxgate compass |
| **Air temperature** | Pt-100 RTD |
| **Relative humidity** | Capacitance |
| **Rainfall** | Capacitance |
| **Downwelling shortwave radiation (Next Generation ATLAS Moorings)** | Pyranometer |
| **Downwelling longwave radiation** | Pyrgeometer |
| **Barometric pressure** | Pressure transducer |
| **Sea surface and subsurface temperature** | Next Generation ATLAS sensor |
| **Sea surface and subsurface temperature** | Thermistor |
| **Salinity** | Internal field conductivity cell |
| **Water pressure** | Transducer |
| **Ocean current (profile)** | ADCP |
| **Ocean current (single point)** | Dopper Current Meter |

*The sensors used in the TAO/TRITON array are depicted here as example of sensors frequently installed on ocean observing moorings. See Supplement 4-9 for more information on these sensors.*

As with coastal observing systems, umbrella organizations that group global observing systems are emerging. An example is the Sargasso Sea Ocean Observatory ($S_2O_2$).[99] This organization is coordinating the activities, data use, and information dissemination of various observation and modeling programs in the western North Atlantic.

# 4.7 Computer and Data Storage Facilities

During the last 20 years, advances in the information technology sector have dramatically increased the capacity to collect, store, process, analyze, and distribute data. For example, it has been projected that between 1990 and 2010, supercomputer speed will outpace by one hundred times the Moore's law that predicts a doubling of microprocessor speed every 18 months.[100] Desktop computers are now ubiquitous in the workplace, many with computational capacity comparable to the supercomputers of two decades ago. Still, the computation capabilities are not adequate for existing and projected ocean science needs. The currently available information technology infrastructure limits many ocean science activities.[101] According to DOE and NASA, one of the principal impediments to the development of better models is the limited computational capacity of present-day supercomputers.[74, 102]

Concurrent with the non-linear increase in computational capacity, the field of ocean science is experiencing major technological advances in the use of instruments and facilities (e.g., ocean-observing systems, remote-sensing satellites) capable of collecting and transmitting massive amounts of data. A recent estimate indicates that for institutions with well-known oceanographic research programs, the monthly computers needs are expected to increase over the next five years from 1 gigabyte[b] to 100 gigabytes for memory, 1 gigabyte to 1 terabyte for archiving, and 1 gigabyte to 10 gigabytes for transfer.[101]

The increase in instrumentation and computer capacity, tied to the fast-paced evolution of the Internet and broadband transmission capacity, has resulted in the proliferation of data distribution centers. Data centers can range from sites administered by local jurisdictions or small academic research programs that store and distribute local or regional environmental or weather data (e.g., water temperature, solar irradiation), to large, joint federal and academic centers with supercomputers that collect, process, and distribute data, and develop and run simulation models of global-scale processes.

The following section focuses on major computer and data storage facilities, as these are the facilities at the forefront of technology development. A short discussion on the ocean science community's use of high-performance computer centers is followed by brief descriptions and examples of two main type of facilities: data archiving and distribution centers, and modeling and prediction centers.

## 4.7.1 High-Performance Computer Centers

In 2002, Office of Naval Research and NSF established a steering committee to assess the immediate and future information technology infrastructure needs of the ocean science community.[101] As part of its assessment, the

[b] *Gigabyte and terabyte are units of measurement of computer memory. A gigabyte is approximately $10^9$ bytes; a terabyte is approximately $10^{12}$ bytes.*

steering committee conducted a survey of the ocean sciences community's use of high-performance computer centers. The 11 centers that responded to the survey comprise 2 federal operational environmental prediction centers, 4 government laboratories, 4 shared academic science centers, and 1 multi-campus university (Supplement 4-10). The number of staff supporting the operation of a center ranged from about 30 to more than 100. The surveyed centers served a community of 15,099 users that ranged from 100 to 2,500 users per center. Oceanographers comprise 584 of the reported users, or about 4 percent of the community.

All centers agreed that a centralized oceanography facility at an existing large computer center could result in significant cost savings. The survey suggested that the option of establishing a new, stand-alone center dedicated to ocean science might take several years. Several respondents indicated that a centralized facility is the best option to address the most demanding computational problems. The survey also suggested that using distributed computer facilities provides the advantage of greater flexibility and leveraging of resources, but requires greater coordination efforts to ensure quality of service.

In terms of growth and future needs, 6 of the surveyed centers expect their capabilities to increase by 8 to 15 times during the next 5 years. The other 5 centers estimate a 20- to 50-fold increase in capabilities during the same period. Most of the centers estimated that increasing the number of users by 200 would require 3 or less new support staff.

To address the ocean community's information technology needs into the future, the steering committee recommended the establishment of a new organization called Ocean.IT. The role envisioned for this proposed organization is to improve access to high-performance computational resources; provide technical support for information technology resources; help with the curatorship of data, models, and software; and facilitate advanced application programming. The steering committee proposed that Ocean.IT will have a high-level information technology advisory role for the ocean science community, while serving individual projects and scientists by providing better access to advances in computational resources.

## 4.7.2 Data Archiving and Distribution Centers

In the United States there are 10 National Data Centers and 8 Distributed Active Archive Centers (DAACs).[c,102] Of these 18 centers, 11 are facilities that directly support ocean and coastal activities. These centers acquire, process, archive, and distribute information to multiple user groups, including researchers, the public, and policy decision makers. The type and format of data distributed depends on each center's mission and the end user. Data can range from raw field data to processed remote-sensing images. The DAACs focus on the scientific aspect of a mission or experiment, while the

[c] *The NAS report does not include NOAA's National Coastal Data Development Center established in April 2002.*

data centers address the long-term stewardship of data.[102]

In addition to the National Data Centers and the DAACs, other major data centers support the mission of several federal agencies. Federal agencies with data centers that directly support ocean and coastal activities are NOAA, DoD, NASA, USGS, EPA, and DOE.[103]
Two programs that maintain important ocean data centers are the World Ocean Circulation Experiment (WOCE), a component of the World Climate Research Program, and the Joint Global Ocean Flux Study (JGOFS).[104,105] From 1990 to 1998, representatives from 30 nations collected in-situ physical and chemical data, and remote-sensing observations from 4 oceans in support of the WOCE. Data collected are freely available over the Internet. Lessons learned during the WOCE program are helping to guide CLIVAR, a global study of ocean climate variability and predictability; GODAE, the Global Ocean Data Assimilation Experiment; and ARGO, a global array of temperature/salinity profiling floats. In turn, these programs will also become major repositories and distributors of ocean data.

JGOFS, launched in the 1980s, has the goal of studying the ocean carbon cycle, with particular interest in understanding the dynamics of the concentrations and fluxes of carbon and associated nutrients in the ocean.[105] JGOFS has been supported primarily by NSF, with additional funding provided by NOAA, NASA, DOE and the U.S. Navy. JGOFS maintains data available on-line solely for scholarly use by the academic and scientific community. JGOFS is currently moving into its final phase of data synthesis and modeling.

### 4.7.2.1 National Oceanic and Atmospheric Administration Data Distribution Centers

NOAA's NESDIS, through its National Data Centers (Table 4-18), receives, collects, distributes, and archives data about global oceans, the U.S. coast, geophysics, and climate. The archives include data from NOAA; other federal, state, and local agencies; academia; the private sector; and foreign governments and institutions. NESDIS archives are the largest collection of oceanographic, geophysical, and atmospheric data in the world. During the 1990s, the Center's holdings increased in size four times, and by 2000, the NESDIS archives exceeded one petabyte[d] in size. For comparison, this volume of information would require the equivalent of 10,000 top-of-the-line (as of May 2003) desktop computers with 100 gigabytes each. By 2005, the holdings probably will be eight times larger. By the year 2017, current and planned remote-sensing observing systems will produce volumes of environmental data expected to exceed 140 petabytes.[106]

The NOAA National Data Centers respond to tens of thousands of requests annually through on-line Internet-based retrievals and off-line orders for publications and data sets. In addition, the centers are contributing to the development of a national strategy for the data management component of

[d] *Petabyte is a unit of measurement of computer memory. A petabyte is approximately $10^{15}$ bytes.*

the Integrated and Sustained Ocean Observing System. Furthermore, the National Data Centers support the international exchange of oceanographic data through its cooperation with the Intergovernmental Oceanographic Commission and Working Group on Marine Data Management of the International Council for the Exploration of the Sea.
Affiliated with NOAA's National Geophysical Data Center is the National

**Table 4-18: NOAA NESDIS National Data Centers**

| Center | Location | Type of data |
|---|---|---|
| **NODC National Oceanographic Data Center** | Silver Spring, Maryland | Physical, chemical, and biological oceanographic data |
| **NCDDC National Coastal Data Development Center** | Stennis Space Center, Mississippi | Coastal data held by state, local and private organizations, as well as the data already held by NOAA and other federal agencies |
| **NGDC National Geophysical Data Center** | Boulder, Colorado | Bathymetry, topography, geomagnetism, habitat, hazards, marine geophysics |
| **NCDC National Climatic Data Center** | Asheville, North Carolina | Climate, meteorology, alpine environment, ocean atmosphere interaction, vegetation |

Snow and Ice Data Center.[107] It manages data on snow, land ice, sea ice, atmosphere, biosphere, and hydrosphere. The center is part of the University of Colorado Cooperative Institute for Research in Environmental Sciences.[107] The National Snow and Ice Data Center, funded by NASA, serves as one of eight DAAC facilities that archive and distribute data from NASA's satellites and field measurement programs. It also supports the NSF through the Arctic System Science Data Coordination Center and the Antarctic Glaciological Data Center.

NOAA's CoastWatch is another data distribution program managed by NESDIS. This program facilitates the distribution and access to NOAA satellite products relevant to the coastal environment. Through an annual grant process, NOAA obtains ocean remote-sensing research relevant to the NOAA operational satellite oceanography mission. Eight regional CoastWatch nodes distributed along the coasts, including the Great Lakes, received or developed satellite and in-situ data and products. The products are distributed via the Internet to federal, state, and local agencies and academic institutions to support environmental monitoring, management, and research.

## 4.7.2.2 U.S. Department of Defense Data Distribution Centers

NAVOCEANO's data warehouse is DoD's main repository of ocean and coastal data. The warehouse is a terabyte-scale digital storage facility that houses bathymetric, hydrographic, and oceanographic data holdings from both NAVOCEANO and other survey operations dating back over a century.

## 4.7.2.3 National Aeronautics and Space Administration Data Distribution Centers

The NASA DAACs are the operational data management and user services arm of NASA's Earth Observing System Data and Information System (EOSDIS).[107] Each DAAC addresses a specific science discipline (Table 4-19). A science advisory group helps guide the DAACs in identifying and generating needed data products.

**Table 4-19: NASA Distributed Active Data Centers**

| Center | Location | Type of Data |
|---|---|---|
| **National Snow and Ice Data Center DAAC** | University of Colorado | Sea Ice, snow cover, ice sheet data, brightness, temperature, polar atmosphere |
| **Goddard Space Flight Center DAAC** | GSFC Maryland | Ocean color, hydrology and precipitation, land biosphere, atmospheric dynamics, and chemistry |
| **Physical Oceanography DAAC** | Jet Propulsion Laboratory California | Atmospheric moisture, climatology, heat flux, ice, ocean wind, sea surface height, temperature |
| **Alaska Synthetic Aperture Radar Facility DAAC** | Alaska Geophysical Institute University of Alaska | Sea Ice, polar processes |

*NASA DAAC centers archive and distribute data collected by NASA research satellites.*

By way of example, the Goddard Space Flight Center DAAC facility stores and distributes biological oceanographic (e.g., SeaWiFS, MODIS) and hydrological data. It processes approximately 530 gigabytes per day from each MODIS instrument, and archives about 180 gigabytes per day of level-2 and level-3 data. Goddard Space Flight Center DAAC archives 2 gigabytes per day of SeaWIFS processed data (levels 1 to 3). The center's total ocean data holdings are 8.7 terabytes of SeaWiFS and 191.5 terabytes of MODIS/Terra data. In FY2001, it delivered 17 terabytes of SeaWiFS data to 531 distinct users. Since the beginning of the MODIS/Terra mission in February 2000, the DAAC has distributed 10.5 terabytes of data to at least 350 users. Oceanographers comprise approximately a third of the users.

The JPL DAAC facility distributes and stores physical oceanographic data collected with satellites (e.g., TOPEX/Poseidon, Jason, SeaWinds). In addition, JPL DAAC receives a copy of the MODIS SST data. The JPL DAAC holdings approximate 14.4 terabytes of data. In FY2001, JPL DAAC delivered 33.3 terabytes of data to more than 23,000 users.

The Alaska Synthetic Aperture Radar Facility, located in the Geophysical Institute at the University of Alaska Fairbanks, downlinks, processes, archives, and distributes data.[108] Data are from the European Space Agency's ERS-1 and ERS-2 satellites, Japan's NASDA JERS-1 satellite, and the Canadian Space Agency's RADARSAT-1 satellite. Data products include seven unrestricted data sets in CD-ROM format and various on-line processed products.

### 4.7.2.4 U.S. Geological Survey Data Distribution Centers

The USGS Earth Resources Observation Systems (EROS) Data Center, located in South Dakota, archives, manages, and distributes land remote-sensing data.[109] The core of the EROS data consists of images from Landsat 1 through 5, and Landsat 7 satellites, including images from the Thematic Mapper and Multispectral Scanner sensor. The center also has more than 28 terabytes of AVHRR images and more than 880,000 declassified intelligence satellite photographs. Even though the center's focus is on land remote-sensing data, many of the images in the center provide vital information about the coastal zone, including sensitive ecosystems such as estuarine wetlands.

### 4.7.2.5 U.S. Environmental Protection Agency Data Distribution Centers

EPA's Office of Water maintains two data management systems that archive and disseminate water-quality information: the Legacy Data Center, and STOrage and RETrieval (STORET).[110] Both systems contain raw biological, chemical, and physical data on surfacewater and groundwater collected by federal, state and local agencies, Indian tribes, volunteer groups, academics, and others.

The Legacy Data Center contains historical water-quality data collected from the early part of the Twentieth century until the end of 1998. STORET contains data collected beginning in 1999, along with older and properly documented data migrated from the Legacy Data Center. STORET is EPA's largest computerized environmental data system and serves as a repository for water quality, biological, and physical data for the use of state environmental agencies, federal agencies, academia, private citizens, and many others. The Legacy Data Center and STORET are available to the public through standard web browsers and allow on-line data review and download. The Legacy Data Center and STORET include information from all 50 states, U.S. territories, and other U.S. jurisdictions.

Every sampling result in the Legacy Data Center and STORET has associated information on sample location (i.e., latitude, longitude, state, county, hydrologic unit code and a brief site identification), when the sample was gathered, the medium sampled (e.g., water, sediment, fish tissue), and the name of the organization that sponsored the monitoring. In addition, STORET contains information on why the data were gathered; sampling and analytical methods used; the laboratory used to analyze the samples; the quality control checks used when sampling, handling the samples, and analyzing the data; and the personnel responsible for the data.

#### 4.7.2.6 U.S. Department of Energy Data Distribution Centers

The Carbon Dioxide Information Analysis Center (CDIAC) is a national data center located at Oak Ridge National Laboratory in Tennessee. It is DOE's primary global-change data and information analysis center. CDIAC responds to data and information requests from users from all over the world who are concerned about the greenhouse effect and global climate change. CDIAC's data holdings include information on atmospheric trace gases, global carbon cycle, solar and atmospheric radiation, and records of the concentrations of carbon dioxide in the oceans. CDIAC provides data management support for the Global Ocean Data Analysis Project (GLODAP). GLODAP is a cooperative effort of investigators funded to conduct synthesis and modeling projects through NOAA, DOE, and NSF. Cruises conducted as part of the WOCE, JGOFS, and the NOAA Ocean-Atmosphere Carbon Exchange Study have generated oceanographic data of unparalleled quality and quantity.[111] CDIAC, through its Ocean Data web site, has carbon and hydrographic data in various formats available to the public.

### 4.7.3 Modeling and Prediction Centers

This section focuses on federal facilities with supercomputers capable of developing and running simulation models used for prediction of large-scale temporal and spatial ocean processes (e.g., basin-wide circulation, climate change). Because of the strong dynamic feedbacks between the ocean and the atmosphere, many of the large-scale modeling and prediction efforts involve coupled ocean-atmosphere models. These models are frequently developed and run at interdisciplinary facilities that support both atmospheric and ocean scientists.

Federal agencies with supercomputer facilities used for ocean and coastal research include NOAA, DoD, NASA, NSF, and DOE. Some academic institutions have supercomputers used for ocean and coastal research (e.g., Oregon State University and University of Alaska-Fairbanks); however, they are not included in this discussion as no detailed information was available.

#### 4.7.3.1 National Oceanic and Atmospheric Administration Modeling Centers

NOAA's Geophysical Fluid Dynamics Laboratory, in Princeton, New Jersey is one of the premier ocean modeling centers. Researchers at the laboratory conduct investigations on many topics, including weather and hurricane forecasts, El Niño prediction, stratospheric ozone depletion, and global warming. The goal is to understand and predict the climate and weather, including the impact of human activities. At least three mainframe Origin 3800 systems support the mission.

NOAA's National Weather Service National Center for Environmental Prediction (NCEP) supercomputer provides support to the National Weather Service programs focusing on ocean and coastal research and monitoring. This supercomputer is located at a commercial facility in Gaithersburg, Maryland, and is available for use only by NCEP collaborators. Its computational capacity and throughput is 3.7 teraflops.[e] The facility is less than 15 years old, and the system is less than a year old. Planned upgrades will occur every 18 to 24 months, and the annual operating cost is $15 million.

### 4.7.3.2 U.S. Department of Defense Modeling Centers

DoD's High-Performance Computing Program manages four Major Shared Resource Centers (MSRC). Two of the centers support ocean and coastal activities: USACE's Engineering Research and Development Center's (ERDC) MSRC and the NAVOCEANO MSRC.

ERDC MSRC computing hardware capability includes a 512 processor SGI Origin 3800; a 1,904 processor Cray T3E; a 512 processor Compaq SC40 Origin 2000™; a 512 processor Compaq SC45 Origin 2000™; and more than 500 terabytes of robotic storage. International access to the MSRC systems is provided through the Defense Research and Engineering Network and the Internet. This system provides access to scientists and engineers across the nation, which shortens the design cycle and reduces reliance on expensive and destructive live experiments and prototype demonstrations. With the aid of High Performance Computing Program capabilities, virtual environments help researchers visualize and interpret their study results. ERDC MSRC facilities also support complex simulation models of ocean, coastal, riverine, and hydrologic dynamic processes.

NAVOCEANO is the U.S. Navy's center for ocean observation and prediction, providing critical ocean information for military purposes. Its computing requirements are served by the NAVOCEANO MSRC. This facility is currently the largest and most capable DoD technical computing facility, and one of the most capable High-Performance Computing Program centers in the world. It serves thousands of nationwide users engaged in research, development, testing, and evaluation activities throughout DoD military services and agencies, and provides one of the world's most capable operational High Performance Computing Program environments for global-scale oceanography and meteorology.

FNMOC mainframe computing facilities, based on SGI Origin architectures, are dedicated operational facilities that primarily focus on global and

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[e] *Teraflops is a unit of measurement of performance of computers used for numerical work, and is equivalent to $10^{15}$ floating-point operations per second.*

mesoscale atmospheric predictions. FNMOC acquires and processes over six million observations per day, creating one of the world's most comprehensive real-time databases of meteorological and oceanographic observations for assimilation into its models. FNMOC employs three primary models, the Navy Operational Global Atmospheric Prediction System (NOGAPS), the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS™), and the WaveWatch III model (WW3), along with a number of specialized models and related applications. NOGAPS is a global weather model, driving nearly all other FNMOC models and applications. COAMPS™ is a high-resolution regional model that has proven to be particularly valuable for forecasting weather conditions in highly complex coastal areas. WW3 is a state-of-the-art ocean wave model employed globally in support of a wide variety of Naval operations.

### 4.7.3.3 National Aeronautics and Space Administration Modeling Centers

To support the investigations of their ocean researchers, NASA has supercomputing facilities located at the Ames Research Center, GSFC, and JPL. At the Ames Research Center, the computer hardware includes a Cray SV1™ (32 CPU), a SGI Origin 2000™ cluster, and a SGI Origin 3000™ cluster. At GSFC, the equipment includes a Cray T3E™ (1360 CPU), a SGI Origin 2000™ (64 CPU), SGI Origin 3800™ (512 CPU), a Compaq SC45™ (1392 CPU), a IBM RS/6000 SP™ (32 CPU), and UniTree™ storage system with 1900 terabyte capacity. At JPL, the equipment includes a SGI Origin 2000™ (128 CPU). The resources available are not sufficient to meet the requirements for ocean science and technology research because of the high demand on the supercomputing resources.

### 4.7.3.4 National Science Foundation Modeling Centers

NSF supports the National Center for Atmospheric Research Scientific Computing Division, which is one of the nation's major computer facilities for atmospheric and ocean modeling and prediction. This facility provides computing support for National Center for Atmospheric Research researchers and academic scientists beyond the scope and capabilities of many university facilities.[112] In addition, the National Center for Atmospheric Research Scientific Computing Division houses, operates, and maintains the Climate Simulation Laboratory, a facility administered by NSF, which supports the U.S. Global Change Research Program.

The Climate Simulation Laboratory provides high-performance computing and data storage systems to support large-scale, long-running simulations of the earth's climate system (i.e., coupled atmosphere, oceans, land and cryosphere, and associated biogeochemistry and ecology, on time scales of seasons to centuries). It also supports appropriate model components of large-scale simulations that need completion in a short period. Large simulations typically require thousands of processor hours for their completion and usually produce many gigabytes of model outputs that require archiving and analysis, including validation, with other simulation model results and field observations. Climate Simulation Laboratory users also have access to the National Center for Atmospheric Research Mass Storage System, which is one of the most voluminous and efficient storage systems in the world, and the National Center for Atmospheric Research Visualization Laboratory.

### 4.7.3.5 U.S. Department of Energy Modeling Centers

The DOE laboratories with high computational capacity to conduct ocean and coastal models are Los Alamos National Laboratory and Lawrence Berkeley National Laboratory.

Two groups of ocean researchers use Los Alamos' supercomputer facilities: the Climate, Ocean and Sea-Ice Modeling Group (COSIMG) and the Earth and Environmental Sciences group. COSMIG develops and applies global coupled atmosphere-ocean-sea-ice general circulation models as part of the DOE Climate Change Prediction Program. The DOE Climate Change Prediction Program is a joint lab-university effort to develop computational methods and capabilities for simulating and predicting future changes in climate. Models developed by COSIMG are the basis for the ocean and sea-ice component of the multi-institutional Community Climate System Model program supported by DOE and NSF. An Origin 3000™ 512 processor system with 0.5 teraflops capability supports these efforts; however, the system is not available to general users.

The Earth and Environmental Sciences group uses the Los Alamos National Laboratory's advanced ocean-circulation models to investigate the interactions of the oceans' circulation and the ecological systems of the surface layers of the ocean. Of particular interest are the distribution and population dynamics of phytoplankton and zooplankton communities.

The National Energy Research Scientific Computing Center at Lawrence Berkeley National Laboratory is one of the nation's most powerful unclassified computing resources and is a world leader in accelerating scientific discovery through computation. Computer hardware capability at the National Energy Research Scientific Computing Center includes an IBM RS/6000 SP™, a Cray T3E™ and a PVP cluster with a peak performance of 5 teraflops. Currently, ocean modeling uses about 5 to10 percent of the system's time.

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# Marine Education and Outreach

## Chapter 5

***Ocean-Related Higher Education Facilities***

***Federal Outreach and Education Programs — Virtual Facilities***

***U.S. Informal Education and Outreach Facilities***

***Marine Education Summary***

The facilities across the United States that support marine-related education and research activities range from major institutions that provide graduate education to small organizations that offer unique learning experiences to the general public. This chapter reviews:

- Formal academic resources and facilities for the ocean science field, focusing on student enrollment in academic programs, the faculty who train the students, physical infrastructure, and funding
- Education and outreach materials and programs sponsored by federal agencies
- Informal education and outreach programs available at marine protected areas as well as zoos, aquariums, and museums.

While there is a wide range of nontraditional educational opportunities offered by private entities, they are beyond the purview of this Appendix. Facilities dedicated to research are discussed in Chapter 4.

The ocean sciences are interdisciplinary, encompassing marine policy, ocean and coastal engineering, and the natural science fields of biology, chemistry, physics and geology. Academic facilities supporting students pursuing formal education comprise graduate and undergraduate universities, maritime academies, military academies, and technical and two-year colleges. This inventory identified 489 ocean-related programs at 139 academic institutions, most of which are located in coastal states or have satellite facilities or partnerships with facilities in coastal areas. A limited number of inland institutions have ocean science programs that focus more on theoretical study and less hands-on experience. Characterizing students of the ocean sciences and the infrastructure that supports them is critical to understanding the current capabilities of the nation's ocean sciences community and identifying areas where additional resources may be required. Although limited historical data were available, this inventory provides a baseline for future inventories, assesses observed trends, and identifies data gaps.

Federal agencies, programs, and funding play critical roles in the entire realm of ocean sciences education, affecting students and teachers at all education levels, as well as the public. Substantial federal funding for the ocean sciences is dispersed through these agencies, which provide formal educational materials for educators and students, as well as numerous informal outreach programs dedicated to ocean science education. Although not a facility per se, the impact of federal resources on ocean-related education merits inclusion in this Appendix.

Informal education and outreach facilities offer programs and activities that inform the public about the nation's ocean and coastal resources. Informal in this context does not infer unstructured or disorganized, but is used to distinguish these facilities from the academic programs described in this chapter. These facilities comprise locations in the natural environment, such as federal and state marine protected areas, as well as zoos, aquariums, and museums. The former offer visitors learning experiences in a natural setting, and the latter provide the public with new experiences at easily accessible locations. The impact of informal facilities on the ocean sciences is more difficult to quantify than the impact of formal education facilities, as information is less centralized. Informal facilities are discussed at the end of this chapter.

# 5.1 Ocean-Related Higher Education Facilities

Developing an inventory of ocean-related educational facilities is essential to evaluating the national workforce capability. For this inventory, student enrollment in the various ocean-related academic programs, the faculty who educate these students, the infrastructure (e.g., laboratories, vessels, and equipment) that facilitates research and training, and the funding that supports ocean-related academic programs were examined. All of these resources factor into the national capability, as illustrated in Figure 5-1.

**Figure 5-1:**
**Components of the U.S. Ocean Science Workforce Capability**


*These seven interrelated elements represent the major resources that influence the nation's ocean science workforce capability.*

Although various organizations have collected data on the ocean science academic community, the focus of this Appendix warranted more extensive data collection than previous efforts. To provide a more thorough and current picture of the ocean sciences academic community, the Commission contracted with the Consortium for Oceanographic Research and Education (CORE) to inventory the higher education resources supporting and promoting the ocean sciences. This effort is the primary source of data for the academic section of the education facilities inventory.[a]

[a] *The full CORE report is included as a separate appendix to the main Ocean Commission report, and includes a listing of the schools that participated in the study.*

This inventory is based on a survey of administrators at U.S. academic institutions and the maritime academies that examines ocean-related academic resources at the graduate, undergraduate, and associate levels. Of the 489 programs at 139 academic institutions surveyed, 69 percent provided data.

While data from some of the major educational institutions engaged in the ocean sciences were not available for the inventory, a robust cross-section of ocean science academic resources is represented in this Appendix. Discussion of trends has been supplemented by information from the National Science Board's *Science and Engineering Indicators–2002*; however, this information addresses all science and engineering fields of study and is not specific to the ocean sciences.[1]

As a result of this inventory, several notable findings, trends, and gaps in formal academics were identified:

- Student resources showed that graduate students studying the ocean sciences rely heavily on research-based financial support, more so than those in other fields. Upon graduation, there is an inadequate tracking by universities of where graduates gain employment.
- Faculty demographics are improving; while still under-represented, the workforce continues to become more diversified with women and, to a lesser extent, minorities.
- Infrastructure maintenance is an issue; replacement plans for aging facilities and equipment are insufficient.

**Primary areas of study defined as ocean sciences:**

- Marine Policy
- Ocean Engineering
- Marine Biology and Biological Oceanography
- Marine Chemistry
- Physical Oceanography
- Marine Geology and Geophysics
- Coastal and Estuarine Studies
- Aquaculture and Fisheries Science
- Marine Technology
- Commercial Diving
- Marine Transportation and Safety
- Marine Mechanics
- Marine Science
- Shipbuilding

- Funding for ocean science study comes from a range of sources, although the majority comes from a decreasing federal pool. Forty-seven percent of total academic funding is granted to 10 institutions.

Some information necessary to build a comprehensive data set was not available for this inventory. Identified data gaps include:

- Limited information on replacement plans for vessels and equipment
- Distinction between education and research funds, particularly by institutions with substantial funding from internal sources
- Limited data from two-year and vocational colleges. Consequently, these institutions were not included in the academic year 2002 (AY2002) analyses on research funding.

## 5.1.1 National Academic Ocean Sciences Programs Student Population

Enrollment of students in ocean sciences programs is a key indicator of the future workforce. This inventory presents information on enrollment in the various programs, types and numbers of degrees awarded in AY2001, and the post-graduation employment of these graduates. Key aspects called out in the inventory are the greater concentration of students studying the biological disciplines compared to other subjects, the increasing number of women and minorities enrolled in these programs, and the degree to which students in ocean sciences rely on research-based financial support.

### 5.1.1.1 Student Enrollment

Graduate-level education offers more ocean-specific programs and is supported by substantially more data than the undergraduate level. With the exception of maritime academies, undergraduate and two-year programs generally are less specialized, tending to focus more broadly on biology, chemistry, engineering, or geology. Therefore, the inventory focuses on graduate-level enrollment in ocean-related programs. For the purpose of this Appendix, graduate programs refer to both doctorate and master's programs. This inventory examines data from 63 graduate programs and covers the number of applications and offers, enrollments, and types of financial support available to students.

#### 5.1.1.1.1 Application and Enrollment in Graduate Programs

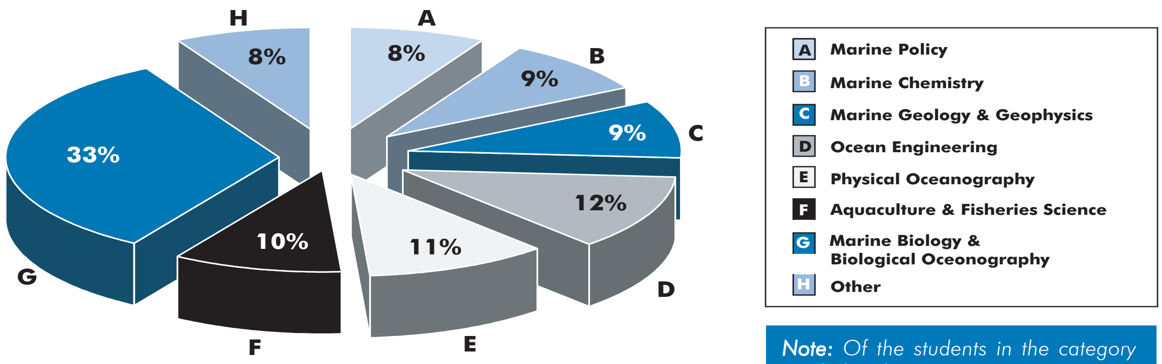
Applications to ocean-related graduate programs[b] remained relatively constant between 2001 and 2002 at approximately 4,000 per year, with one third of applicants admitted each year. Distribution of fall 2001 enrollments by area of study is summarized in Figure 5-2. The greatest concentration (one-third) of students admitted to a marine graduate program was in marine biology and biological oceanography. Students focusing on other areas were almost equally distributed among other marine-related fields.

Women were greatly concentrated in the biological, chemical and geological fields, while men predominantly chose the fields of engineering and physical oceanography. Figure 5-3 illustrates the distribution of women and men in each area of study. Long-term trends show the proportion of women enrolled in all graduate science and engineering fields to be increasing.[1]

*The percentage of minorities enrolled in science and engineering graduate programs has increased over the past decade, while enrollment of white students has declined.*

[b] *58 responses from 63 programs queried.*

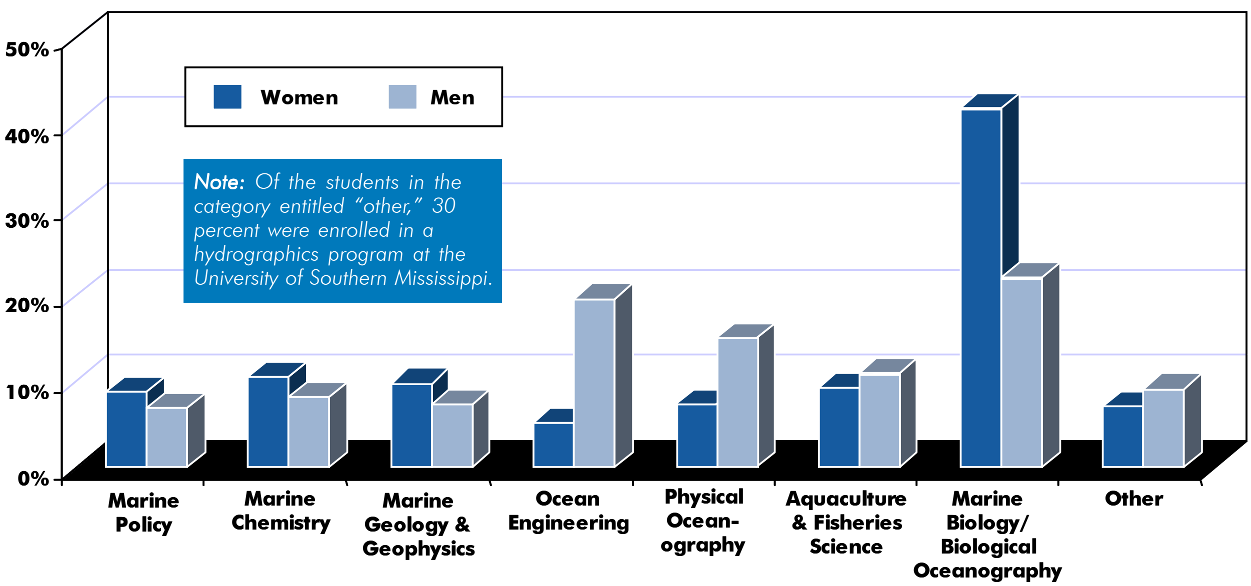
### Figure 5-2: First-Year Enrollments in Graduate Programs, by Field, *Data from Fall 2001*




*The majority of first-year graduate students were enrolled in marine biology and biological oceanography, a trend throughout the field of ocean science.*

***Note:*** *Of the students in the category entitled "other," 30 percent were enrolled in a hydrographics program at the University of Southern Mississippi.*

### Figure 5-3: First-Year Enrollments in Graduate Programs, by Gender and Field, *Data from Fall 2001*



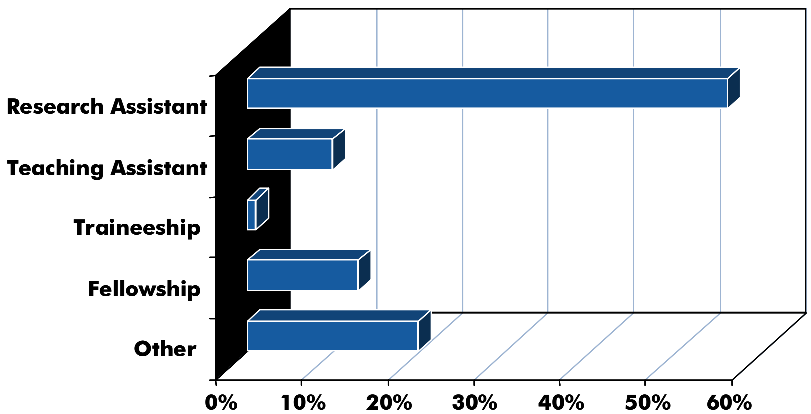

*Women are strongly represented in marine biology and biological oceanography, while men are strongly represented in ocean engineering and physical oceanography.*

Of the 671 graduates for whom citizenship data were available, 21 percent claimed foreign citizenship. Foreign citizen enrollment in science and engineering graduate programs overall continues to increase.[1] Of the U.S. citizens enrolled in ocean-related programs during AY2001, racial distribution was reported for 96 percent of students. These reports indicate that approximately 90 percent of the students were white. The percent of white students enrolled in science and engineering graduate programs overall has decreased in the past decade, while the percent of minorities has continued to increase; however, this increase slowed to 4.1 percent during 1992-1999.[1]

### 5.1.1.1.2 Types of Student Financial Support

Forty-six graduate programs of the 63 queried reported on the type of financial support their students received during AY2001. These results are presented in Figure 5-4, which illustrates how the study of ocean science relies on research assistantships as the primary source of financial support. Graduate students in ocean sciences tend to be more reliant on research assistantships than their counterparts in physical and life science fields, who also rely heavily on teaching assistantships and traineeships. The relatively large number of students in the "other" category can be attributed to students supporting themselves through means apart from their graduate programs, often a result of attending policy or management programs that do not offer research assistantships, fellowships, or traineeships.[C]

**Figure 5-4: Graduate Student Support by Area of Study, *Data from Fall 2001***




*The single-most important source of student financial support in ocean sciences is research assistantships.*

## 5.1.1.2 Graduate and Undergraduate Degrees Awarded and Employment Trends

Information on degrees awarded and post-graduation employment for doctorate, master's, and bachelor's degree recipients are presented in this section. Awarded degrees and post-graduation employment for graduates of two-year programs are discussed separately in the following section due to their vocational and specialized nature.

### 5.1.1.2.1 Graduate and Undergraduate Degrees Awarded

The academic programs that make up this inventory awarded 798 graduate degrees and 1,238 undergraduate degrees in AY2001 in fields of study pertaining to the ocean sciences. Of the graduate degrees awarded, 33 percent were doctorate degrees and 67 percent were master's degrees. Degrees awarded by graduate programs tend to reflect greater diversity in

[C] *This assumption was based directly on the CORE report.*

terms of race and nationality than undergraduate programs, although the number of master's degrees awarded to minorities is still disproportionately low. The number of women earning doctorate degrees remains relatively low, but as the number of master's and bachelor's degrees awarded to women in the ocean sciences increases, enrollment in doctoral programs is expected to rise.

Table 5-1 summarizes degrees awarded in AY2001 by education level, field of study, and gender. Table 5-1 also shows the top three fields of study in graduate programs to be marine biology and biological oceanography, ocean engineering, and aquaculture and fisheries science. The table shows that as students move through the graduate levels of study, they continue to narrow their focus of study and become increasingly specialized.

**Table 5-1: Degrees Awarded in AY2001**

| | Level of Degree** | | | | Total Degrees by Field of Study |
|---|---|---|---|---|---|
| | Doctorate | Master's | Total Graduate Degrees | Bachelor's | |
| **Marine Technology** | - | - | - | 5 (4/1) | 5 (4/1) |
| **Marine Geology and Geophysics** | 18 (10/8) | 28 (14/14) | 46 (24/22) | - | 46 (24/22) |
| **Coastal and Estuarine Studies/Coastal Zone Management** | 11 (7/4) | 18 (11/7) | 29 (18/11) | 27 (18/9) | 56 (36/20) |
| **Marine Policy** | 4 (0/4) | 60 (29/31) | 64 (29/35) | - | 64 (29/35) |
| **Marine Chemistry** | 36 (22/14) | 27 (14/13) | 63 (36/27) | - | 63 (36/27) |
| **Physical Oceanography** | 40 (31/9) | 52 (32/20) | 92 (63/29) | - | 92 (63/29) |
| **Marine Transportation and Safety** | - | - | - | 134 (113/21) | 134 (113/21) |
| **Aquaculture and Fisheries Science** | 26 (14/12) | 74 (48/26) | 100 (62/38) | 77 (58, 19) | 177 (120/57) |
| **Marine Science** | - | - | - | 230 (113, 117) | 230 (113, 117) |
| **Ocean Engineering** | 29 (24/5) | 82 (65/17) | 111 (89/22) | 173 (146, 27) | 284 (235/49) |
| **Marine Biology and Biological Oceanography** | 89 (52/37) | 166 (73/93) | 255 (125/130) | 260***(79, 154) | 515 (204/284) |
| **Other Degrees*** | 12 (7/5) | 26 (16/9) | 38 (23/14) | 332 (180, 152) | 370 (203/166) |
| **Total by Level** | 265 | 533 | 798 | 1,238 | 2,036 (1180, 828) |

*Students become more specialized across fields of study as they advance their education. The overall number of women graduates across all degree levels was around 58 percent, with the greatest number of these graduates in biological fields.*

*Degrees awarded are shown with total recipients, then by gender (men, women).*
** "Other" includes atmospheric and ocean sciences, general oceanography, fisheries oceanography, interdisciplinary oceanography. Bachelor's degrees awarded is the largest category and includes 15 subcategories*
*** Doctorate degrees are from a total of 42 programs, master's degrees are from a total of 53 programs, and bachelor's degrees are from a total of 42 programs.*
**** Grice Laboratory, College of Charleston did not delineate between men and women bachelor's recipients for marine biology.*

For undergraduate degrees, the "other" category, marine biology and biological oceanography, and marine science are the top three fields of study. The large number of graduates in the "other" category can be attributed to the broad nature of undergraduate study in marine-related fields. Marine transportation and marine science are programs that are more prevalent at maritime academies, explaining the large number of undergraduate degree recipients in these two fields.

The number of women receiving degrees was relatively even across the academic levels in AY2001 (57 to 63 percent). At the doctoral level the proportion of science and engineering degrees earned by women has increased considerably in the past three decades.[1]

More doctoral degrees were awarded to foreign students and minorities than master's and bachelor's degrees. One-third of doctoral degree recipients were non-U.S. citizens. This figure is based on AY2001 citizenship data reported by 40 programs for 245 of 265 students. Approximately 80 percent of students receiving postgraduate degrees were white. Of the master's degree recipients for AY2001, 16 percent reported foreign citizenship. Forty-five of the 50 programs that provided citizenship data also reported racial information for 91 percent of the U.S. citizens who received their master's degree. This group was again predominately white, with small numbers of Hispanic Americans, African Americans, Asian Americans, and Native Americans.

A total of 140 minors in marine-related fields were awarded by 16 of the 24 bachelor's programs included in the CORE report. Compared to some other disciplines, this is a large number of minors awarded for a relatively small field. This may be attributed to the largely multidisciplinary nature of the ocean sciences, which makes it well suited to being offered as a complementary focus of a larger core discipline such as physics, biology, or chemistry.

#### 5.1.1.2.2 Post-Graduation Employment Trends

In general, tracking post-graduate employment is difficult, most notably at the bachelor's degree level. In terms of post-graduation employment, doctoral degree recipients tend to work at academic institutions while master's degree recipients find employment in nonacademic positions. With respect to the 737 graduate-degree recipients for whom postgraduate employment data were reported, 25 percent were employed at a 4-year college, a university, or a university-affiliated research center. The majority of this 25 percent were doctorate recipients. Approximately 26 percent of the graduate programs surveyed could not report post-graduation employment information.

The 42 bachelor's programs that were part of this inventory awarded degrees to 1,238 students; the post-graduation employment of almost half is unknown. This data gap limits assessment of bachelor's degree recipients' impact on the ocean sciences workforce or enrollment in advanced education. Table 5-2 summarizes postgraduate employment for doctorate,

**Table 5-2: Postgraduate Employment**
***Data from AY2001***

| Post-Graduate Employment | Doctorate Recipients (40 Programs) (%) | Master's Recipients (48 Programs) (%) | Bachelor's Recipients (65 Programs) (%) |
|---|---|---|---|
| Employed at a 4-year college or university | 29 | 5 | - |
| Employed at university-affiliated research center | 21 | 7 | - |
| Employed at a federal agency | 13 | 17 | 2 |
| Employed at a state or local agency | 2 | 3 | 1 |
| Employed by civilian government agency: unspecified | - | - | 2 |
| Employed at a non-profit organization | 2 | 4 | - |
| Employed by private, for-profit sector | 11 | 11 | 18 |
| Employed–other* | 4 | 7 | 5 |
| Employment unknown | 10 | 34 | 46 |
| Enrolled at another university | - | 7 | 12 |
| Employed as a K-12 teacher | - | - | 1 |
| Active military | - | - | 13 |
| Foreign Students no longer is the U.S. | 8 | 5 | - |

*While it appears that a majority of doctorate degree recipients gain employment at academic institutions, and master's recipients gain employment at federal agencies, the deficiency in graduate tracking presents a difficulty in assessing future workforce capabilities.*

*The data in this table represent 252 doctorate recipients, 485 master's recipients, and 1,238 bachelor's recipients.*
** "Other" was not specified for this inventory.*

master's and bachelor's degree recipients. Lack of information regarding post-graduation employment across the different levels of education is a substantial data gap in assessing the marine-related workforce.

### 5.1.1.3 Associate Degrees Awarded and Employment Trends

Data available for two-year and vocational programs were limited in comparison to higher academic levels. Survey respondents reported a total of 595 associate degrees awarded in AY2001. The majority of degrees earned were in marine technology and commercial diving by graduates who moved directly into the workforce.

Ninety-five percent of the associate degrees and certificates were awarded to men and five percent were awarded to women. These data are consistent with those collected through the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS) for AY2000. Ninety-four percent of the 568 degree recipients for whom data were available in

AY2001 claimed U.S. citizenship. Too few data were available for a robust racial analysis of associate degree recipients. Data from IPEDS for AY2000 revealed that 84 percent of all associate degree recipients were white, with smaller percentages of African American, Native American, and Hispanic American graduates.

Nine of the 13 two-year programs that participated in this inventory provided information regarding post-graduation employment for a total of 429 degree or certificate recipients. The responses are summarized in Table 5-3. It appears that two-year colleges tend to track post-graduation plans better than four-year institutions. The high percentage of graduates going into the general workforce may be explained by the respondents not interpreting "ocean sciences-related" as broadly as the inventory intended. Additionally, the respondents may have been unsure of where their graduates went, but had a general feeling they went into the workforce.[d]

**Table 5-3: Post-associate Degree and Certificate Employment**
***Data from AY2001***

| Post-Graduation Employment of Community College Students | % of Total (Total =429) |
|---|---|
| Transferred to a four-year college | 4 |
| Went into general workforce | 67 |
| Went into an ocean sciences-related job | 9 |
| Other *(not specified)* | 17 |
| Unknown | 3 |

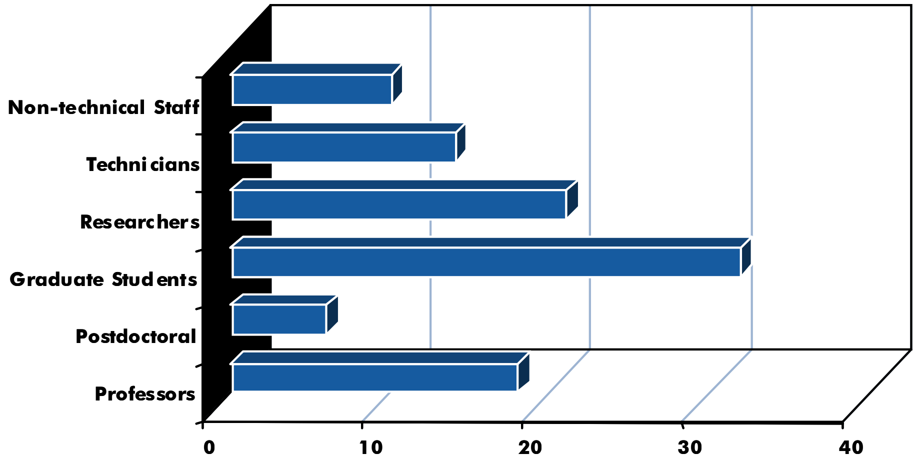
*Tracking of post-graduation employment at two-year colleges is more complete than for four-year institutions; however, an unexpected high percentage of graduates in the general workforce category was likely due to survey respondent misinterpretation.*

## 5.1.2 National Academic Faculty and Staff

Characterizing faculty and staff demographics at U.S. academic institutions provides insight into future as well as current capabilities of the nation's ocean sciences workforce, and includes studying the nation's faculty and staff by position (e.g., full professor, researcher), area of study, race, and gender. Based on responses by 75 programs to this inventory, available research funding in AY2002 supported an academic workforce of 8,361. Figure 5-5 depicts the distribution of the academic workforce supported specifically by research funding broken out by occupation (e.g., professor, technician). It shows that graduate students are the largest contingency of the academic workforce supported by research funding. As previously stated, this is their greatest means of financial support during their tenure at academic institutions.

[d] *The assumptions in the preceding paragraphs are based on the CORE report.*

**Figure 5-5: Academic Faculty and Staff, *Data from AY2002***

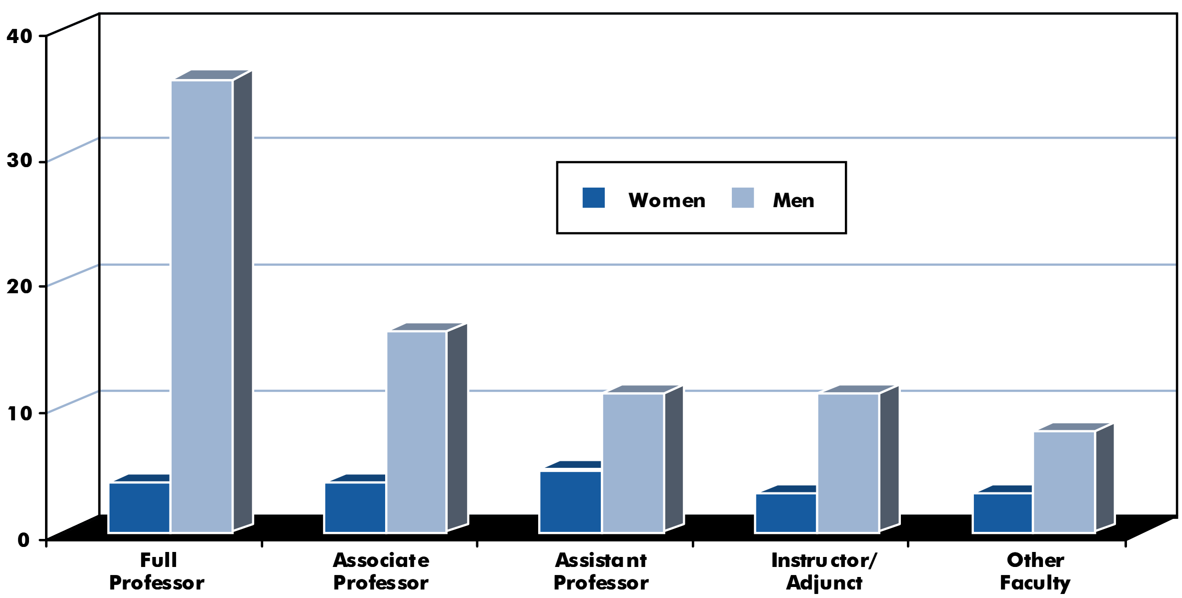



*In terms of faculty supported strictly by research funding, graduate students comprise the greatest percentage (30). Research funding specifically supported these faculty members.*

## 5.1.2.1 Faculty for Graduate and Undergraduate Programs

Respondents from 86 institutions of the 90 queried for this inventory reported 2,562 faculty involved in undergraduate and graduate programs. Figure 5-6 classifies these faculty members by occupation and gender. The low number of women in senior faculty positions can be attributed to the relatively low number of women receiving advanced degrees in the past. This has changed with the increased percentage of doctorates being received by women in the

**Figure 5-6: Faculty and Staff in Graduate and Undergraduate Programs by Gender**
***Data from AY2002***




*Low percentages of women in senior faculty positions is most likely due to past trends of low numbers of women graduating with doctorates. This is expected to shift with the increasing number of women in graduate studies.*

past 5 to 8 years (approximately 25 to 30 percent). Based on the current enrollment in ocean sciences academic programs, the number of women in senior faculty positions is expected to increase. A National Research Council panel reported that women represent a growing percentage of the overall scientific workforce, increasing from 7 percent in 1973 to 22 percent in 1999.[2]

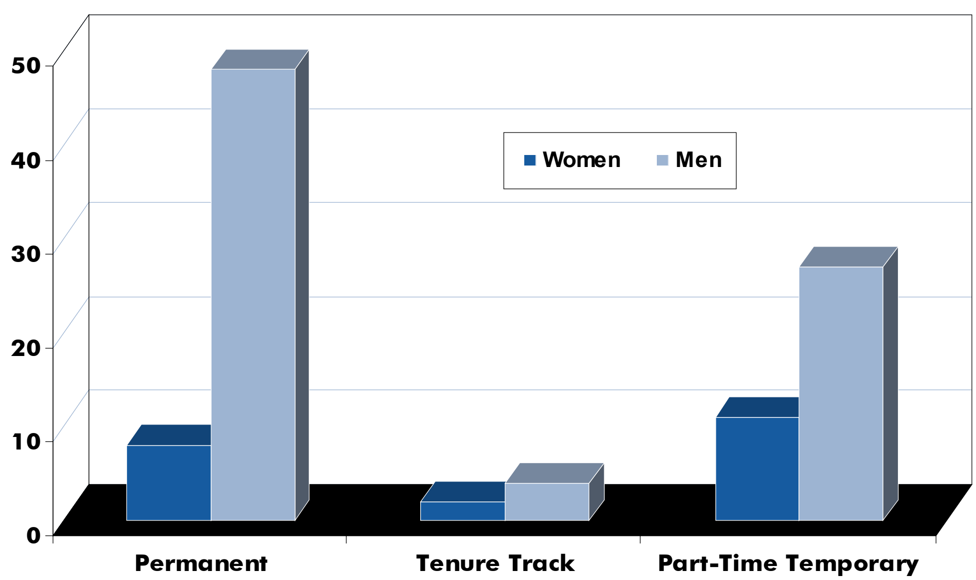
Racial distribution was reported for 91 percent of the faculty. Of this percentage, 88 percent were white, while African-Americans, Hispanic Americans, Asian Americans, and Native Americans were each under 7 percent. African Americans and Hispanic Americans fill just eight percent of all science and engineering positions in the U.S. each—a third of their representation in the general population.[3] The face of the ocean sciences community is evolving, however, and is expected to continue to evolve, as women and minorities increase their representation in the previously discussed academic programs.

Based on the current enrollment in ocean sciences academic programs, the number of women in senior faculty positions is expected to increase.

## 5.1.2.2 Faculty and Staff for Two-Year Programs

Faculty categories are defined differently for two-year programs than for graduate and undergraduate programs because they have a different structure. Of the programs included in this inventory, tenure was available at few two-year institutions, and tenured faculty comprise less than 10 percent of the permanent positions (Figure 5-7). Many faculty members were classified as part-time temporary, although the full-time permanent positions that were not tenured comprised the majority. In terms of gender, this two-year faculty breaks down to 20 percent women and 80 percent men.

**Figure 5-7: Faculty in Graduate & Undergraduate Programs by Gender**
***Data from AY2002***




*While only a limited number of faculty positions offer tenure, a large percent of faculty are in permanent positions.*

### 5.1.2.3 Postdoctorates

Respondents from 59 programs reported 561 postdoctoral researchers as of May 2002, yielding the following data:

- The 59 programs reported 67 percent of their postdoctoral research staff were men and 33 percent were women. Recently released data from the National Science Foundation (NSF) on doctorates earned during AY2001 show a similar figure (33 percent) for women earning science and engineering degrees.[1]
- Of the 59 programs, 58 provided citizenship data on their postdoctoral researchers, showing almost an equal number of foreign and U.S. citizens. Thirty-one programs provided data on the racial distribution of postdoctoral staff who were U.S. citizens. Of those positions, all but nine postdoctoral researchers were white.

## 5.1.3 National Academic Infrastructure

The infrastructure that supports ocean-related academic programs includes vessels, laboratories, and specialized equipment. For the purpose of this Appendix, discussion focuses on non-University-National Oceanographic Laboratory System (UNOLS) vessels. Of the 131 academic programs from which data were requested, 66 percent provided data as to infrastructure type, number, ownership, age, and plans for replacement.

Of the vessels for which data were provided, approximately 60 percent of the vessels greater than 25 feet are less than 20 years old, with 25 percent being 10 years old or less. Many of these vessels are reaching the end of their functional life span, and very few institutions have replacement plans for their facilities (approximately 23 percent to 36 percent). A number of programs surveyed noted that the primary factor preventing preparation of replacement plans is a lack of available funding.

Supplement 5-1 provides a list of 64 academic institutions and their non-UNOLS vessels, laboratories, and specialized equipment, by region. While this is not an exhaustive compilation of universities and their resources, it is a substantial cross-section of facilities nationwide. In addition to highlighting the unique aspects at each institution, data on students and faculty are included where possible. The institutions themselves own a majority of the resources they utilize. The federal government is the second most frequently listed owner, primarily for special instrumentation, underwater vehicles and large research vessels. States own a small number of research vessels of various sizes and a larger number of buildings and laboratories at the academic institutions. Additional data regarding academic facilities used for research, academic vessels and laboratories, and UNOLS are provided in Chapter 4 of this Appendix.

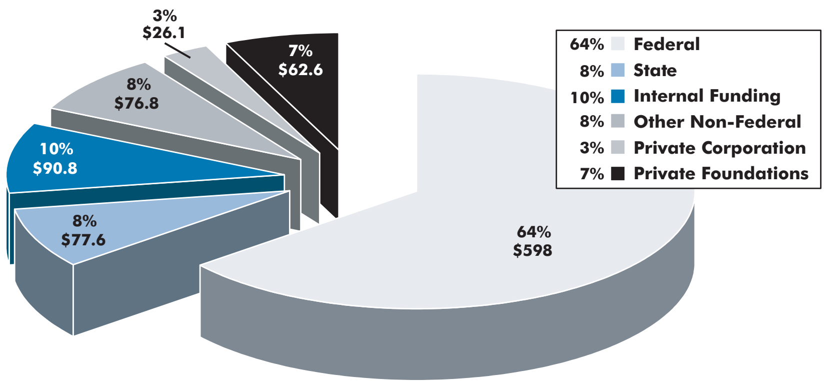
## 5.1.4 National Academic Funding

Adequate funding is the primary resource that drives the capability of all of the previously discussed resources. For this inventory, funding was examined to determine the primary sources, any increases or decreases over time, and how it is divided among the academic institutions. The Commission received 79 responses from the 131 programs surveyed.

Total ocean-related research support in AY2002 was $932 million for the survey respondents. The federal government was the greatest source of funding, with $598 million, or about 64 percent of the total. The remaining funding sources were each less than 10 percent of the total. The breakout for these funding sources is presented in Figure 5-8.

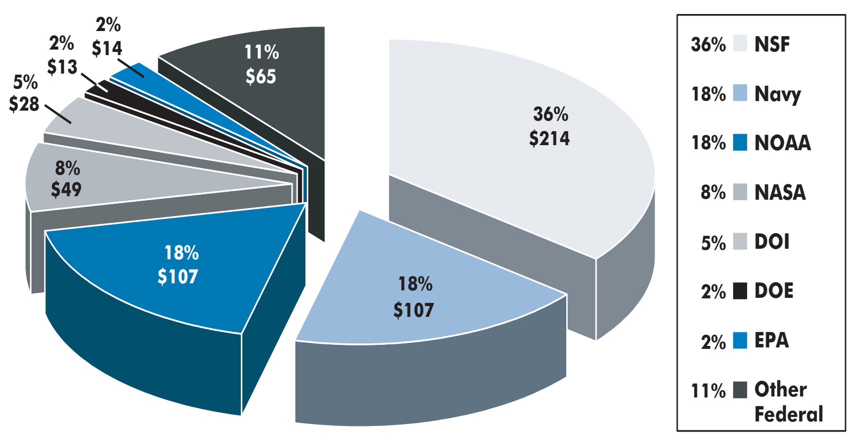
Figure 5-9 delineates federal funding for the ocean sciences by agency. NSF provided the largest amount of federal funding during AY2002, contributing more than a third of the total federal funding for the ocean sciences. This amount equals the combined investment of the next two largest federal funding sources, the U.S. Navy and the National Oceanic and Atmospheric

**Figure 5-8: Sources of Academic Funding Overall**
***Data from AY2002 ($ Millions)***




*Federal funding is by far the greatest source of financial support to the nation's academic institutions, contributing approximately 64 percent of the total funding in AY2002.*

**Figure 5-9: Sources of Funding for Academic Research Federal**
***Data from AY2002 ($ Millions)***




*Of the eight federal funding categories studied, the National Science Foundation was the predominant source, contributing nearly 36 percent of the total in AY2002.*

Administration (NOAA), who each contributed approximately 18 percent to the total federal funding. The remaining federal agencies provided a combined total of approximately 28 percent toward the total federal funding in AY2002.

### 5.1.4.1 Funding at Selected Ocean Sciences Programs

Because the 10 original members of the Joint Oceanographic Institutions (JOI)[e] have the largest and most comprehensive ocean sciences research programs, they were selected to compare funding trends between AY1997 and AY2002. Supplement 5-2 of this Appendix contains a brief overview of each institution. These schools receive 47 percent ($439.5 million) of all research dollars in the ocean sciences — almost 53 percent ($314.4 million) of the federal source funds — and employed about 43 percent of the related workforce in AY2002.

The total amount of funding spent on research at the JOI programs increased marginally from $398.8 million in AY1997 to $439.5 million in AY2002 (10.2 percent). These numbers were not adjusted for inflation; therefore, the actual increase is likely smaller. Table 5-5 illustrates the overall funding comparisons for the selected programs, comparing AY1997 and AY2002.

The federal government remains the largest source of funding for the ocean sciences at the JOI programs, but federal funding is decreasing in terms of percentage of the selected programs' total funding. In AY2002, the federal government provided 71.6 percent ($314.5 million) of the total funding for the selected programs. This is a decrease of 5.6 percent from AY1997 when federal funds comprised 85 percent ($337.4 million) of the research dollars.

**Table 5-5: Funding Comparisons at JOI Program Institutions**
***Data from AY1997 and AY2002 ($ Millions, rounded)***

| Funding Source | AY1997 | AY2002 |
|---|---|---|
| Federal | $337.4 (85%) | $314.5 (72%) |
| State & Local | $37.7 (9%) | $21.2 (5%) |
| Private | $23.1 (6%) | $15.2 (4%) |
| Other Non-Federal | $0.5% (0%) | $88.8 (22%) |

*While the total funding amount increased slightly from AY1997 to AY2002 at the selected JOI programs, federal funding decreased. This decrease has resulted in institutions using partnerships and innovative means for securing adequate funding for their programs.*

[e] *The 10 original members of the JOI are Columbia University (Lamont-Doherty Earth Observatory), Oregon State University (College of Oceanic and Atmospheric Sciences), Texas A&M University (College of Geosciences), University of California at San Diego (Scripps Institution of Oceanography), University of Hawaii (School of Ocean & Earth Science & Technology), University of Miami (Rosentiel School of Marine & Atmospheric Sciences), University of Rhode Island (Graduate School of Oceanography), University of Texas at Austin (Institute for Geophysics), University of Washington (School of Oceanography), and Woods Hole Oceanographic Institution.*

Table 5-6 illustrates the breakout, by school, of the federal funding in AY1997 compared with AY2002.

From AY1997 to AY2002, only three federal agencies — NSF, the National Aeronautics and Space Administration (NASA) and the U.S. Geological Survey (USGS) — increased their support for ocean science study at the selected programs. NSF increased its research support by approximately $13.6 million from AY1997 to AY2002, and now provides 42.6 percent ($134.1 million) of the federal funds supporting the selected programs.

Among the federal agencies, funding from the U.S. Navy has seen the biggest decline during this five-year period, from 24.8 percent ($83.8 million) of total federal funding in AY1997 to 19.6 percent ($61.6 million) in AY2002. State and local support of ocean research at the selected programs also has decreased substantially, from 9.6 percent ($37.7 million) in AY1997 to 4.8 percent ($21.2 million) in AY2002.

Despite the overall declines in total federal, state, and private research funding, the research budgets of the 10 selected programs have increased by 10.2 percent since AY1997. The only funding category to show substantial increases is the catchall "other non-federal research," which grew from less

The U.S. Navy has seen the biggest decline during this five-year period, from 24.8 percent ($83.8 million) of total federal funding in AY1997 to 19.6 percent ($61.6 million) in AY2002.

**Table 5-6: Sources of Federal Funding for Academic Research at JOI Program Institutions**
***Data for AY1997 and AY2002 ($ Million)***

| University | Academic Year | Federal Agency | | | | | | | | | Total Federal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NSF | U.S. Navy | Other DoD | NOAA | NASA | DOI | EPA | DOE | Other Federal | |
| **USCD-SIO** | AY97 | 26.2 | 17.9 | 4.3 | 8.8 | 4.0 | 1.0 | - | 1.8 | 14.0 | 78.9 |
| | AY02 | 36.0 | 6.8 | 1.4 | 11.9 | 6.8 | 0.0 | 0.0 | 2.1 | 30.4 | 95.4 |
| **Columbia** | AY97 | 15.0 | 2.0 | 0.0 | 10.3 | 2.0 | 0.5 | - | 0.8 | 10.6 | 41.2 |
| | AY02 | 18.2 | 1.3 | 1.5 | 1.5 | 1.6 | 0.6 | 0.0 | 0.0 | 10.2 | 34.9 |
| **U. Hawaii** | AY97 | 10.6 | 4.0 | 4.0 | 13.0 | 3.0 | - | - | - | 2.6 | 38.1 |
| | AY02 | 11.0 | 4.2 | 2.0 | 16.8 | 4.2 | 9.2 | 0.0 | 0.5 | 0.0 | 47.9 |
| **U. Miami** | AY97 | 7.5 | 4.9 | 0.0 | 4.2 | 4.0 | - | 0.6 | 0.4 | 2.8 | 24.4 |
| | AY02 | 0.2 | 0.4 | - | 0.2 | 0.1 | - | - | - | - | 0.9 |
| **OSU** | AY97 | 7.5 | 5.9 | - | 0.3 | 3.5 | 0.4 | - | 0.2 | 2.3 | 20.1 |
| | AY02 | 12.9 | 3.9 | 0.0 | 0.0 | 6.7 | 0.3 | 0.0 | 0.1 | 0.3 | 24.2 |
| **URI** | AY97 | 7.7 | 3.0 | - | 5.9 | 1.1 | - | 0.4 | - | 4.6 | 22.7 |
| | AY02 | 4.6 | 5.5 | - | 3.0 | 9.8 | 0.2 | 0.2 | 0.0 | 6.4 | 29.7 |
| **TAMU** | AY97 | 1.4 | 0.1 | - | 0.2 | - | 1.0 | 0.1 | 0.1 | 0.2 | 3.1 |
| | AY02 | 1.6 | 0.7 | - | 0.5 | 0.2 | 1.5 | 0.0 | - | 0.4 | 4.9 |
| **UTIG** | AY97 | 2.6 | 0.5 | - | 0.0 | - | 0.0 | - | - | 0.0 | 3.1 |
| | AY02 | 1.9 | 0.5 | 0.0 | - | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 2.6 |
| **UW** | AY97 | 8.9 | 25.4 | 0.0 | 3.3 | 0.3 | - | - | 1.0 | 6.1 | 45.0 |
| | AY02 | 7.8 | 4.6 | - | 0.1 | 0.4 | 0.2 | 0.0 | 0.0 | 2.7 | 15.8 |
| **WHOI** | AY97 | 33.2 | 20.1 | 1.7 | 2.1 | 1.0 | 0.7 | 0.1 | 1.1 | 0.4 | 60.4 |
| | AY02 | 32.3 | 16.3 | - | 5.1 | 0.8 | 0.9 | 0.0 | 0.2 | 7.5 | 63.1 |

*Of the federal agencies studied, only NSF, NASA, and USGS increased their funding at the selected programs from AY1997 to AY2002. Despite this, nearly all of these schools increased their overall funding largely through unique funding initiatives.*
*OSU - Oregon State University, URI - University of Rhode Island, TAMU - Texas A&M University , UTIG - University of Texas at Austin, UW - University of Washington*

than $1 million in AY1997 to over $88 million in AY2002. This increase may be attributed to several factors:

- Programs did not provide sufficient information to classify funding under a more appropriate category
- Programs are receiving greater support from nontraditional funding sources
- There has been a growth in partnerships and matching arrangements for funding purposes (examples include The National Oceanographic Partnership Program and the National Sea Grant College Program).

### 5.1.4.2 Funding Allocation: Comparison of JOI Programs to Other Programs

Although the 10 JOI programs are among the nation's largest, they are only an indicative subset of the ocean sciences academic community. For this reason, the JOI programs were compared to the remaining 76 programs that were part of this inventory, using the AY2002 data.

Federal agencies provide the greatest source of funding. Federal support comprised roughly 72 percent of all research funding at the JOI programs compared with 58 percent for the non-JOI programs. The non-JOI programs appear to make up this difference through a greater reliance on funding from state governments, private corporations, and private foundations.

For JOI programs, the primary federal funding sources were NSF (42.6 percent), the U.S. Navy (24.8 percent) and NOAA (14.3 percent). These agencies also provided a significant portion of the research budgets of

**National Sea Grant College Program**

The National Sea Grant College Program is committed to enhancing the practical use and conservation of coastal, marine, and Great Lakes resources to create a sustainable economy and environment. Efforts include educational programs for students and professional development opportunities for teachers. Faculty and students at over 300 universities have participated in the Sea Grant Program during the last five years.[4] Since its inception in 1966, the National Sea Grant College Program has supported more than 12,000 undergraduate and graduate students in disciplines ranging from oceanography to engineering to economics. Additionally, 479 graduate students have completed the yearlong Knauss Marine Policy Fellowship in Washington, D.C. As of 2000, the 2-week Operation Pathfinder courses in marine sciences trained over 700 teachers who in turn trained 14,000 other professionals who have the potential to educate 5.5 million K-12 students.[5]

non-JOI programs as follows: NSF (28.3 percent), NOAA (21.0 percent), and the U.S. Navy (16.1 percent). Table 5-7 illustrates federal funding for all programs, and funding for the selected programs versus all other programs.

NOAA funding offers the greatest parity between the JOI programs and non-JOI programs. NOAA provided a total of $107.4 million, with the 10 JOI programs receiving 44 percent of this total. In contrast, the U.S. Navy, NASA, and NSF invested more heavily in the JOI programs. For example, U.S. Navy funding totaled $107.3 million, of which 57 percent went to JOI programs; 54 percent of NASA's $49.0 million was awarded to JOI programs. Additionally, NSF invested $214.4 million, or 63 percent of its funding, in JOI programs, while $80.3 million, or 37 percent, of NSF support went to non-JOI programs. By contrast, the ocean science research funds from the U.S. Environmental Protection Agency (EPA), USGS, the Minerals Management Service, and the U.S. Department of Energy generally support coastal and applied research and go predominantly to non-JOI institutions in the study.

**Table 5-7: JOI Programs versus Non-JOI Programs, Major Federal Funding Sources. *Data from AY2002 ($ Million)***

| Federal Funding Agency | All Programs | JOI Programs | All Other Programs |
|---|---|---|---|
| NSF | 214.4 | 134.5 (62.7%) | 80.3 (37.5%) |
| U.S. Navy | 107.3 | 61.6 (57.4%) | 45.7 (42.6%) |
| NOAA | 107.4 | 47.7 (44.4%) | 59.6 (55.5%) |
| NASA | 49.1 | 26.5 (54.0%) | 22.6 (46.0%) |
| DOI | 27.8 | 7.8 (28.1%) | 20.0 (71.9%) |
| USEPA | 14.1 | 1.4 (10%) | 12.6 (89.4%) |
| DOE | 12.6 | 3.8 (30.2%) | 8.8 (69.8%) |
| Other Federal | 65.3 | 31.4 (48.1%) | 33.9 (51.9%) |
| Total Federal | 598.0* | 314.6** | 283.5 *** |

*While JOI programs typically receive a greater percentage of the available funding from NSF, Navy, NOAA, and NASA, non-JOI programs typically receive a greater percentage of the available funding from DOI, DOE, and other federal agencies.*

## 5.1.5 Maritime Education and Professional Training

Approximately 1.25 million seafarers are employed worldwide in the shipping industry, which relies heavily on the expertise of U.S. maritime officers.[6] These officers receive their training from one of the seven U.S. maritime academies. While the previous discussions on academic institutions included data from the maritime academies, this section focuses on the unique aspects of the maritime academies and professional maritime institutions. The maritime academies focus on educating future marine officers, while the professional marine institutions focus more on providing post-graduate and professional training.

Ships' officers must be qualified in the competence standards required by the Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) Convention. Officers are only permitted to work on internationally trading ships if they hold STCW certificates in either the deck or the engine departments. These certificates are typically awarded after a year or more of on-board training at sea, in addition to shore-based education and training in college. Depending on the national system, most newly qualified officers typically have between three and four years of total training. Domestically, merchant mariners are subject to national licensing requirements, as promulgated by the U.S. Coast Guard. This section examines trends affecting maritime education and vocational training, as well as the potential sources for obtaining this education and training.

### 5.1.5.1 Trends in Maritime Education anhd Workforce

Trends in maritime education at the nation's seven maritime academies have a significant impact on workforce capabilities. This discussion focuses on some of the barriers to the workforce and their impact on the recruitment of mariners.

The 1995 STCW amendments (STCW-95) impose strict training requirements on the mariner, maritime education and training institutions, and the industry as a whole. The system makes it nearly impossible for an unlicensed mariner to become a licensed officer independently. The time and cost involved in maintaining unlicensed and licensed qualifications are a significant deterrent to the recruitment and retention of mariners. The proliferation of state and local safety and environmental statutory and regulatory regimes that overlap across the international and U.S. systems create an additional concern. Many professionals in the maritime trade cite STCW-95 as a significant deterrent to young people entering the profession. [6]

The U.S. Merchant Marine, as in other Organization for Economic Cooperation and Development countries, has been impacted by a critical loss of professional mariners in recent years. According to the Baltic and International Maritime Council/International Shipping Federation (BIMCO/ISF) *2000 Manpower Update*, [7] the current shortfall of 16,000 officers worldwide could reach 46,000 within 10 years, unless there is a significant increase in new recruits. Speaking at a conference organized by the Danish Maritime Authority held in July 2002, Mr. Bjarne Tvilde, vice president of BIMCO, stated that the industry could no longer hide shortfalls through reductions in crew size per ship. He added that, while the replacement of older, more labor-intensive ships will bring some economy in manpower, the ships of 5 to 10 years from now "will probably have a crew much the same size as that of a new ship today."[8]

According to proceedings of the Maritime Careers Conference held in May 2002, the shortfall in the U.S. Merchant Marine crewing force can be attributed to a lack of general public awareness of the value and critical need for the U.S. Marine Transportation System as a component of the U.S. intermodal national transportation system. Current national security issues have heightened this value and critical need. Another more recent barrier to recruitment and retention, as identified in the conference proceedings, is criminal liability for pollution incidents.[9]

The Maritime Careers Conference proceedings noted the lifestyle of mariners is characterized by significant time away from home and family. Living aboard vessels involves close accommodations, lack of socialization opportunities with small crews, and quick-turnaround times in port with little or no opportunity for shore leave. Crew reductions due to the replacement of human labor with technological resources leave more administrative and maintenance work for fewer crew members.[9]

Finally, there is no central source of information where potential mariners can determine how to enter the industry or obtain career path information. Many marine industry positions leave little opportunity for or lack a planned career path compared to many other occupations. STCW-95 has also impacted this issue. Tough requirements paired with a lack of information on recruiting and clear upward mobility opportunities are deterrents and lead to short careers for existing mariners.

### 5.1.5.2 Federal and State Maritime Academies

The United States has several institutions where future mariners acquire the requisite education and training to become professionals in the maritime community and pursue specialized advanced education. Maritime institutions are located in most coastal regions of the nation. In addition to the U.S. Merchant Marine Academy, the nation's only federal academy, six state academies graduate qualified mariners:

- U.S. Merchant Marine Academy, Kings Point, New York
- California Maritime Academy, Vallejo, California
- Great Lakes Maritime Academy, Traverse City, Michigan
- Maine Maritime Academy, Castine, Maine
- Massachusetts Maritime Academy, Cape Cod, Massachusetts
- State University of New York Maritime College, Throggs Neck, New York
- Texas Maritime Academy, Galveston, Texas.

Additional information regarding the location, degrees and certifications, and unique attributes for these academies is provided in Supplement 5-3. Degree programs range from marine transportation and engineering to business administration. Most of these academies blend classroom education with at-sea programs and offer graduates the opportunity to become commissioned maritime officers.

### 5.1.5.3 Maritime Graduate and Continuing Education

In addition to the seven academies listed above, there are several graduate and continuing education institutions in the United States for maritime studies. These institutions tend to provide more specialized maritime training for seafarers than undergraduate maritime academies. The graduate and continuing education institutions include:

- Seattle Maritime College, Seattle, Washington
- Calhoon Marine Engineers' Beneficial Association Engineering School, Easton, Maryland
- Marine Institute of Technology and Graduate Studies, Linthicum Heights, Maryland
- Simulation, Training, Assessment, and Research Center, Toledo, Ohio, and Dania Beach, Florida
- Elkins Marine Training International, Petaluma, California
- Pacific Marine Institute, Seattle, Washington
- Port Canaveral Maritime Academy, Port Canaveral, Florida
- Resolve Fire and Hazard Response, Everglades, Florida.

Programs range from vocational education to technical training and licensure. A majority of these institutions provide STCW-95 certification and combine classroom education with hands-on training. These institutions also provide a range of specialized courses in safety, firefighting, and U.S. Coast Guard-certified programs. Additional information regarding the location, programs offered, and unique attributes for each institution can be found in Supplement 5-4.

# 5.2 Federal Outreach and Education Programs — Virtual Facilities

As discussed in Section 5.1.3, federal agencies are a significant source of funding for academic institutions. In addition, they also offer marine-related educational programs and materials for students of all academic levels, educators, and the public. While these programs and materials are not "facilities" as defined in this Appendix, they are important educational resources. These resources include on-line tutorials, lesson plans, information packets, fact sheets, educator workshops, and other educational programs. In addition to formal educational materials for educators and students, these agencies offer numerous informal outreach programs dedicated to ocean sciences education. The resources each agency provides are typically in line with its mission. The discussion below highlights some of these facilities, but is not comprehensive. This information is primarily based on each agency's submittal to the Commission and supplemented as necessary through Internet research on agency web sites.

## 5.2.1 National Oceanic and Atmospheric Administration Outreach

NOAA's educational resources reflect the agency's mission to describe and predict changes in the Earth's environment, and conserve and wisely manage the nation's coastal and marine resources. The National Ocean Service provides educational materials about oceans, coasts, and charting and navigation through online tutorials and educational Roadmap to Resources guides for teachers and students. The Ocean Explorer web site offers lesson plans and opportunities for teachers to participate in expeditions. In addition, the Ocean Explorer web site provides a platform for students to follow ocean explorations in near real-time, learn about ocean exploration technologies, observe remote marine flora and fauna in the multimedia gallery, review NOAA's history, and discover additional resources in a virtual library.[10] NOAA also provides educational resources through its main education web site. The site is designed to help students, teachers, librarians, and the general public access many educational activities and publications.[11]

NOAA's National Sea Grant College Program provides educational opportunities and resources. A partnership between NOAA and universities, the program offers teaching curriculum, training, and other learning opportunities.

## 5.2.2 U.S. Environmental Protection Agency Outreach

The mission of EPA's Office of Environmental Education is to advance and support education efforts that develop an environmentally conscious and responsible public. To accomplish this, EPA offers a wide variety of education and outreach resources. The agency's collection of fact sheets, brochures, and web sites for teachers to explain environmental issues provides basic and clear information to facilitate teaching students about the environment.

Similar resources are available to educate the general public. The Environmental Education and Training Partnership is the national training program established through the National Environmental Education Act of 1990, and is implemented by a consortium of national partner organizations under the leadership of the University of Wisconsin-Stevens Point. The program's mission is to deliver training and support services to education professionals to advance education and environmental literacy in the United States.[11]

## 5.2.3 National Aeronautics and Space Administration Outreach

NASA's mission includes the advancement of human exploration, use, and development of space as well as the advancement and communication of scientific knowledge and understanding of the Earth (including its oceans), the solar system, and the universe. NASA provides numerous educational opportunities that reflect its commitment to this mission. NASA's Spacelink is a virtual library in which local files and hundreds of NASA web sites are arranged in a manner familiar to educators. Teacher preparation and enhancement activities include workshops, courses, and internships that serve to update skills and enrich and strengthen the theoretical and practical basis for classroom and laboratory instruction. Student support includes enrichment activities such as brief courses, summer workshops, and hands-on science education experiences that expose students to Earth system science subjects and processes.[13] The Educator Resource Network Center provides educators with in-service and pre-service training, demonstrations, and access to NASA instructional products. NASA has established a standard that requires all of NASA's printed educational materials to be available via the Internet.[14] Informal education and outreach programs include The Dynamic Earth, Earth and Sky Broadcast Fellowship, and Forces of Change.

## 5.2.5 U.S. Department of the Interior Outreach

The Department of the Interior (DOI) has many organizations, each with its own unique mission. One division of DOI, The Minerals Management Service, has the primary mission of managing the mineral resources on the Outer Continental Shelf in an environmentally sound and safe manner. DOI provides books and activities about energy, several hands-on activity guides, and teacher and student educational workshops. In addition, the Minerals Management Service's regional web sites contain educational and outreach materials specific to each region.[15]

Part of DOI's National Park Service mission is to conserve national parks for future generations through a variety of resources. LearnNPS is an online resource for teachers searching for classroom materials, students doing research, and the general public. The different zones direct users through a multitude of resources and programs The GoZONE is an area of the National Park Service web site that provides outreach information and activities for the general public.[16]

The U.S. Fish and Wildlife Service helps promote its mission of conserving fish, wildlife, plants, and their habitats primarily through its National Conservation Training Center. The Center has diverse course offerings and the ability to provide remote training. In addition, U.S. Fish and Wildlife Service has numerous online educational materials such as videos, maps, and publications that cater to students, educators, and the general public.[17]

USGS's mission of managing water resources and describing and understanding the Earth is reflected in its various educational web sites, including:

- The Learning Web – dedicated to K-12 education with online resources for students and teachers (lesson plans, research projects, and so forth)
- The Kids Corner – games, activities, projects, and quizzes (preschool and up)
- The Learning Room – online access to publications, homework help, and interesting links (mid-elementary and older).

Additionally, USGS has educational fact sheets, posters, and interactive maps intended for use by educators.[18]

## 5.2.6 National Science Foundation Outreach

NSF's primary mission is to promote the progress of science; advance national health, prosperity, and welfare; and secure national defense. In addition to the education-related grants and awards in all areas of science, mathematics, and engineering education, NSF supports several education and outreach initiatives. Among its resources, the What's Cool web pages offer hands-on learning activities and games for kids and parents; teaching materials for educators and students; and lectures by distinguished scientists, engineers, and educators. A relatively new program, Centers for Ocean Sciences Education Excellence, is building a nationally coordinated effort in ocean science education designed to integrate ocean science research into delivery of high-quality education programs in the ocean sciences.[19]

### 5.2.7 U.S. Navy Outreach

The U.S. Navy, through the Office of Naval Research, the Oceanographer of the Navy, and the Naval Meteorology and Oceanography Command, provides numerous opportunities for the public to learn about the marine environment. Through interactive web sites, videos, science fairs and other outreach efforts, the Navy supports a variety of mechanisms for capturing and nurturing public interest in the ocean. Special programs include:

- The International Hydrographic Science Applications Program (partnership with University of Southern Mississippi)
- The International Hydrographic Management and Engineering Program
- The OCEANS ALIVE outreach program for students and teachers (focus on naval oceanography)
- The Sea Scholars program – designed for K-12 teachers
- The Ocean Science Mentoring Program
- The Naval High School Science Awards Program
- The Naval Research Enterprise Intern Program.[20]

## 5.3 U.S. Informal Education and Outreach Facilities

Supplementing the formal education resources discussed in the first part of this chapter, numerous informal education and outreach facilities provide learning opportunities about ocean and coastal resources. For the purpose of the inventory, this section focuses on two key areas:

- Facilities in the natural environment, such as marine protected areas (MPAs)
- Zoos, aquariums, and museums that allow the public to learn about ocean and coastal environments even when they are not locally accessible.

MPAs, established to preserve the nation's diverse marine ecosystems, serve to educate the public about the ocean and coastal sciences and unique marine environments through site-specific, interactive, and educational programs. These facilities also educate decision makers who can influence coastal and ocean resource conservation. MPAs include national marine sanctuaries, national seashores, national parks, national monuments, critical habitats, national wildlife refuges, national estuarine research reserves, state conservation areas, and state reserves. Discussion of MPAs is primarily based on Internet research.

Zoos, aquariums, and museums are located across the country and, unlike many marine facilities, are not limited to coastal areas. The nation's zoos, aquariums, and museums form a network of educational institutions that target the public with an array of educational opportunities about oceans, coasts, and the Great Lakes in addition to initiatives in environmental conservation and research. These facilities continue to expand and increase in number in order to keep pace with current educational and conservation needs. A 1996 poll by the Mellman Group named aquariums as the third most trusted messenger concerning conservation and the environment.[21] Discussion regarding zoos, aquariums, and museums is largely based on information provided to the Commission and supplemented through Internet research.

## 5.3.1 Marine Protected Areas

MPAs have different characteristics, and have been established for different purposes, but share a common goal of providing educational opportunities for the public in a natural environment. As required by Executive Order 13158, which established MPAs, an effort to inventory these sites is underway.[22] To date, 328 MPAs have been identified, with the majority falling under federal jurisdiction. The agencies under DOI and NOAA are the principal managers of MPAs. Additional information regarding the inventory is available on the MPA Web site (www.mpa.gov).[22]

Table 5-7 illustrates some of the types, numbers, general missions, and legislation that established the nation's federal MPAs. Additional federal sites include the extensive number of national parks, national wildlife refuges, federal threatened and endangered critical habitat sites, and federal threatened and endangered species protected areas.

The 14 National Marine Sanctuaries described in Table 5-8 are located in nearly every region of the United States, with the largest concentration in the Pacific and Western Pacific regions.[23] Additional information regarding the size, designation year, unique characteristics, and educational opportunities for each of these sanctuaries is included in Supplement 5-5.

NOAA's National Estuarine Research Reserve System (NERRS) contains reserves in nearly every region of the United States, with a greater concentration on the East Coast.[24] Additional information regarding the size, designation year, unique characteristics, and educational opportunities for each of these reserves is included in Supplement 5-6.

Like NOAA's NERRS program, EPA's National Estuary Program is an example of a joint venture among federal, state, and local entities. There are 28 estuaries included in this program, dedicated to maintaining the integrity of the sites as well as educating and involving the general public in their natural environments.[25]

## Table 5-8: Marine Protected Areas

| Type of MPA | Total Number | Primary Goal | Governing Legislation |
|---|---|---|---|
| **National Marine Sanctuaries** | 14 | • Protect nearly 18,000 square miles of ocean waters and habitats.<br>• While some activities are regulated or prohibited in sanctuaries to protect resources, multiple uses such as recreation, commercial fishing, and shipping, are encouraged.<br>• Research, educational, and outreach activities are other major components in each sanctuary's program of resource protection. | National Marine Sanctuaries Act of 1972 |
| **National Estuarine Research Reserves*** | 25 | • The National Estuarine Research Reserve System's primary goal is to sustain healthy coasts by improving the nation's understanding of estuaries.<br>• These "living laboratories" are the subject of extensive research and education programs.<br>• Under the jurisdiction of NOAA. | Coastal Zone Management Act of 1972 |
| **National Estuary Program** | 28 | • Voluntary program brings communities together to improve their estuaries with EPA serving as the overall facilitator.<br>• The goal is to develop and implement a comprehensive conservation and management plan tailored to meet the specific needs of each estuary, while meeting national program requirements. | Water Quality Act of 1987 |
| **Federal Seashore, Lakeshore, and Coral Reef Parks** | 24 | • The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations.<br>• The National Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world. | The National Park Service Organic Act of 1916; National Interest Lands Conservation Act of 1980 |
| **National Wildlife Refuges** | 162 in marine coastal areas | • The National Wildlife Refuge System's mission is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, plant resources, and their habitats within the United States for the benefit of future generations of Americans. | National Wildlife Refuge Improvement Act of 1997 formalized mission established in 1903 |

* *Estuarine research reserves are federal/state partnerships.*

There are 24 national seashore, lakeshore, and coral reef parks. Under the National Park Service's jurisdiction, these parks are located in nearly every region of the United States, with aspects unique to their regions. Supplement 5-7 contains additional information regarding the designation year, size, 2001-2002 attendance, and educational opportunities for each of these parks. Collectively, these parks received a total of more than 23 million visitors in 2001-2002.[26]

States also administer numerous seashore and lakeshore parks. For example, California has over 260 state parks, with 150 of those being in coastal areas.[27] Alaska has more than 3.2 million acres of state park lands. Although a centralized list of these parks is not available to date, several efforts are underway to quantify them. These parks provide a range of educational opportunities to the many visitors they host each year.

### 5.3.2 MPAs as an Educational Resource

Interpretive exhibits and programs provided at MPAs offer recreational and educational experiences to the general public and assist the MPAs in carrying out their missions. Educational programs at these facilities are diverse, and focus on the local and regional ecosystems they support. This section offers examples of such programs at different types of MPAs.

National Marine Sanctuaries offer a wide range of unique educational opportunities to the public. For example, Monterey Bay National Marine Sanctuary in California, the largest sanctuary at 5,300 acres, provides public outreach through exhibits, publications, programs, events, and services. The Florida Keys National Marine Sanctuary is known worldwide for its extensive offshore coral reefs, and a number of the educational programs focus on the importance of this resource. Supplement 5-5 of this Appendix contains more detailed information on the available educational programs at the National Marine Sanctuaries.[23]

Decision makers in the position to affect coastal resources are the primary targets of the NERRS Coastal Decision-Maker Workshop series. These workshops focus on local and regional coastal resource issues important to citizens, landowners, interest groups, and government officials.[25] Since 1994, through workshops and seminars, estuarine reserves efforts have reached over 13,000 coastal decision makers. These programs have enhanced decision-making related to coastal issues, as well as increased coastal stewardship at the local and regional levels. In addition, most of the estuarine reserves, such as Narragansett Bay, Rhode Island, have interpretive hikes, tours, and hands-on exhibits available to the general public. Additional educational opportunities are included for all 25 reserves in Supplement 5-6.[24]

The Massachusetts Bays Program, one of EPA's six National Estuary Programs situated along the East Coast, recently completed a wide range of research, planning, and education efforts that culminated in the Comprehensive Conservation and Management Plan. The Lower Columbia River Estuary in

Oregon conducts hundreds of class visits, field trips, and on-river education programs. This estuary has also established a Kids for the Columbia Club and special Kids Club web site and newsletter.[28]

Assateague Island National Seashore along the Virginia and Maryland coasts is an example of one of the national seashore, lakeshore, and coral reef parks managed by the National Park Service. The park has programs that focus on beach conservation and marine species education. Buck Island Reef National Monument in the Virgin Islands has a famous underwater trail, which has been incorporated into an interpretive exhibit for visitors to the park. Supplement 5-7 provides additional detailed information regarding the educational opportunities at the 24 national seashore, lakeshore, and coastal reef parks.[26]

About 37 million people visit the National Wildlife Refuges every year for many reasons, including environmental education. Many visitors are children whose schools arrange day trips or long-term outdoor programs. Refuges provide outdoor classrooms for teaching children about art, science, and other disciplines, using nature as a context for learning.[29] Due to the large number of National Wildlife Refuges (162 marine and coastal), this Appendix does not include specific data on their educational resources.

The educational value of state seashore and lakeshore parks, which are located in every region of the nation, is similar to that of federal parks. For example, Indiana Dunes State Park spans over three miles of Lake Michigan shoreline and 2,182 acres. Educational facilities include a nature center and education staff that develops materials and conducts workshops focusing on Lake Michigan and the coastal environment. South Cape Beach State Park, Massachusetts, is a component of the Sauquoit Bay National Estuarine Research Reserve, and has over a mile of beach as well as interpretive programs during the summer.[30] In Washington, the Joseph Whidbey State Park located on Puget Sound provides hiking, biking, water activities and opportunities for observing wildlife within its 112-acre boundaries.[31] Due to the large number of state seashore and lakeshore parks, this Appendix does not include specific data on their educational resources.

While formal studies on the success of these educational programs are lacking, most of these facilities conduct some form of evaluation to measure the success of their educational resources. For example, the 2002 National Wildlife Refuge System Visitor Satisfaction Survey showed that 90 percent of the respondents were either satisfied or very satisfied with their educational and recreational experiences at refuges.[29]

## 5.3.3 Public and Private Zoos, Aquariums, and Museums

One of the primary missions of zoos, aquariums, and museums is to engage and enlighten the public about the Earth's different environments and the species that inhabit them. Aquariums focus their efforts specifically on ocean and coastal environments, while zoos and museums dedicate variable proportions of their exhibits to oceans and coasts. Additionally, most of these facilities conduct scientific research aimed at resource conservation. This section describes:

- Zoos and aquariums, which offer exposure to marine mammals and other sea creatures
- Museums, which offer a science-based educational perspective on marine animals, plants, and ecosystems.

The most inherent message that comes through in assessing these facilities is dedication to public interest and trust. The high volume of visitors from the general public paired with the numbers of students and teachers who benefit from these facilities illustrate this message. They continue to expand and grow in number to meet the demands of the viewing public. Another key factor to their success is they are not limited to coastal areas. One can find zoos, aquariums, and museums across the nation, including inland areas.

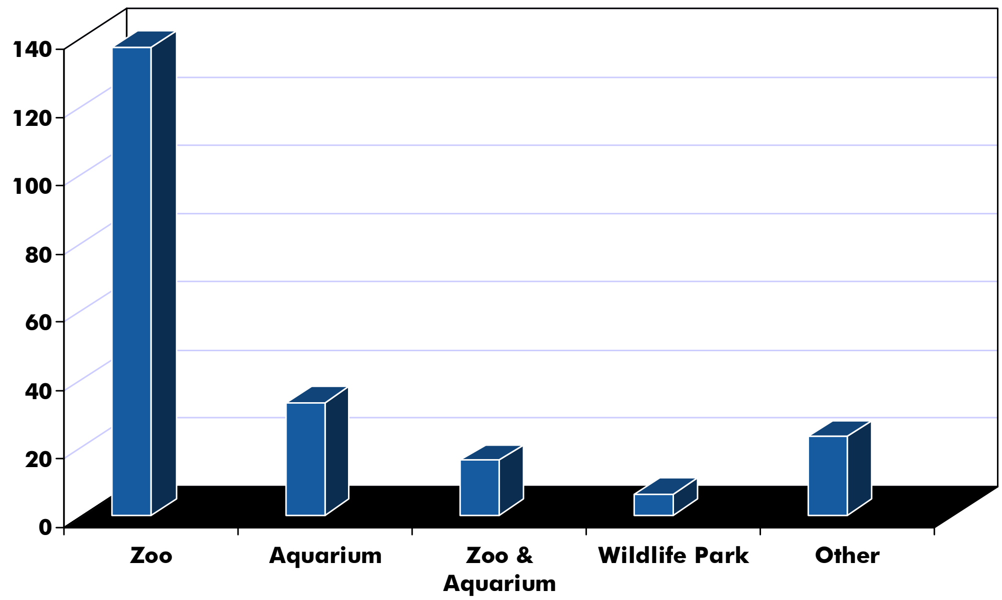
### 5.3.3.1 Aquariums and Zoos

America's zoos and aquariums form a network of educational institutions that offer an array of effective educational initiatives. The primary focus of aquariums is on oceans and the Great Lakes; however, zoos also dedicate a portion of their exhibits to these environments. Currently there are 212 accredited members of the American Zoo and Aquarium Association (AZA). Of these, the federal government and private nonprofit foundations are the two greatest operators (42.0 percent and 42.6 percent, respectively). The remaining facilities are operated by for-profit foundations or other entities.[32] Figure 5-10 shows the various types and numbers of this expansive association.

Collectively, these institutions have demonstrated the ability to reach a wide variety of audiences throughout the nation, claiming nearly 135 million visitors annually. An AZA aquarium typically serves 100,000 students and 20,000 teachers annually with both on- and offsite programs. Public programs enroll an additional 114,000 people onsite and 22,000 offsite. AZA member zoos and aquariums as a whole dedicate $52 million annually to their education programs. The total number of specimens across all American Zoo and Aquarium Association members in 2000 was over 750,000. Additional information regarding AZA members and direct links to these members can be found on the AZA Web site (www.aza.org).[32]

A unique aspect about zoos and aquariums is their presence across the country; they are not limited to the oceans or coastlines. Inland zoos and aquariums educate people who may never see the coast. The Denver Zoo, for example, is the most popular cultural attraction in Colorado, with over 1.7 million visitors annually. As reported to the Commission, the Denver Zoo is consistently ranked as one of the most popular zoos in the United States.[33]

**Figure 5-10:**
**American Zoo and Aquarium Association Members**




*The American Zoo and Aquarium Association institutions span across the nation, and are not limited to coastal regions. The 137 zoos, the largest component of the Association, devote various portions of their facilities to marine-related resources.*

As with formal education, zoos and aquariums provide unique opportunities for educating women and minorities. For example, the Young Women in Science at Monterey Bay Aquarium in Monterey, California, has been active since 1998. This week-long program encourages middle- and high-school girls to continue with their science education at a time in their lives when young women typically tend to abandon their interest in science. Students are paired with female aquarists and other scientists to build relationships with strong female role models. In addition, the Splash Zone Discovery Program partners with local counties to provide educational opportunities to a largely Hispanic community that has never visited the aquarium.[34]

## 5.3.3.2 Museums

While zoos and aquariums focus their exhibits on living creatures, museums provide educational opportunities through their non-living collections. Museums, like zoos and aquariums, educate a large number of visitors annually. For example, the National Museum of Natural History in Washington, D.C., had 8.4 million visitors in 2001 alone.[35] As with zoos and aquariums, museums provide an opportunity for the public to learn about marine resources without having to live near a coastline. There are more than 111 natural history museums across the nation, many of which devote segments of their facilities to marine-related exhibits.[36] Depending on their location, museums may focus on the specific region they are located in or the world's oceans as a whole.

The American Museum of Natural History in New York has the Irma and Paul Milstein Family Hall of Ocean Life. Home to a 94-foot-long model of a blue whale, this facility has extensive interactive exhibits that span the oceans. There are numerous hands-on models, interactive computer stations, and other educational activities. The Hall has been newly restored and renovated to keep pace with the needs of the public.[37] The Natural Museum of Los Angeles, California, has on display the Megamouth — the world's rarest shark — as well as the Marine Hall, focusing its exhibits on the sea life in California. The Ralph M. Parsons Discovery Center is the educational center within the museum, with numerous activities for all ages.[38]

The Smithsonian Institution is a large organization focusing on diverse subject areas, with 16 museums and 98 affiliate museums. One of the Smithsonian's primary missions is to provide experiences to the science community as well as the general public that promote innovation, research, and discovery in science.[35] More specifically, the Smithsonian National Museum of Natural History serves this role in relation to ocean sciences. Currently, there are three exhibits with a marine focus on display: Life in the Ancient Seas is divided into three time periods to show the evolution of the seas from 570 million years ago to today; The Mighty Marlin is a series of multiple exhibits that display the various attributes and characteristics of marlin; and Squid: The Inside Story, which primarily focuses on the comparison between the giant squid and *Taningia*, another large, deep-sea squid known for its light-producing organs. The Smithsonian offers a wide array of innovative, hands-on educational facilities supported by more than 200 trained volunteer docents.[39]

Another example, the Cleveland Museum of Natural History, has plans to increase the number of its marine exhibits. One recent example of a marine exhibit was a fossil of a 16-foot-long fish that lived in Ohio during prehistoric times. The museum's Science Resource Center offers teachers information, skills, and materials to educate their students in an accurate and exciting way.[40]

# 5.4 Marine Education Summary

The facilities that support ocean and coastal sciences education range from large academic institutions to small state and local organizations that provide informal education opportunities. This inventory illustrates the capacity and diversity of these facilities.

Formal education is offered through almost 500 programs at more than 100 academic institutions. Most students concentrate on marine biology and biological oceanography. While still under-represented, women and minorities continue to increase their presence in the field.

The informal education examples provided are a small sample of the opportunities available at the nation's MPAs, zoos, aquariums, and museums. These facilities serve a vital role in increasing knowledge about ocean and coastal resources for both schoolchildren and the general public.

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# Acronyms

| | |
|---|---|
| **ABE** | Autonomous Benthic Explorer |
| **ADCP** | Acoustic Doppler Current Profiler |
| **ADEOS** | Advanced Earth Observation Satellite |
| **ADV** | Atmospheric Diving Suit |
| **AFS** | Aquaculture and Fisheries Science |
| **AIS** | Automatic Identification System |
| **AMSR-E** | Advanced Microwave Scanning Radiometer |
| **AMVER** | Atlantic Merchant Vessel Emergency Reporting |
| **ANT** | Aids-to-Navigation Team |
| **AOML** | Atlantic Oceanographic and Meteorological Laboratory |
| **APL** | Applied Physics Laboratory |
| **APT** | Automatic Picture Transmission |
| **ARC** | Ames Research Center AND Applied Research Center |
| **ARI** | Arctic Research Initiative |
| **ARL** | Air Resources Laboratory |
| **ARRV** | Alaska Region Research Vessel |
| **ASC** | Autonomous Surface Craft |
| **AtoN** | Aids-to-Navigation |
| **ATLAS** | Autonomous Temperature Line Acquisition System |
| **AUV** | Autonomous Underwater Vehicle |
| **AVHRR** | Advanced Very High Resolution Radiometer |
| **AY** | Academic Year |
| **AZA** | American Zoo and Aquarium Association |
| **BIMCO/ISF** | Baltic and International Maritime Council/International Shipping Federation |
| **C2** | Command-and-control |
| **CCPP** | Climate Change Prediction Program |
| **CCSM** | Community Climate System Model |
| **CDA** | Command and Data Acquisition |
| **CDEP** | Climate Dynamics and Experimental Prediction |
| **CDIAC** | Carbon Dioxide Information Analysis Center |
| **CHL** | Coastal and Hydraulics Laboratory |
| **CICOR** | Cooperative Institute of Climate and Ocean Research |
| **CIFAR** | Cooperative Institute for Arctic Research |
| **CILER** | Cooperative Institute for Limnology and Ecosystems Research |
| **CIMAS** | Cooperative Institute for Marine and Atmospheric Studies |
| **CIRPAS** | Center for Interdisciplinary Remotely Piloted Aircraft Studies |
| **CITAT** | Container Inspection Training and Assistance Team |
| **CLIVAR** | Climate Variability and Predictability Experiment |
| **C-MAN** | Coastal Marine Automated Network |

| | |
|---|---|
| **CNES** | Centre National d'Etudes Spatiales (French Space Agency) |
| **COAMPS** | Coupled Ocean Atmospheric Mesoscale Prediction System |
| **CODAR** | Coastal Ocean Dynamic Application Radar |
| **COP** | Coastal Ocean Program |
| **CORE** | Consortium for Oceanographic Research and Education |
| **CORS** | Continually Operated Reference Station |
| **COSEE** | Centers for Ocean Sciences Education Excellence |
| **COSIMG** | Climate, Ocean, and Sea-Ice Modeling Group |
| **COTP** | Captain of the Port |
| **COTS** | Commercial off-the-shelf |
| **CPC** | Climate Prediction Center |
| **CPD** | Coastal Programs Division |
| **CRRF** | Coral Reef Research Foundation |
| **CSL** | Climate Simulation Laboratory |
| **CTD** | Conductivity-Temperature-Depth |
| **CURV** | Cable-controlled Undersea Recovery Vehicle |
| **CZM** | Coastal Zone Management |
| **CZMA** | Coastal Zone Management Act |
| **DAAC** | Distributed Active Archive Center |
| **DART** | Deep-Ocean Assessment and Reporting of Tsunamis |
| **DGPS** | Differential Global Positioning System |
| **DISL** | Dauphin Island Sea Lab |
| **DMSP** | Defense Meteorological Satellite Program |
| **DOC** | Department of Commerce |
| **DoD** | Department of Defense |
| **DOE** | Department of Energy |
| **DOI** | Department of the Interior |
| **DOT** | Department of Transportation |
| **DREN** | Defense Research and Engineering Network |
| **DSV** | Deep Submergence Vehicle |
| **DWT** | Deadweight Tons |
| **EETAP** | Environmental Education and Training Partnership |
| **EEZ** | Exclusive Economic Zone |
| **ELC** | Engineering Logistics Center |
| **EÑSO** | El Niño-Southern Oscillation |
| **EO** | Executive Order |
| **EOS** | Earth Observing System |
| **EOSDIS** | Earth Observing System Data and Information System |
| **EPA** | U.S. Environmental Protection Agency |
| **ERDC** | Engineering Research and Development Center |
| **ERL** | Environmental Research Laboratory |
| **EROS** | Earth Resources Observation System |
| **ESA** | Endangered Species Act |
| **ETL** | Environmental Technology Laboratory |
| **EUMETSAT** | European Organization for the Exploitation of Meteorological Satellites |

| | |
|---|---|
| **FDA** | Food and Drug Administration |
| **FMP** | Fishery Management Plan |
| **FMRI** | Florida Marine Research Institute |
| **FNMOC** | Fleet Numerical Meteorology and Oceanography Center |
| **FOCI** | Fisheries Oceanography Coordination Investigations |
| **FOSC** | Federal On-Scene Coordinator |
| **FRF** | Field Research Facility |
| **FSS** | Fast Sealift Ship |
| **FTE** | Full-Time Equivalent |
| **FWS** | U.S. Fish and Wildlife Service |
| **FY** | Fiscal Year |
| **GB** | Gigabyte |
| **GCOOS** | Gulf Coastal Ocean Observing System |
| **GCOS** | Global Climate Observing System |
| **GFDL** | Geophysical Fluid Dynamics Laboratory |
| **GIS** | Geographic Information System |
| **GLAS** | Geoscience Laser Altimetry Sensor |
| **GLERL** | Great Lakes Environmental Research Laboratory |
| **GLODAP** | Global Ocean Data Analysis Project |
| **GODAE** | Global Ocean Data Assimilation Experiment |
| **GOES** | Geostationary Operational Environmental Satellite |
| **GOOS** | Global Ocean Observing System |
| **GPS** | Global Positioning System |
| **GRACE** | Gravity Recovery and Climate Experiment |
| **GSFC** | Goddard Space Flight Center |
| **GSOS** | GPS Surface Observing System |
| **HBOI** | Harbor Branch Oceanographic Institution |
| **HIAPER** | High-Performance Instrumented Airborne Platform for Environmental Research |
| **HPC** | High Performance Computing |
| **HPCC** | High Performance Computing and Communications |
| **HRPT** | High Resolution Picture Transmission |
| **HURL** | Hawaii Undersea Research Laboratory |
| **ICESat** | Ice, Cloud, and Land Elevation Satellite |
| **IGC** | Information Gatekeepers Consulting |
| **IGEB** | Interagency GPS Executive Board |
| **IMO** | International Maritime Organization |
| **INA** | Institute of Nautical Archaeology |
| **IOOS** | Integrated Ocean Observing System |
| **IPEDS** | Integrated Postsecondary Education and Data System |
| **IPO** | International Program Office |
| **IRICP** | International Research Institute for Climate Prediction |
| **IT** | Information Technology |
| **JALBTCX** | Joint Airborne LIDAR Bathymetry Technical Center of Expertise |
| **JAMSTEC** | Japan Marine Science and Technology Center |
| **JGOFS** | Joint Global Ocean Flux Study |

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|---|---|
| **JIMAR** | Joint Institute for Marine and Atmospheric Research |
| **JIMO** | Joint Institute for Marine Observations |
| **JISAO** | Joint Institute for the Study of the Atmosphere and Ocean |
| **JOI** | Joint Oceanographic Institutions |
| **JPL** | Jet Propulsion Laboratory |
| **JSL** | Johnson Sea Link |
| **K-12** | Kindergarten through 12$^{th}$ grade |
| **LANL** | Los Alamos National Laboratory |
| **LASH** | Lighter Aboard Ship |
| **LBNL** | Lawrence Berkeley National Laboratory |
| **LDC** | Legacy Data Center |
| **LIDAR** | Light Detection and Ranging |
| **LMSR** | Large-Medium-Speed RO/ROs |
| **LORAN** | Long-Range Radio Navigation |
| **LRS** | Long-Range Search |
| **LSU** | Loran Support Unit |
| **LTPY** | Long-Term Potential Yield |
| **LUMCON** | Louisiana Universities Marine Consortium |
| **MARAD** | Maritime Administration, Department of Transportation |
| **MARS** | Monterey Accelerated Research System |
| **MBARI** | Monterey Bay Aquarium Research Institute |
| **MBL** | Marine Biological Laboratory |
| **MIT** | Massachusetts Institute of Technology |
| **MML** | Mote Marine Laboratory |
| **MMPA** | Marine Mammal Protection Act |
| **MMS** | Minerals Management Service |
| **MODIS** | Moderate-Resolution Imaging Spectroradiometer |
| **MON** | Marine Operation Network |
| **MOOS** | MBARI Ocean Observing System |
| **MPA** | Marine Protected Area |
| **MRE-FC** | Major Research Equipment-Facilities Construction |
| **MRS** | Medium-Range Search |
| **MSC** | Military Sealift Command |
| **MSFCMA** | Magnuson-Stevens Fishery Conservation and Management Act |
| **MSO** | Marine Safety Offices |
| **MSP** | Maritime Security Program |
| **MSRC** | Major Shared Resource Center |
| **MSS** | Multi-spectral Scanner |
| **MSST** | Maritime Safety and Security Team |
| **MTS** | Marine Transportation System |
| **NAS** | National Academy of Sciences |
| **NASA** | National Aeronautics and Space Administration |
| **NASDA** | National Space Development Agency of Japan |
| **NAVCEN** | U.S. Coast Guard Navigation Center |
| **NAVOCEANO** | U.S. Naval Oceanographic Office |

| | |
|---|---|
| **NCAR** | National Center for Atmospheric Research |
| **NCCOS** | National Centers for Coastal Ocean Science |
| **NCEP** | National Center for Environmental Prediction |
| **NDBC** | National Data Buoy Center |
| **NDGPS** | Nationwide Differential Global Positioning System |
| **NDRS** | National Distress Response System |
| **NDSF** | National Deep Submergence Facility |
| **NEERL** | National Health and Environmental Effects Research Laboratory |
| **NEOS** | Northeastern Observing System |
| **NEPA** | National Environmental Policy Act |
| **NERRS** | National Estuarine Research Reserve System |
| **NESDIS** | National Environmental Satellite, Data and Information Service |
| **NGS** | National Geodetic Survey |
| **NGWLMS** | Next Generation Water-Level Measurement System |
| **NIC** | Naval Ice Center |
| **NIS** | Navigation Information System |
| **NISA** | National Invasive Species Act |
| **NM** | Nautical Miles |
| **NMFS** | National Marine Fisheries Service |
| **NMSP** | National Marine Sanctuary Program |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NOMAD** | Navy Oceanographic Meteorological Automatic Device |
| **NOPP** | National Ocean Partnership Program |
| **NOS** | National Ocean Service |
| **NPS** | National Park Service |
| **NPOESS** | National Polar-Orbiting Operational Environmental Satellite System |
| **NRC** | National Research Council |
| **NRL** | Naval Research Laboratory |
| **NRL-CBD** | Naval Research Laboratory - Chesapeake Bay Detachment |
| **NRL-FSD** | Naval Research Laboratory - Flight Support Detachment |
| **NRL-MRY** | Naval Research Laboratory - Marine Meteorology Division |
| **NSB** | Non-standard Boats AND National Science Board |
| **NSCAT** | NASA Scatterometer |
| **NSF** | National Science Foundation |
| **NSIDC** | National Snow and Ice Data Center |
| **NSRS** | National Spatial Reference System |
| **NURC** | National Undersea Research Center |
| **NURP** | National Undersea Research Program |
| **NWLON** | National Water Level Observation Network |
| **NWRC** | National Wetland Research Center |
| **NWS** | National Weather Service |
| **OACES** | Ocean Atmospheric Exchange Study |
| **OAR** | Office of Oceanic and Atmospheric Research |
| **OCRM** | Office of Ocean and Coastal Resource Management |
| **OCS** | Outer Continental Shelf |

| | |
|---|---|
| **OFA** | Office of Finance and Administration |
| **Ohmsett** | Oil and Hazardous Material Simulated Environmental Test Tank |
| **OI** | Oceanic Institute |
| **OLE** | Office of Law Enforcement |
| **OMAO** | Office of Marine and Aviation Operations |
| **ONR** | Office of Naval Research |
| **OOI** | Ocean Observatories Initiative |
| **ORNL** | Oak Ridge National Laboratory |
| **ORR** | Office of Response and Restoration |
| **OSTM** | Ocean Surface Topographic Mission |
| **OSU** | Oregon State University |
| **OSV** | Ocean Survey Vessel |
| **OTA** | Office of Technical Assessment |
| **PB** | Petabyte |
| **PIRATA** | Pilot Research Moored Array in the Tropical Atlantic |
| **PMEL** | Pacific Marine Environmental Laboratory |
| **POES** | Polar-Orbiting Operational Environmental Satellite |
| **PORTS** | Physical Oceanographic Real-Time System |
| **PPS** | Precise Positioning System |
| **PSU** | Port Security Unit |
| **R&D** | Research and Development |
| **ROPOS** | Remotely Operated Platform for Ocean Science |
| **RO/RO** | Roll-On/Roll-Off |
| **ROV** | Remotely Operated Vehicle |
| **RRF** | Ready Reserve Force |
| **RSMAS** | Rosenstiel School of Marine and Atmospheric Science |
| **R/V** | Research Vessel |
| **S&E** | Science and Engineering |
| **$S_2O_2$** | Sargasso Sea Ocean Observatory |
| **SAR** | Search-and-rescue |
| **SCD** | Scientific Computing Division |
| **SCOOP** | SURA Costal Ocean Observing Program |
| **SEA-COOP** | South Eastern Atlantic Coastal Observing System |
| **SeaWiFS** | Sea-viewing Wide Field-of-View Sensor |
| **SHOALS** | Scanning Hydrographic Operational Airborne LIDAR Survey |
| **SIO** | Scripps Institution of Oceanography |
| **SLAR** | Side-Looking Airborne Radar |
| **SOEST** | School of Ocean and Earth Science and Technology |
| **SPS** | Standard Positioning System |
| **SRA** | Short-Range Aids to Navigation |
| **SRU** | Search-and-Rescue Unit |
| **SSC** | Stennis Space Center |
| **SST** | Sea Surface Temperature |
| **STCW** | Standards of Training, Certification, and Watchkeeping |
| **STORET** | Storage and Retrieval |

| | |
|---|---|
| **STRI** | Smithsonian Tropical Research Institute |
| **SUNY** | State University of New York |
| **SURA** | Southeastern University Research Association |
| **SUPSALV** | U.S. Navy Office of the Director of Ocean Engineering, Supervisor of Salvage and Diving |
| **SWATH** | Small Waterplane Area Twin Hull |
| **SWISS** | Shallow Water Intermediate Search System |
| **TAMU** | Texas A&M University |
| **TAO/TRITON** | Tropical Atmospheric Ocean/Triangle Trans-Ocean Buoy Network |
| **TB** | Terabyte |
| **TM** | Thematic Mapper |
| **TMI** | TRMM Microwave Imager |
| **TOSS** | Towed Ocean Survey System |
| **TOV** | Towed Vehicles |
| **TOWDEX** | Towed Defined Excitation |
| **T/P** | TOPEX/Poseidon |
| **TPPN** | Trans-Pacific Profiler Network |
| **TRMM** | Tropical Rainfall Measuring Mission |
| **UAV** | Unmanned Aerial Vehicle |
| **UMCES** | University of Maryland Center for Environmental Science |
| **UNOLS** | University–National Oceanographic Laboratory System |
| **USACE** | U.S. Army Corps of Engineers |
| **USCG** | U.S. Coast Guard |
| **USCGC** | U.S. Coast Guard Cutter |
| **USDA** | U.S. Department of Agriculture |
| **USIABP** | U.S. Inter-Agency Arctic Buoy Program |
| **USGCRP** | U.S. Global Change Research Program |
| **USGS** | U.S. Geological Survey |
| **VIMS** | Virginia Institute of Marine Science |
| **VOS** | Voluntary Observing Ship |
| **VOSS** | Vessel of Opportunity Skimming System |
| **VHF** | Very High Frequency |
| **VHF-FM** | Very High Frequency-Frequency Modulation |
| **VTS** | Vessel Traffic Services |
| **WHOI** | Woods Hole Oceanographic Institution |
| **WOCE** | World Ocean Circulation Experiment |
| **XBT** | Expendable BathyThermograph |

# Supplemental Materials

## SUPPLEMENT 2-1: U.S. Ports Handling Over One Million Tons of Cargo (2000)

| Port Name | Cargo Handled (Tons) |
|---|---|
| South Louisiana | 217,756,734 |
| Houston | 191,419,265 |
| New York | 138,669,879 |
| New Orleans | 90,768,449 |
| Corpus Christi | 83,124,950 |
| Beaumont | 82,652,554 |
| Huntington | 76,867,987 |
| Long Beach | 70,149,684 |
| Baton Rouge | 65,631,084 |
| Texas City | 61,585,891 |
| Plaquemine | 59,910,084 |
| Lake Charles | 55,517,891 |
| Mobile Harbor | 54,156,967 |
| Pittsburgh | 53,922,676 |
| Los Angeles | 48,192,271 |
| Valdez | 48,080,894 |
| Tampa Bay | 46,460,327 |
| Philadelphia | 43,854,766 |
| Norfolk Harbor | 42,376,778 |
| Duluth-Superior | 41,677,699 |
| Baltimore | 40,831,802 |
| Portland | 34,333,784 |
| Saint Louis | 33,337,815 |
| Freeport | 30,984,736 |
| Portland | 29,330,407 |
| Pascagoula | 28,710,087 |
| Paulsboro | 26,874,417 |
| Seattle | 24,158,942 |
| Chicago | 23,929,489 |
| Marcus Hook | 22,583,985 |
| Port Everglades | 22,500,201 |
| Tacoma | 22,286,610 |
| Port Arthur | 21,387,322 |
| Charleston | 21,081,838 |
| Boston | 20,750,789 |
| Jacksonville | 19,701,277 |
| Savannah | 19,670,923 |
| Richmond | 19,463,609 |
| Memphis | 18,269,265 |
| Anacortes | 18,034,543 |
| Detroit | 17,294,541 |
| Indiana Harbor | 16,187,079 |
| Honolulu | 15,796,807 |
| Cleveland | 14,390,802 |
| Cincinnati | 14,337,043 |
| Lorain | 14,180,191 |
| San Juan Harbor | 13,904,237 |
| Newport News | 13,803,114 |
| Toledo | 13,321,657 |
| Two Harbors | 13,060,019 |
| Ashtabula | 12,322,430 |
| Oakland | 12,176,045 |

## SUPPLEMENT 2-1: U.S. Ports Handling Over One Million Tons of Cargo (2000)

| Port Name | Cargo Handled (Tons) |
|---|---|
| Presque Isle | 10,741,845 |
| Galveston | 10,643,215 |
| New Haven | 10,603,972 |
| Conneaut | 10,603,367 |
| Matagorda Ship Channel | 10,551,726 |
| Gary | 9,712,109 |
| Burns Waterway Harbor | 9,346,320 |
| Louisville | 9,167,326 |
| Providence | 8,869,974 |
| New Castle | 8,745,200 |
| Escanaba | 8,646,811 |
| Miami | 8,609,996 |
| Taconite Harbor | 8,504,541 |
| Calcite | 8,474,781 |
| Stoneport | 7,841,997 |
| Vancouver | 7,652,631 |
| Barbers Point | 7,141,165 |
| Wilmington | 6,716,503 |
| Albany | 6,127,096 |
| Kalama | 5,790,677 |
| Saint Clair | 5,553,477 |
| Port Inland | 5,483,044 |
| Silver Bay | 5,390,009 |
| Saint Paul | 5,254,012 |
| Wilmington | 5,183,513 |
| Camden-Gloucester | 5,170,588 |
| Nikishka | 5,109,341 |
| Victoria | 5,104,245 |
| Vicksburg | 4,972,751 |
| Nashville | 4,523,011 |
| Portsmouth | 4,462,133 |
| Morehead City | 4,365,470 |
| Port Manatee | 4,279,750 |
| Bridgeport | 4,254,965 |
| Port Canaveral | 4,247,027 |
| Longview | 4,113,111 |
| Marine City | 3,987,317 |
| Kansas City | 3,819,732 |
| Marblehead | 3,717,018 |
| San Diego | 3,652,734 |
| Sandusky | 3,644,571 |
| San Francisco Bay | 3,626,462 |
| Milwaukee | 3,538,522 |
| Penn Manor | 3,531,474 |
| Kahului, Maui | 3,476,672 |
| Everett | 3,457,140 |
| Alpena | 3,404,858 |
| Fall River | 3,402,023 |
| Brownsville | 3,267,513 |

## SUPPLEMENT 2-1: U.S. Ports Handling Over One Million Tons of Cargo (2000)

| Port Name | Cargo Handled (Tons) |
|---|---|
| Port Dolomite | 3,205,181 |
| Anchorage | 3,157,247 |
| Greenville | 3,069,359 |
| Mount Vernon | 3,067,268 |
| Palm Beach | 2,950,183 |
| Chattanooga | 2,854,579 |
| Port Jefferson Harbor | 2,840,432 |
| Brunswick | 2,580,647 |
| Panama City | 2,573,045 |
| Kivilina | 2,572,670 |
| Fairport Harbor | 2,538,850 |
| Biloxi | 2,508,367 |
| Muskegon | 2,434,620 |
| Ponce | 2,264,619 |
| Chester | 2,235,557 |
| Gulfport Commercial Harbor | 2,228,741 |
| Coos Bay | 2,210,140 |
| Buffalo | 2,168,557 |
| Stockton | 2,051,086 |
| Georgetown | 2,009,273 |
| Minneapolis | 1,936,945 |
| Tulsa | 1,926,638 |
| Port Angeles | 1,886,064 |
| Guntersville | 1,862,593 |
| Helena | 1,797,390 |
| Charlevoix | 1,748,111 |
| Fajardo | 1,716,839 |
| Hilo | 1,651,075 |
| Pensacola | 1,617,201 |
| Nawiliwili, Kauai | 1,580,962 |
| Trenton | 1,574,107 |
| Grand Haven | 1,554,784 |
| Green Bay | 1,551,130 |
| Buffington | 1,544,762 |
| Erie | 1,501,167 |
| Richmond | 1,488,505 |
| Searsport | 1,440,897 |
| Olympia | 1,433,663 |
| Drummond Island | 1,357,645 |
| Charlotte Harbor | 1,356,295 |
| Kawaihae Harbor | 1,310,139 |
| Huron | 1,275,242 |
| Grays Harbor | 1,250,636 |
| Marysville | 1,227,099 |
| Salem | 1,205,158 |
| Port Hueneme | 1,193,742 |
| Hempstead | 1,192,719 |
| Humboldt Bay | 1,062,672 |
| Stamford | 1,037,224 |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Port of South Louisiana (Plaquemines) | Houston | New York/New Jersey |
|---|---|---|---|
| **Harbor Size** | The Port of South Louisiana has 156 barge terminals, a pilot station, headquarters for channel maintenance engineers, and a lighthouse. | The Port of Houston is a 25-mile-long complex of diversified public and private facilities. | The NY/NJ port complex has a depth of 35 feet, a width of 400 feet, and 7 cargo terminals. |
| **Web Site** | www.portsl.com | www.portofhouston.com | www.panynj.gov |
| **Channel Depth** | 45 feet | 36-40 feet | 40-45 feet |
| **Total Volume (Tonnage)** | 215930915 | 186567246 | 137170810 |
| **Total Value (in millions)** | 11124 | 43365 | 80941 |
| **Number of Calls** | Not Available | In 2000, a total of 6,613 vessel calls, 2,988 Tanker Calls, 748 Dry Bulk Calls, 614 Containership Calls, 779 Other General Calls | In 2000, 1,271 Tanker Calls, 301 Dry Bulk Calls, 2,172 Containership Calls, and 861 Other General Calls |
| **Imports** | steel, crude oil, iron ore | petroleum products and related chemicals, cement, lime, concrete, minerals, potassium, selenium, sodium, acid chemicals, ores, metals, steel, rail equipment, steel/iron copper | furniture, paper, beer and ale |
| **Exports** | coal, coke, soybean, corn, wheat, crude oil, phosphate | petroleum products and related chemicals, potassium, selenium, sodium, acid chemicals, grain products, rice, potato, starch, benzene, naphthalene chemicals, stones, clay, crude minerals | paper/paperboard, logs and lumber, auto parts |
| **Major Trade Partners Served** | Not Available | Mexico, Venezuela, Saudi Arabia, Iraq, Algeria, Germany, and Brazil | United Kingdom, Singapore, Belgium, Korea, Japan, China, and Hong Kong |
| **Future Improvements Planned** | Expansion in Plaquemines Parish has been heavily oriented to oil and gas exploration and production as well as the push toward diversification into other industries including coal and fuel storage, primary metals, manufacturing and aquaculture.  A proposal to use the Port Eads area for a "topping off" basin for over-draft vessels were studied hard in the early 1980's and several tries for a steamboat cruise were tried in the late 1970's-early 1980's to the Jetties, the return overnight. | The Port Authority has developed a master plan of several phases for the Bayport area, which includes 7 container terminals and a cruise complex. In the first phase, the Port Authority Commission plans to develop a new container terminal in southeast Harris County to assist the Bayport Terminal Complex meet the needs of expanding growth patterns in the container industry. Cruise development, which will take place only as the market dictates, will allow for the building of several cruise berths, an east-end turning basin and a co-development area. | Scheduled maintenance dredging of the East River seeks to maintain a depth of 35 feet and width of 400 feet in the South Brother Island Channel. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | New Orleans | Corpus Christi | Beaumont |
| --- | --- | --- | --- |
| **Harbor Size** | The Port's facilities include 22 million square feet of cargo handling area and more than 6 million square feet of covered storage area. | The Port of Corpus Chrisit is more than 125 acres, with 11 public oil docks with berths between 246 feet to 1,000 feet and depths up to 45 feet. | The Port of Beaumont has a total of 6,088 linear feet of harbor front, with 8 ship berths, afford wide concrete aprons and a constant minimum water depth of 36-40 feet at mean low tide at the face of all docks. |
| **Web Site** | www.portno.com | www.portofcorpuschristi.com | www.portofbmt.com |
| **Channel Depth** | 36-45 feet | 45 feet | 40 feet |
| **Total Volume (Tonnage)** | 89998825 | 81315333 | 76894358 |
| **Total Value (in millions)** | 18768 | 10305 | 10606 |
| **Number of Calls** | In 2000, 1,371 Tanker Calls, 2,676 Dry Bulk Calls, 388 Containership Calls, 655 Other General Calls | In 2000, 974 Tanker Calls, 230 Dry Bulk Calls, 2 Containership Calls, 142 Other General Calls | In 2000, 1,053 Tanker Calls, 99 Dry Bulk Calls, Zero Containership Calls, 67 Other General Calls |
| **Imports** | steel, rubber, plywood, coffee | Not Available | forest products, steel, project, military cargo |
| **Exports** | forest products, steel, foodstuff, chemicals | crude oil, fuel oil, gasoline, feed stock, gas oil, bauxite ore, slop and slurry, naphtha, diesel, toluene | forest products, project, agricultural commodities, iron and steel, military cargoes, bulk grain |
| **Major Trade Partners Served** | Japan, Brazil, Mexico, Indonesia, and Malaysia | Venezuela, Nigeria, Mexico, Saudi Arabia, Iraq, Columbia, Jamaica, Algeria, Kuwait, and the U.K. | Not Available |
| **Future Improvements Planned** | A new container terminal is under construction at Napoleon Avenue. The state-of-the-art complex will operate with four multi-purpose gantry cranes and rubber tire gantry cranes in the marshalling yard. Projected annual capacity is 366,000 TEUs. The 57-acre terminal is scheduled to open in the mid-2002. | A two-year study recommended the proposed $190m improvements: 1) Widening the Corpus Christi Ship Channel to 530 feet 2) Deepening the Corpus Christi Ship Channel from 45 to 52 feet 3) Adding 200 feet wide barge shelves along both sides of the channel across Corpus Christi Bay, and 4) Extending La Quinta Channel approximately 7400 feet at a depth of 39 feet. The Joe Fulton International Trade Corridor encompasses an 11.5-mile road and 7-mile rail project for Port of Corpus Christi that will improve access to over 2,000 acres of land along the north side of the channel for development. The corridor will make approximately 1,000 acres of land (which has no access) available for use as marine terminals and industrial sites. | Construction of the BEAU's new, state-of-the-art transit shed is right on schedule. The 100,000 square foot shed is adjacent to the port's new Harbor Island Wharf Extension, which opened in the summer of 2001. The new shed, to be designated Harbor Island Shed C, is expected to be completed in October of this year. The $4.7 million shed will increase the port's covered cargo capacity by 20%. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Huntington-Tristate | Long Beach | Baton Rouge |
|---|---|---|---|
| **Harbor Size** | The Huntington Tri-state port stretches along 100 miles of the Ohio River, 90 miles of the Kanawha River and 9 miles of the Big Sandy River. | LB/LA Port has a 7500-acre harbor with 6 modern container facilities. | Port of Baton Rouge has 3,000 linear feet of continuous berthing space for ships and barges on the harbor front with a 40- to 60-foot apron. |
| **Web Site** | Not Available | www.polb.com | www.portgbr.com |
| **Channel Depth** | Not Available | 76 feet | 45 feet |
| **Total Volume (Tonnage)** | 76867987 | 69850483 | 65207276 |
| **Total Value (in millions)** | Not Available | 101819 | 4357 |
| **Number of Calls** | Not Available | Not Available | Not Available |
| **Imports** | Not Available | petroleum, electric machinery, plastic products, clothing, furniture | petroleum, molasses, rail, steel coils, chemicals |
| **Exports** | Not Available | petroleum, petroleum coke, chemicals, wastepaper, foods | grain, forest products, chemicals, coal, coke, petroleum products, pipe, sugar |
| **Major Trade Partners Served** | Not Available | China/Hong Kong, Japan, Korea, Taiwan, and Ecuador | Not Available |
| **Future Improvements Planned** | Open channel work on the Ohio River within the limits of the Huntington District consists of widening, deepening and maintaining the navigation channel in the pools of dams to provide and maintain full project depth of 9 feet at minimum pool conditions. Open channel work also includes construction and maintenance of back-channel dams and dikes and the removal of snags and wrecks. The Port District has provided the West Virginia Public Port Authority (WVPPA) with the appropriate supporting documents to fulfill the request for start-up funding for development of the Buffalo/Putnam area. The Weirton Port project to explore the possibilities of a joint, two-state compact to coordinate regional port development is developing. | LB Port: plans to create 5 container terminals of more than 300 acres each and to build 2 other large terminals within 10-15 years; consolidate and redevelop several piers to meet additional needs. LB: Plans to invest $1.9b in capital projects. | Land for development includes an additional 55 acres at the Inland Rivers Marine Terminal on the Intracoastal Canal and also two parcels of land in Ascension Parish which include a 20 acre site on the east bank of the river and 300 acres on the west bank of the river. |

**SUPPLEMENT 2-2: Selected U.S. Ports Information**

| Port | Texas City | Pittsburgh | Mobile |
|---|---|---|---|
| **Harbor Size** | The Port of Texas City includes 43 docks. | The Pittsburgh Port District encompasses an 11-county area, essentially all 200 miles of commercially navigable waterways in southwestern Pennsylvania. | The Port of Mobile has 3,487 acres available, with facilities for handling all types of ocean-going vessels with up to 45-foot drafts. |
| **Web Site** | www.railporttc.com | www.port.pittsburgh.pa.us | www.asdd.com |
| **Channel Depth** | 50 feet | at least 9 feet | 45 feet |
| **Total Volume (Tonnage)** | 58108858 | 53922676 | 53658350 |
| **Total Value (in millions)** | 4871 | 8000 | 3793 |
| **Number of Calls** | In 2000, 1,105 Tanker Calls, 64 Dry Bulk Calls, 2 Containership Calls, 26 Other General Calls | | In 2000, 140 Tanker Calls, 408 Dry Bulk Calls, 5 Containership Calls, 204 Other General Calls |
| **Imports** | Not Available | coal, lignite, coke | petroleum, coal, iron ore |
| **Exports** | coke, potash, fertilizers | petroleum products, soil, sand and gravel | coal, petroleum, forest products |
| **Major Trade Partners Served** | Not Available | Not Available | Not Available |
| **Future Improvements Planned** | It has been estimated that between 4 and 11 new containerized cargo terminals will be needed in the Texas Central Gulf region, particularly at the Port of Houston and Texas City, between the years of approximately 1998-2028. A $20 million bond issue will finance street, sewer and drainage work throughout the city. The city also has taken steps to develop a proposed Megaport at Shoal Point as a possible deep water container terminal (or 'Mega Port') in south Texas. | A $705 million project is under way to make the Monongahela the most efficient river in the nation. The U.S. Army Corps of Engineers has started construction of a project to replace the fixed-crest dam at Locks and Dam 2 with a gated dam; remove Locks and Dam 3; and construct two new 84-foot by 720-foot locks at Locks and Dam 4. The dam at Locks and Dam 2 is nearly 100 years old and has deteriorated beyond repair. The new dam will control the water level along the river. | The port is beginning a 5-year improvement and expansion plan of $300 million through the issuance of general obligation bonds. The port's first phase investment of $45 million will include the new warehouse and a second roll on-roll off ramp at North A; container operating equipment; a 60,000 square foot warehouse expansion at Pier South C, and the paving of a 10-acre site for lay down of metals. Docks' operational costs are funded through port revenues. About $7.5 million of Phase One funding will be used for permit approvals and design preparation for Choctaw Point Terminals, where a new intermodal center will be built. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Lake Charles | Los Angeles | Valdez |
|---|---|---|---|
| **Harbor Size** | The Lake Charles District (LCD) encompasses 203 square miles in Calcasieu Parish. | The port complex occupies 7500 acres of land and water along 43 miles of waterfront. | The Port of Valdez has three main docks, including the 600-foot City dock, the 700-foot concrete floating Valdez Container Terminal Dock and the Container Dock, which is tied to a 21-acre marshalling yard by two 200-foot ramps. A grain terminal consisting of 9 concrete silos 112 feet tall and 33 feet in diameter with a total capacity of 522,000 bushels is also located on the Container Terminal grounds. |
| **Web Site** | www.portlc.com | www.portoflosangeles.org | Not Available |
| **Channel Depth** | 36-40 feet | 45 feet | 25-56 feet |
| **Total Volume (Tonnage)** | 53007284 | 48127534 | 48080894 |
| **Total Value (in millions)** | 4964 | 98202 | 292 |
| **Number of Calls** | In 2000, 518 Tanker Calls, 115 Dry Bulk Calls, 3 Containership Calls, 79 Other General Calls | Not Available | Not Available |
| **Imports** | petrochemical, barite, rutile | furniture, apparel, computer equipment, toys, electrical products | Not Available |
| **Exports** | petrochemical, rice, bagged goods | wastepaper, resins and plastic, pet and animal feeds, cotton, fruit | oil |
| **Major Trade Partners Served** | Not Available | Not Available | Not Available |
| **Future Improvements Planned** | The Lake Charles Deepwater Channel project originally provided for Federal maintenance of the 30-foot-deep by 125-foot-wide channel constructed by local interests between the Calcasieu and Sabine rivers, a distance of approximately 25 miles. However, the project is now inactive, because direct access from Lake Charles to the Gulf was provided by the "Calcasieu River and Pass Project," described previously. | Conducting project to dredge main channel to a depth of 53-foot MLLW and planning a 20-acre expansion of the facility. | The Port Commission, in conjunction with the Valdez City Council, has recently formed the Waterfront Task Force. Their first meeting was in February 2002. The City Council approved an economic benefit analysis research project for the Task Force. They will research facts on the economics of moving the cruise ships to town. The Commission is also working with the Corps of Engineers regarding the harbor expansion. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Tampa | Duluth-Superior | Baltimore |
|---|---|---|---|
| **Harbor Size** | The Tampa port has over 1500 acres of heavy industrial land with deep water access. | The waterfront area of the Port of Duluth-Superior is 49 miles long, with 17 miles of dredged channels, 19 square miles of land, and a naturally protected harbor 602 feet above sea level. There are 30 acres of property within the complex. | The Port of Baltimore is located on a 32-square-mile area. Zone space is presently contained over 1,400 acres at 11 sites. |
| **Web Site** | www.tampaport.com | www.duluthport.com | www.mpa.state.md.us |
| **Channel Depth** | 43 feet | 27 feet | 50 feet |
| **Total Volume (Tonnage)** | 46460327 | 41677699 | 40831802 |
| **Total Value (in millions)** | 2304 | 786 | 20606 |
| **Number of Calls** | In 2000, 228 Tanker Calls, 367 Dry Bulk Calls, 6 Containership Calls, 178 Other General Calls | Not Available | In 2000, 151 Tanker Calls, 426 Dry Bulk Calls, 409 Containership Calls, 650 Other General Calls |
| **Imports** | coal and petroleum imports | limestone, cement, eastern coal, salt | forest products, automobiles, machinery, rolling stock, ores and metals, manufactured goods |
| **Exports** | phosphate and related products, cement, limestone, citrus pellets, and aggregate, citrus and melons, new and used cars, frozen poultry and steel coils, limestone and lumber, pulp and paper | iron ore (taconite), coal, grain, coke | coal, autos, machinery, project cargo, manufactured goods |
| **Major Trade Partners Served** | Not Available | Not Available | Not Available |
| **Future Improvements Planned** | Port Manatee is in the midst of investing about $40 million for expansion. The port's plans include dredging to a depth of 40 feet at its berths to accommodate larger ships and it also plans a new 60,000-square-foot cruise terminal. In addition, the projects include more warehouse space for both dry and chilled products. The proposed work on the Hillsborough River involves expanding the channel to 3700 feet long, 290 feet wide, and 42 feet deep. The length of project is 10.0 miles. Planned improvements to the Alafia River consists of a channel 30 feet deep and 200 feet wide from the ship channel in Hillsborough Bay to and including a turning basin 700 feet wide and 1,200 feet long. The length of project is about 3.6 miles. | The U.S. Army Corps of Engineers is looking to research the effects of enlarging the 2,300-mile waterway system, stretching from the St. Lawrence River to Duluth-Superior. Canada has been asked to pick up half the study's tab. | Not Available |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Philadelphia | Portland and the Columbia River | St. Louis |
|---|---|---|---|
| **Harbor Size** | Port of Philadelphia comprises 5 piers and 2 marine terminals, covering approximately 390 acres and 23 berths. | The Port of Portland comprises 5 marine facilities over approximately 1800 acres. | The Port of St. Louis extends 70 miles along both banks of the Mississippi River. A total of 134 piers, wharves and docks are located within the Port of St. Louis (76 on the Missouri side and 58 on the Illinois side). |
| **Web Site** | www.philaport.com | www.portofportlandor.com | Not Available |
| **Channel Depth** | 40 feet | 55 feet | Not Available |
| **Total Volume (Tonnage)** | 40824498 | 34313663 | 33337815 |
| **Total Value (in millions)** | 9986 | 10533 | Not Available |
| **Number of Calls** | In 2000, 954 Tanker Calls, 492 Dry Bulk Calls, 468 Containership Calls, 825 Other General Calls | In 2000, 277 Tanker Calls, 1,279 Dry Bulk Calls, 262 Containership Calls, 345 Other General Calls | Not Available |
| **Imports** | steel, fruit, cocoa beans, paper/pulp, motor vehicles, over-dimension/heavy-lift, liquid bulk, project | automobiles, steel products, footwear, clothing, toys, canned foods | Not Available |
| **Exports** | Not Available | wheat, lumber, hay, barley, machinery, paperboard, linerboard, frozen vegetables, soda ash, potash, urea | Petroleum, chemicals, grain and coal |
| **Major Trade Partners Served** | Canada, Mexico, the U.K., Japan, Germany, the Netherlands, France, and South Korea | Not Available | Not Available |
| **Future Improvements Planned** | PRPA and its 11-member Board of regional business leaders are now pursuing the next phase of the Port of Philadelphia's evolution: Project 21. The aim of this project is the total modernization of the Delaware River's industrial waterfront. As part of an EPA Superfund agreement, a 1,200-foot pier along the Delaware River is planned to support warehouses, special port facilities, a container cargo dock, and the city's first dedicated passenger ship terminal. Plans also include refrigerated warehouses and container ship berths with on-dock rail service and special facilities for handling automobiles, dry bulk materials, and refrigerated liquid bulk commodities. The Port of Philadelphia is in the process of deepening from 40' to 45' the main channel of the Delaware River from the ocean to the marine terminals in Philadelphia and Camden. | The Columbia River Channel improvement project aims to deepen the Columbia River navigation channel from 40 to 43 feet, at a cost of $156 million | The City of St. Louis is also examining ways to make needed repairs and upgrade its port facilities. A recent study recommended that the city improve port access, navigation and technology. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Freeport, Texas | Seattle | Port Everglades |
|---|---|---|---|
| **Harbor Size** | The Port of Freeport land and operations currently include 186 acres of developed land and 7,723 acres of undeveloped land, and 5 operating berths. | The Port of Seattle is composed of three harbors with the North Harbor located in Puget Sound and the Central and South Harbors are located within Elliot Bay. | Port Everglades's jurisdiction encompasses 2,190 total acres, which includes 1,742 acres of upland and 448 acres of submerged land. |
| **Web Site** | www.portfreeport.com | www.portseattle.org | www.broward.org/port |
| **Channel Depth** | 45 feet | 50 feet | 47 feet |
| **Total Volume (Tonnage)** | 28966389 | 24155552 | 22500201 |
| **Total Value (in millions)** | 4944 | 32306 | 10540 |
| **Number of Calls** | In 2000, 516 Tanker Calls, 18 Dry Bulk Calls, 46 Containership Calls, 61 Other General Calls | In 2000, 49 Tanker Calls, 229 Dry Bulk Calls, 794 Containership Calls, 78 Other General Calls | In 2000, 345 Tanker Calls, 123 Dry Bulk Calls, 211 Containership Calls, 135 Other General Calls |
| **Imports** | bananas, miscellaneous fruit, project cargo, aggregate | wearing apparel, office and data processing machines, motor vehicle parts, electrical/electronic equipment, and telecommunications, sound and recording equipment | gasoline and aviation fuel, cement and clinkers, petroleum/crude and fuel oil, apparels, fruits, residues, steel bars, asphalt and calcined alumina, bypsum, beer and ale, coal and coke, coffee |
| **Exports** | rice, chemicals, general cargo | paper, meats, industrial equipment, hides, grains, cereals, motor vehicle parts, inorganic chemicals, frozen vegetables, animal feeds | general cargo, grocery products, fabrics, building/construction material, paper, poultry, automobile parts, logs and lumber, automobiles, gasoline and aviation fuel, trucks, lifts and parts, non-alcoholic beverages, fruits |
| **Major Trade Partners Served** | Saudi Arabia, Honduras, Mexico, Africa, and the Dominican Republic | China, Hong Kong, Korea, Japan, Singapore, Taiwan, Thailand, and the Philippines | Brazil, Dominican Republic, Honduras, Costa Rica and Colombia |
| **Future Improvements Planned** | Future expansion includes building a 1,300-acre multi-modal facility, cruise terminal and containers terminal. | A $7.1 million electrical upgrade will accommodate additional large vessels and seiners or long-liners. The Port also plans to reconfigure the docks at Fishermen's Terminal. At the Bell Street Pier Cruise Terminal, a $16.9 million capital upgrade is scheduled. The Port is conducting a joint dredging project for the first 3,000 feet (914 meters) of the East Waterway of the Duwamish River. The Port is investing more than $1 billion over 10 years in capital improvements aimed at upgrading and expanding its waterfront facilities. | The Port Everglades 20-year Master Plan envisions four complex projects: Project 1 – Petroleum Facilities; Projects 2 and 3 – Cruise Facilities; and Project 4 – Container Facilities. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Tacoma | Charleston | Boston |
|---|---|---|---|
| **Harbor Size** | The Port of Tacoma has 2,400 acres that are used for shipping terminal activity and warehouse, distributing, and manufacturing | The Port of Charleston has 4 marine terminals with over 12,00 total feet of berthing space on over 400 acres. | Not Available |
| **Web Site** | www.portoftacoma.com | www.port-of-charleston.com | www.massport.com |
| **Channel Depth** | 45-55 feet | 45 feet | 40 feet |
| **Total Volume (Tonnage)** | 22286610 | 21081838 | 20750789 |
| **Total Value (in millions)** | 19843 | 31516 | 5780 |
| **Number of Calls** | In 2000, 68 Tanker Calls, 218 Dry Bulk Calls, 568 Containership Calls, 342 Other General Calls | In 2000, 149 Tanker Calls, 139 Dry Bulk Calls, 1,547 Containership Calls, 332 Other General Calls | 120 Calls in 2001 |
| **Imports** | machinery, vehicles, electronics, toys and sports equipment, footwear and apparel | consumer goods, iron and steel, chemicals, foodstuffs, textiles, machinery | automobiles, beer and wine, games and sport equipment, ceramic tiles, fish and shellfish, footwear, furniture, paper |
| **Exports** | forest products, cereals, grain, machinery, meat, vehicles, fruit and vegetables | chemicals, paper products, wood pulp, foodstuffs, machinery, vehicles, clay | fish and products, hides and skins, household goods, logs and lumber, metal waste and scrap, paper and waste paper resin |
| **Major Trade Partners Served** | Japan and China | North Europe and Asia | Halifax, the Suez Canal, China, Korea, Malaysia, Thailand, and Singapore |
| **Future Improvements Planned** | PT is participating in the FAST Corridor program – a regional effort to increase the efficiency of moving freight and people in and around Puget Sound. The $33 million PT Road Overpass project was the first FAST Corridor project to be completed. Vision 2020: Over the next 20 years, the study recommends that the Port undertake more than $250 million in capital projects to: 1) Accommodate larger ships 2) Stimulate business growth, and 3) Meet the Port's public responsibilities. | The SPA's near-term capital expansion program calls for $300 million to improve productivity and utilization. The $150 million Charleston harbor deepening project began in 1999 and will deepen channels to 45 feet at low tide by 2004. Over the coming seven years, the Ports Authority plans to invest $300 million, from internal funds and revenue bonds, in its facilities to handle growth by existing customers and to continue improving service levels. The SPA has 3 major projects underway to serve its customers and the state's business community. Long-term needs require the development of new capacity, and the SPA is preparing to permit a new marine terminal on the Cooper River side of Daniel Island. | Funds for the Boston Harbor Navigation Improvement Project have been appropriated to proceed with maintenance and improvement dredging. The project will increase the depth in the Reserved Channel and Mystic River to 40 feet, matching the depth of the main ship channel. The Massachusetts Seaport Bond Bill, approved in 1996, authorizes funding for doublestack clearances in Massachusetts. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Jacksonville | Savannah | Honolulu |
|---|---|---|---|
| **Harbor Size** | The Port of Jacksonville's three public seaport terminals cover a combined 1,600 acres of land. | The Port of Savannah has over 1400 acres of terminal area (total) and over 14,000 linear feet for berthing. | Essentially all of the of Hawaii's overseas waterborne traffic enters and leaves Honolulu Harbor. It is comprised of over 30 berths and is almost 30,000 feet long. |
| **Web Site** | www.jaxport.com | www.gaports.com | www.hawaii.gov/dot |
| **Channel Depth** | 38 feet | 42 feet | 45 feet |
| **Total Volume (Tonnage)** | 19701277 | 19516589 | 15501001 |
| **Total Value (in millions)** | 10264 | 16324 | 1920 |
| **Number of Calls** | In 2000, 204 Tanker Calls, 190 Dry Bulk Calls, 305 Containership Calls, 592 Other General Calls | In 2000, 253 Tanker Calls, 330 Dry Bulk Calls, 739 Containership Calls, 447 Other General Calls | In 2000, 141 Tanker Calls, 84 Dry Bulk Calls, 339 Containership Calls, 112 Other General Calls |
| **Imports** | petroleum, coal and coke, gypsum, gasoline/aviation fuel, automobiles, cement, limestone chips, granite, crude minerals, steel wire rods | Not Available | petroleum products, crude material, primary manufactured goods, food and farm products, manufacture equipment, machinery and products |
| **Exports** | containers, phosphoric/sulfuric acids, bulk potassic fertilizer, paper/paperboard, automobiles, beer and ale, grocery products, honey and syrup | Not Available | food and farm products, manufactured equipment, machinery and products |
| **Major Trade Partners Served** | Puerto Rico, Brazil, Venezuela, Russia, Mexico, Canada, Colombia, Virgin Islands, Japan, Italy, and the U.K. | Canada, Japan, Mexico, the U.K., and Germany | Not Available |
| **Future Improvements Planned** | In 1999 President Clinton signed into law the Water Resources Development Act (WRDA), which authorized the deepening of Jacksonville's harbor to a depth of 40 feet to meet the needs of new, even larger cargo ships which will seek to call Jacksonville in the future. To better serve existing and future port users, JAXPORT has committed more than $200 million in capital projects over the past several years to improve its three marine terminals and Jacksonville's harbor. | Container Berth Eight will commence development during 2001. Upon completion, CB-8 will offer more than 70 acres for marshalling of containerized cargo. 1700 feet of berthing space and four high-speed super post-Panamax container cranes. The deepening of the Savannah Channel up to 48 feet (14.6 m) or more at mean low water. Additional land to increase capacity now (200+/80.9+hectares). | Efforts to further deepen the harbor and improve the entrance channel will be coordinated with the U.S. Army Corps of Engineers. Recommendations for Barbers Point Deep Draft Harbor under the 2020 Master Plan include the expansion of the harbor with additional piers and yards to accommodate expanded cargo capabilities. Federal funds will be used toward the installation of new technology that utilizes Global Positioning Satellites to facilitate the identification, delivery, and transfer of cargo. Additionally, Kewalo Basin's plans reflect a gradual transition to ocean-based tourist activities with commercial fishing being relocated to Honolulu Harbor and Keehi Lagoon. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | San Juan (PR) | Oakland | Miami |
|---|---|---|---|
| **Harbor Size** | The San Juan Seaport Project includes the pier district and the San Antonio Channel district, an area that covers approximately 87 acres. | Port of Oakland has 10 container terminals and 2 intermodal rail facilities serve the Oakland waterfront, with 17 deepwater berths and 32 container cranes. | The Port of Miami is situated on 640 acres with 19,687 linear feet of berthing space. |
| **Web Site** | Not Available | www.portofoakland.com | www.co.miami-dade.fl.us/portofmiami |
| **Channel Depth** | 40 feet | 42 feet | 42 feet |
| **Total Volume (Tonnage)** | 13839937 | 12161363 | 8609996 |
| **Total Value (in millions)** | 4402 | 25063 | 17546 |
| **Number of Calls** | In 2000, 80 Tanker Calls, 101 Dry Bulk Calls, 610 Containership Calls, 553 Other General Calls | In 2001, the Port had 1,856 vessel arrivals. | In 2000, 11 Tanker Calls, 65 Dry Bulk Calls, 766 Containership Calls, 370 Other General Calls |
| **Imports** | petroleum derivative, miscellaneous food products, apparel, molasses, basic chemicals, paper products | auto parts, computer equipment, apparel, manufactured metal items, beverages, prepared foods, frozen meat, newsprint, paper and paperboard, monument or building stone, electrical machinery and appliances | stone, clay, cement and cement tiles, fruits and vegetables, apparel, alcoholic beverages, lumber and wood |
| **Exports** | fish, shellfish, electrical machinery, gasoline, and apparel | fruits and vegetables, waste paper, red meat and poultry, resins, chemicals, animal feed, raw cotton, wood and lumber, beverages and scrap metal | textiles, paper, food products, spare parts, iron, steel and other materials |
| **Major Trade Partners Served** | Cargo to PR is nearly all one way | Japan, mainland China, Taiwan, Thailand, Malaysia, Hong Kong, and South Korea | Honduras, Italy, Spain, Guatemala, Brazil, Venezuela, Dominican Republic and Jamaica |
| **Future Improvements Planned** | A mitigation plan will create 1.8 acres of shallow water habitat to mitigate for the loss of 1.2 acres of algal beds. An additional 3.2 acres of low emergent islands/mudflats will be created through the beneficial use of dredged material. Authorization was also given for San Antonio Channel to be extended 1,500 feet east with a depth increase to 36 feet along the varying channel width; Cruise Ship Basin to a depth of 36 feet at an irregular width between San Antonio Channel and the cruise ship piers on the south side of Old San Juan; and Ancorage Area E to a depth of 38 feet and mooring dolphins added for vessels using the area. | The $700 million Vision 2000 program includes deepening channels and berths from -42' to -50'. A central feature of the Vision 2000 project is an increase in facilities and storage needed for efficient cargo movement. The new Berths 55-58 will provide 5400 feet of berthing area where four ships may be loaded or unloaded and will include 250 acres of new marine terminals and container yards. The alignment and size of the new marine and rail terminals provide the storage necessary for efficient throughput of containers from ship to rail or truck and on to their destinations. | Phase II of the port's dredging project continues the deepening of the South Channel and the Central Turning Basin. The forecast schedule calls for the physical completion of the project construction by the summer of 2003. A GRR study is also underway to examine the feasibility of widening and lowering the depth of the channels. New construction projects, which total $170 million, include: the construction of new cruise terminals; remodeling of two existing terminals; two additional multi-level parking garages; reconfiguration for access roads; a cruise, cargo and security gateway complex; storage sheds; additional wharf construction; mooring improvements; security improvements; and, new warehouse space. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Anchorage | San Francisco | Hampton Roads |
|---|---|---|---|
| **Harbor Size** | A 128.96 acre Industrial Park adjoins the Port to the east. Approximately 80.87 acres of the Park are under long-term lease to various Port users. Additionally, there are 31.0 acres for the staging and storage of marine cargo in transit. | The Port of San Francisco is 7-1/2 miles of San Francisco Bay shoreline with more than 1,000 acres under its jurisdiction. | The Port of Virginia boasts 16 Foreign Trade Zone Sites covering more than 3,500 acres with 3 marine terminals. |
| **Web Site** | www.muni.org/port/index.cfm | www.sfport.com | www.vaports.com |
| **Channel Depth** | 30 to 70 feet | 55 feet | 50 feet |
| **Total Volume (Tonnage)** | 3827886 | 3588324 | |
| **Total Value (in millions)** | 1909 | 6830 | 28386 |
| **Number of Calls** | Not Available | Not Available | In 2000, 155 Tanker Calls, 436 Dry Bulk Calls, 1,557 Containership Calls, 348 Other General Calls |
| **Imports** | containerized, liquid bulk, dry bulk | coffee, steel, wine, frozen meat, lumber | tobacco, auto engines and parts, natural rubber, paper and paperboard, construction and building equipment, alcoholic beverages, metal manufactures, cocoa beans, machinery parts, manufactured or processed food |
| **Exports** | containerized, liquid bulk | wastepaper, cotton, animal feed, foodstuffs | logs and lumber, paper and paperboard, wood pulp, tobacco, auto parts, alcoholic beverages, poultry, pet and animal feeds, staple fibers and fabrics, alcohol and alcoholic derivatives |
| **Major Trade Partners Served** | Japan, Korea | Mexico, Japan, Canada, Taiwan, the U.K., South Korea, China, and Germany | Canada, Japan, Germany, Mexico, and the U.K. |
| **Future Improvements Planned** | The Port is currently participating in regional efforts to develop of natural resource industries. To facilitate movement of these cargoes and provide for the requirements of existing customers, the Port is concentrating its efforts in three areas: 1) developing and improving land managed by the Port; 2) improving and expanding the intermodal network serving the Port; 3) replacing an aging under-capacity petroleum valve yard needed to service fuel distributions. A 2-year maintenance-dredging contract was awarded. Also underway is the resurfacing, rehabilitation and reconstruction project of Ocean Dock Road. | With the demolition of the double-decked Embarcadero Freeway, the Port has the opportunity to reunite the City with its waterfront. Throughout the waterfront, the Port provides plazas, walks, parks, and public access on piers, which afford City residents and visitors alike the opportunity to enjoy the spectacular waterfront setting. Projects include the Pier 43 Ferry Terminal, the Pier 27-31 Mixed Use Recreation Project, the Bryant Street Pier and Cruise Terminal Project, and the Pier 70 Opportunity Area. | The Port has identified more than $334.8 million in significant improvements to existing facilities and construction of new facilities in order to accommodate the potential cargo growth, including plans for each of the VPA terminals, with a focus on the expansion of NIT and the need for expanded on–terminal intermodal rail access, are included. The navigation system will get an upgrade as part of several safety and security enhancements that the VPA plans to fund with a portion of $135 million in revenue bonds. The bulk of proceeds from the bonds will cover the costs to replace the aging wharf, dredge the river, improve equipment and modernize cranes at the Norfolk International Terminals South. |

## SUPPLEMENT 2-2: Selected U.S. Ports Information

| Port | Morgan City |
| --- | --- |
| **Harbor Size** | The Port of Morgan City has a 500-foot dock with 300-foot extension can easily accommodate large vessels. There is also a 20,000 sq. feet warehouse with security and sprinkler systems. |
| **Web Site** | www.portofmc.com |
| **Channel Depth** | 20 feet |
| **Total Volume (Tonnage)** | Not Available |
| **Total Value (in millions)** | 9387 |
| **Number of Calls** | Not Available |
| **Imports** | steel, wire rod, galvanized coils, produce, fertilizers, and alcoholic beverages. |
| **Exports** | newsprint, forest products, steel, cotton, pipe, and pharmaceuticals. |
| **Major Trade Partners Served** | Not Available |
| **Future Improvements Planned** | There are two primary objectives for this MARITECH project. Project Task 1 seeks to improve the existing product lines and develop a new product line, the "Swift Express" family of crew/supply vessels, utilizing multiple diesel engines combined with waterjet propulsors. Project Task 2 has as its objective the improvement of the existing Swiftships, Inc. physical plant and the design and development of an entirely new "Shipyard 2000" to build the Swift Express vessels for world markets. |

## NO SUPPLEMENTAL INFORMATION FOR CHAPTER 3: OCEAN AND COASTAL SAFETY AND PROTECTION

## SUPPLEMENT 4-1: National Marine Fisheries Service Facilities

| Facility | Location of Facility | Description of Facility |
|---|---|---|
| **Alaska Regional Office** | Juneau, AK | Primarily focuses on management and regulations for the Alaskan region. |
| **Alaska Fisheries Science Center (AFSC)** | Seattle, WA | Conducts resource assessment and conservation engineering and resource ecology and fisheries management. Also contains the National Marine Mammal Laboratory for ecosystem studies. |
| **Auke Bay Laboratory (ABL)** | Juneau, AK | Primarily used for salmonid research. Plans to relocate to a new NOAA Consolidated Facility in Juneau. |
| **Kodiak Laboratory** | Kodiak, AK | Primary facility for Alaska's Shellfish Assessment Program. Also houses an extensive museum collection of marine species. |
| **Little Port Walter Field Station (LPW)** | Sitka, AK | LPW is the oldest year-round biological research station in Alaska, accessible only by boat or seaplane. Projects primarily focus on salmonid experimentation and research. |
| **Dutch Harbor Facility** | Dutch Harbor, AK | A field office for the North Pacific Groundfish Observer Program. |
| **Anchorage Observer Office** | Anchorage, AK | Coordinates support for observers involved in the North Pacific Groundfish Observer Program, provides assistance to the North Pacific Observer Training Center, and coordinates Community Development Quota activities with the NMFS Regional Office. |
| **Hatfield Marine Science Center** | Newport, OR | Conducts laboratory research on the behavioral responses of commercially important marine fishes to environmental factors. |
| **Lena Point Research Facility Project** | Juneau, AK | Under construction. Will allow NMFS to increase its capability to conduct critical and scientific research programs in Alaska. |
| **Juneau Subport** | Gastineau Channel, Juneau, AK | Part of ABL. Supports ABL research by providing construction, maintenance, and warehouse space, in addition to moorage and support services for NOAA vessels. |
| **NMFS Office of Exxon Valdez Oil Spill Damage Assessment and Restoration (EVOS)** | Juneau, AK | Research focuses on the impact of the remaining oil on the environment, and new research is developing long-term strategies for understanding the relative roles of human and natural factors as sources of change in the ecosystem. |
| **Northeast Regional Office** | Gloucester, MA | Administers NOAA's programs in the Northeastern United States to manage living marine resources for optimum use. |
| **Northeast Fisheries Science Center** | Woods Hole, MA | The Center plans, develops, and manages a multidisciplinary program of basic and applied research to better understand living marine resources of the Northeast Continental Shelf Ecosystem. |
| **Woods Hole Laboratory** | Woods Hole, MA | Conducts fisheries and ecosystem monitoring research. Homeport for two research vessels, the R/V Albatross IV and R/V Delaware II. |
| **Milford Laboratory** | Milford, CT | Present research emphasizes aquaculture and habitat-related work. A 49-foot vessel, the R/V Victor Loosanoff, is also docked at the Laboratory for nearshore research. |
| **James J. Howard Laboratory** | Sandy Hook, NJ | The primary mission of the Howard Laboratory is to conduct research in ecology, leading to a better understanding of both coastal and estuarine organisms and the effects of human activities on nearshore marine populations. |

## SUPPLEMENT 4-1: National Marine Fisheries Service Facilities

| Facility | Location of Facility | Description of Facility |
|---|---|---|
| **Narragansett Laboratory** | Narragansett, RI | Supports research on the effects of changing environmental conditions on the growth and survival of fish stocks from an ecosystem perspective. |
| **National Systematics Laboratory** | Washington, DC | Serves as the taxonomic research arm of NOAA Fisheries as a whole. The Laboratory describes and names new species, and revises existing descriptions and names based on new information, of fishes, squids, crustaceans, and corals of economic or ecological importance to the United States. |
| **Orono Field Station** | Orono, ME | NA |
| **Northwest Regional Office** | Seattle, WA | Conserve, protect, and manage Pacific salmon, groundfish, halibut and marine mammals and their habitats under the Endangered Species Act and other laws. |
| **Northwest Fisheries Science Center (NFSC)** | Seattle, WA | Conducts research in conservation biology, environmental conservation, fish ecology, fishery resource analysis and monitoring, and resource enhancement and utilization technology. |
| **Manchester Field Station** | Manchester, WA | Not Available |
| **Mukilteo Field Station** | Mukilteo, WA | Not Available |
| **Pasco Field station** | Pasco, WA | Not Available |
| **Hammond Field Station** | Hammond, OR | Not Available |
| **Newport Field Station** | Newport, OR | Not Available |
| **Southeast Regional Office (SERO)** | St. Petersburg, FL | Responsible for the conservation, management, and protection of marine fishery resources inhabiting waters off the southeastern United States, the management and protection of marine mammals and endangered species, and habitat protection and restoration. |
| **Southeast Fisheries Science Center (SEFSC)** | Miami, FL | The Center provides supervisory and administrative support to large marine ecosystems programs performing fishery research, collecting and reporting on statistical data and controlling and operating Center data management support systems. |
| **Panama City Laboratory** | Panama City, FL | The current research program encompasses a spectrum of research projects ranging from basic research on fishery ecology and oceanography to routine monitoring and data collection. The fisheries of primary interest are for reef fish and coastal pelagic species. |
| **Galveston Laboratory** | Galveston, TX | The only Federal fisheries laboratory west of the Mississippi River on the Gulf of Mexico. Contains the largest and most extensive federally operated sea water system in the southeastern United States. In addition, is the only federal facility in the United States dedicated to captive rearing of sea turtles. This laboratory provides scientific information on the management of commercial and recreational shellfish and finfish, conservation of coastal habitats, and protection of threatened and endangered marine species of the Gulf of Mexico. |

## SUPPLEMENT 4-1: National Marine Fisheries Service Facilities

| Facility | Location of Facility | Description of Facility |
|---|---|---|
| **Mississippi Laboratory** | Pascagoula, MS | Conducts vessel, submersible, and aircraft surveys of fish, endangered species, and marine mammals; gear research to achieve conservation objectives, improve operating efficiencies and develop new fisheries; and research to improve effectiveness of sampling systems and to apply satellite technology to fisheries. This branch includes staff at the Stennis Space Center facility. |
| **Beaufort Laboratory** | Beaufort, NC | Conducts research in habitat utilization, fish ecology, chemical and physiological processes, reef resources, population dynamics, and technology and spatial analysis. |
| **Southwest Regional Office** | Long Beach, CA | Its programs assess, manage, and promote the conservation of living marine resources. |
| **La Jolla Laboratory** | La Jolla, CA | Conducts research on Pacific and Antarctic fish, marine mammals, sea turtles, and marine habitats. |
| **Santa Cruz Laboratory** | Santa Cruz, CA | A state-of-the art facility for Pacific salmon and groundfish research and home of the new National Science Center for Marine Protected Areas. |
| **Pacific Fisheries Environmental Laboratory** | Pacific Grove, CA | Emphasizes the study of environmental influences on marine resources and provides environmental information to fishery researchers and managers. Work closely with FNMOC, which is the primary U.S. government facility concerned with marine weather and ocean conditions. |
| **Honolulu Laboratory** | Honolulu, HI | Conducts research on tunas and billfishes, bottom fishes, lobster, deep-sea shrimp, sea turtles, and the highly endangered Hawaiian monk seal. |
| **Kewalo Research Facility** | Honolulu, HI | This facility includes laboratories tailored for various research activities, including saltwater tanks for fisheries and protected marine animal research. |
| **Pacific Islands Area Office** | Honolulu, HI | Provides assistance and support with the sustainable fisheries program, protected resources program, habitat conservation program, and Hawaii long line observer program in the Pacific Islands geographical area. |

## SUPPLEMENT 4-2: UNOLS Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| KNORR | 1991 | 279 | Woods Hole Oceanographic Institution | Oceanography (Global) | NE |
| MELVILLE | 1991 | 279 | Scripps Institution of Oceanography | Oceanography (Global) | WC |
| ATLANTIS | 1997 | 274 | Woods Hole Oceanographic Institution | Oceanography (Global) submersible support | NE |
| ROGER REVELLE | 1996 | 274 | Scripps Institution of Oceanography | Oceanography (Global) | WC |
| THOMAS G. THOMPSON | 1991 | 274 | University of Washington | Oceanography (Global) | WC |
| MAURICE EWING | 1983 | 239 | Lamont-Doherty Earth Observatory | Oceanography and geophysical survey (Global) | MA |
| SEWARD JOHNSON | 1984 | 204 | Harbor Branch Oceanographic Institution | Oceanography (intermediate) submersible support | SE |
| WECOMA | 1975 | 185 | Oregon State University | Oceanography (intermediate) | WC |
| ENDEAVOR | 1993 | 184 | University of Rhode Island | Oceanography (intermediate) | NE |
| GYRE | 1980 | 182 | Texas A&M University | Oceanography (intermediate) | GM |
| OCEANUS | 1975 | 177 | Woods Hole Oceanographic Institution | Oceanography (intermediate) | NE |
| NEW HORIZON | 1978 | 170 | Scripps Institution of Oceanography | Oceanography (intermediate) | WC |
| SEWARD JOHNSON II | 1988 | 168 | Harbor Branch Oceanographic Institution | Oceanography (intermediate) | SE |
| CAPE HATTERAS | 1981 | 135 | Duke University | Oceanography (Regional) | SE |
| POINT SUR | 1981 | 135 | Moss Landing Marine Laboratories | Oceanography (Regional) | WC |
| ALPHA HELIX | 1965 | 133 | University of Alaska | Oceanography (Regional) | AK |
| ROBERT GORDON SPROUL | 1981 | 125 | Scripps Institution of Oceanography | Oceanography (Regional) | WC |
| CAPE HENLOPEN | 1976 | 120 | University of Delaware | Oceanography (Regional) | MA |
| WEATHERBIRD II | 1993 | 115 | Bermuda Biological Station for Research | Oceanography (Regional) | MA |
| KILO MOANA | 2002 | 113 | University of Hawaii/SOEST | Oceanography (Regional) | WP |
| PELICAN | 1985 | 105 | Louisiana Universities of Marine Consortium | Oceanography (Regional) | GM |
| LONGHORN | 1986 | 103 | University of Texas Marine Science Institute | Oceanography (Local) | GM |
| URRACA | 1986 | 96 | Smithsonian Tropical Research Institute | Oceanography (Local) | C |
| F. G. WALTON SMITH | 2000 | 96 | University of Miami | Oceanography (Local) | SE |
| SAVANNAH | 2001 | 92 | Skidaway Institute of Oceanography | Oceanography (Local) | SE |
| BLUE HERON | 1985 | 87 | Large Lakes Observatory University of Minnesota | Oceanography (Local) | GL |
| CLIFFORD A. BARNES | 1966 | 66 | University of Washington | Oceanography (Local) | WC |

*Regions: GL – Great Lakes; NE – Northeast; MA – Mid Atlantic; SA – South Atlantic; C – Caribbean; GM – Gulf of Mexico; WC – West Coast; AK – Alaska; WP – Western Pacific

## SUPPLEMENT 4-3: Academic Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| **LITTLE DIPPER** | 2002 | 26 | University of Alaska Fairbanks | Coastal research and marine education | AK |
| **GAVIOTA** | 1957 | 34 | Department of Marine Sciences, University of Puerto Rico | Coastal research and marine education | C |
| **SULTANA** | NA | 54 | Department of Marine Sciences, University of Puerto Rico | Coastal research and marine education | C |
| **PEZMAR** | 1975 | 58 | Department of Marine Sciences, University of Puerto Rico | Coastal research and marine education | C |
| **CHAPMAN** | 1980 | 127 | Department of Marine Sciences, University of Puerto Rico | Oceanography | C |
| **D. J. ANGUS** | 1985 | 45 | Grand Valley State University | Coastal research and marine education | GL |
| **W. G. JACKSON** | 1995 | 65 | Grand Valley State University | Coastal research and marine education | GL |
| **INLAND SEAS** | 1994 | 62 | Inland Seas Education Association | Coastal research and marine education | GL |
| **NOODIN** | NA | 25 | Large Lakes Observatory University of Minnesota | Coastal research and marine education | GL |
| **NAVICULA** | 1961 | 30 | Michigan Technological University | Coastal research and marine education | GL |
| **GIBRALTAR III** | 1981 | 42 | Ohio State University Ohio State Franz Theodore Stone Laboratory | Coastal and fisheries research, and marine education | GL |
| **BIOLAB** | 1947 | 37 | Ohio State University | Coastal research and marine education | GL |
| **STATE OF MICHIGAN** | 1985 | 224 | U.S. Merchant Marine Academy Great Lakes | Maritime education | GL |
| **LAURENTIAN** | 1974 | 80 | University of Michigan | Oceanography and marine education | GL |
| **MELOSIRA** | NA | 45 | University of Vermont | Coastal research and marine education | GL |
| **NEESKAY** | 1970 | 71 | University of Wisconsin | Oceanography and marine education | GL |
| **BOAT** | 1982 | 32 | Auburn University | Coastal research and marine education | GM |
| **VERRILL** | 1965 | 65 | Dauphin Island Sea Lab | Coastal research and marine education | GM |
| **LONE STAR** | NA | 70 | Department of Geology and Geophysics, Rice University | Geophysical research, oceanography , and marine education | GM |
| **BELLOWS** | 1969 | 72 | Florida Institute of Oceanography | Oceanography and marine education | GM |
| **SUNCOASTER** | 1962 | 107 | Florida Institute of Oceanography | Oceanography | GM |
| **SEMINOLE** | NA | 41 | Florida State University | Coastal research and marine education | GM |
| **HERMES** | 1968 | 38 | Gulf Coast Research Laboratory, University of Southern Mississippi | Coastal and fisheries research, and marine education | GM |
| **TOM MCILWAIN** | 1978 | 55 | Gulf Coast Research Laboratory, University of Southern Mississippi | Coastal research and marine education | GM |
| **TOMMY MUNRO** | 1981 | 87 | Gulf Coast Research Laboratory, University of Southern Mississippi | Oceanography | GM |
| **ACADIANA** | 1985 | 58 | Louisiana Universities Marine Consortium | Coastal research and marine education | GM |

## SUPPLEMENT 4-3: Academic Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| EUGENIE CLARK | 1999 | 46 | Mote Marine Laboratory | Coastal research and marine education | GM |
| JOIDES RESOLUTION | 1984 | 470 | Texas A&M University | Geophysical survey | GM |
| IX508 | 1959 | 125 | University of Southern Mississippi | Oceanography | GM |
| T. GUY BRAGG | 1990 | 38 | University of Texas at Austin | Coastal research and marine education | GM |
| KATY TRAWLER | 1981 | 57 | University of Texas at Austin | Coastal research and marine education | GM |
| MARIE HALL | 1996 | 60 | University of Texas Medical Branch | Coastal research and marine education | GM |
| HENRY M. STOMMEL | NA | 41 | Bermuda Biological Station for Research, Inc. | Coastal research and marine education | MA |
| AQUARIUS | 1970 | 40 | Buffalo State College Great Lakes Center | Coastal and fisheries research, and marine education | MA |
| SENECA | 1961 | 46 | Buffalo State College Great Lakes Center | Coastal and fisheries research, and marine education | MA |
| H.W.S. EXPLORER | 1954 | 61 | Hobart and William Smith Colleges | Coastal research and marine education | MA |
| PHILIP N PARKER | NA | 50 | Marine Science Consortium | Coastal research and marine education | MA |
| DONALD W. PRITCHARD | 1989 | 28 | Marine Sciences Research Center, SUNY | Coastal research and marine education | MA |
| SEAWOLF | 1982 | 80 | Marine Sciences Research Center, SUNY | Oceanography and marine education | MA |
| FAY SLOVER | 2002 | 55 | Old Dominion University | Coastal research and marine education | MA |
| LINWOOD HOLTON | 1953 | 66 | Old Dominion University | Coastal research and marine education | MA |
| CALETA | NA | 30 | Rutgers State University of New Jersey and IMCS | Coastal research and marine education | MA |
| ARABELLA | 1996 | 48 | Rutgers State University of New Jersey and IMCS | Coastal research and marine education | MA |
| SAXATILIS | NA | 42 | Satellite Education Resources Consortium | Coastal research and marine education | MA |
| JOHN M. KINGSBURY | 1984 | 47 | Shoals Marine Laboratory | Coastal research and marine education | MA |
| SHINNECOCK | 1984 | 34 | Southampton College of Long Island Univ. | Coastal research and marine education | MA |
| PAUMANOK | 1986 | 44 | Southampton College of Long Island Univ. | Coastal research and marine education | MA |
| FOOT PARKER OUTBOARD COASTAL RESEARCH VESSEL | 1991 | 26 | Stevens Institute of Technology | Coastal research and marine education | MA |
| FOOT CUSTOM DIESEL COASTAL RESEARCH VESSEL | 1992 | 36 | Stevens Institute of Technology | Coastal research and marine education | MA |
| JOSEPH LEIDY | NA | 42 | The Academy of Natural Sciences Estuarine Research Center | Coastal research and marine education | MA |
| MATTHEW F. MAURY | NA | 51 | Tidewater Community College | Coastal research and marine education | MA |
| KING'S POINTER | 1985 | 224 | U.S. Merchant Marine Academy Kings Point | Maritime education | MA |

## SUPPLEMENT 4-3: Academic Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| YARD PATROL CRAFT YPS86 | 1986 | 108 | U.S. Naval Academy | Maritime education | MA |
| AQUARIUS | 1972 | 65 | University of Maryland | Coastal research and marine education | MA |
| HERON | NA | 26 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| MARSH HAWK | NA | 26 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| OSPREY | NA | 26 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| WOODEN SCOW | NA | 26 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| CAROLINA SKIFF | NA | 27 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| STURE OLSSON | NA | 29 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| FISH HAWK | 1990 | 30 | Virginia Institute of Marine Science, College of William and Mary | Coastal and fisheries research, and marine education | MA |
| WOODEN BOAT | NA | 30 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| EAGLE'S NEST | NA | 36 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| LANGLEY | 1972 | 44 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| BAY EAGLE | 1981 | 65 | Virginia Institute of Marine Science, College of William and Mary | Coastal research and marine education | MA |
| VIRAZON | NA | 65 | Institute Nautical Archaeology, Texas A&M | Marine archaeology | Med |
| ARGO MAINE | 1968 | 80 | Maine Maritime Academy | Maritime education | NE |
| GEMMA | NA | 50 | Marine Biological Laboratory | Coastal research and marine education | NE |
| MYSIS | 1963 | 50 | Northeastern University Marine Science Center | Coastal research and marine education | NE |
| NERITIC | NA | 25 | School of Marine Science and Technology University of Massachusetts | Coastal research and marine education | NE |
| HURRICANE | NA | 48 | School of Marine Science and Technology University of Massachusetts | Coastal research and marine education | NE |
| LUCKY LADY | Na | 50 | School of Marine Science and Technology, University of Massachusetts | Coastal research and marine education | NE |
| SOUNDER | 1974 | 42 | Schooner Sound Learning | Coastal research and marine education | NE |
| ROBERT C. SEAMANS | 2001 | 135 | Sea Education Association | Marine education | NE |
| WESTWARD | 1961 | 125 | Sea Education Association | Marine education | NE |
| CORWITH CRAMER | 1988 | 135 | Sea Education Association | Marine education | NE |

## SUPPLEMENT 4-3: Academic Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| CORSAIR | 1966 | 65 | Southeastern Massachusetts University | Coastal research and marine education | NE |
| C.M. HALL | 1988 | 26.7 | Southern Maine Technical College | Coastal research and marine education | NE |
| MARINE SCIENCE | 1979 | 30 | U.S. Coast Guard Academy | Maritime education | NE |
| CONNECTICUT | 1998 | 77 | University of Connecticut | Oceanography and marine education | NE |
| NUCELLA | NA | 27 | University of Maine | Coastal research and marine education | NE |
| LEE | 1975 | 34 | University of Maine | Coastal research and marine education | NE |
| IRA C | NA | 42 | University of Maine | Coastal research and marine education | NE |
| RESEARCH VESSEL | 1984 | 50 | University of Massachusetts System | Coastal research and marine education | NE |
| BLUE FIN | NA | 26 | University of New Hampshire | Coastal research and marine education | NE |
| GALEN J. | NA | 26 | University of New Hampshire | Coastal research and marine education | NE |
| COASTAL SURVEYOR | NA | 40 | University of New Hampshire | Coastal research and marine education | NE |
| ROCK 'N ROLL | NA | 40 | University of New Hampshire | Coastal and fisheries research, and marine education | NE |
| GULF CHALLENGER | 1993 | 51 | University of New Hampshire | Coastal research and marine education | NE |
| CAPTAIN BERT | 1987 | 54 | University of Rhode Island | Coastal and fisheries research, and marine education | NE |
| CT-1 | 1979 | 80 | University of Rhode Island | Oceanography and marine education | NE |
| ASTERIAS | 1979 | 46 | Woods Hole Oceanographic Institution | Coastal research and marine education | NE |
| MARTECH I | 1981 | 53 | Cape Fear Community College | Coastal research and marine education | SE |
| DAN MOORE | 1967 | 85 | Cape Fear Community College | Oceanography and maritime education | SE |
| SUSAN HUDSON | 1991 | 57 | Duke University Marine Laboratory | Coastal research and marine education | SE |
| PARKER | 1992 | 25 | East Carolina University | Coastal research and marine education | SE |
| SANDRINE | 1990 | 25 | East Carolina University | Coastal research and marine education | SE |
| NITRO | 1964 | 33 | East Carolina University | Coastal research and marine education | SE |
| PERKINS | 1953 | 65 | East Carolina University | Coastal research and marine education | SE |
| OCEANEER IV | 1978 | 34 | Florida Atlantic University | Coastal research and marine education | SE |
| STEPHAN | 1991 | 65 | Florida Atlantic University | Ocean engineering | SE |
| DELPHINUS | 1991 | 60 | Florida Institute of Technology | Coastal research and marine education | SE |
| CORAL REEF II | 1984 | 80 | John G. Shedd Aquarium | Oceanography and marine education | SE |
| HUMPHRIES | 2003 | 48 | North Carolina State University | Coastal research and marine education | SE |
| GEORGIA BULLDOG | 1977 | 73 | University of Georgia Marine Extension Service | Oceanography and marine education | SE |

## SUPPLEMENT 4-3: Academic Research Vessels

| Name | Year | Length (ft) | Institution | | Region* |
|---|---|---|---|---|---|
| **DRUM** | NA | 25 | University of Miami | Coastal research and marine education | SE |
| **SEAHAWK** | 1999 | 41 | University of North Carolina | Coastal research and marine education | SE |
| **CAPE FEAR** | 1998 | 70 | University of North Carolina | Oceanography and marine education | SE |
| **MACGINITIE** | 1999 | 28 | California State University at Monterey Bay | Coastal research and marine education | WC |
| **FORERUNNER** | 1969 | 50 | Clatsop Community College | Coastal research and marine education | WC |
| **CORAL SEA** | 1974 | 90 | Humboldt State University | Oceanography | WC |
| **ZEPHYR** | 1972 | 87 | Monterey Bay Aquarium Research Institute | Oceanography | WC |
| **POINT LOBOS** | 1989 | 110 | Monterey Bay Aquarium Research Institute | Oceanography | WC |
| **WESTERN FLYER** | 1996 | 117 | Monterey Bay Aquarium Research Institute | Oceanography (Ocean) | WC |
| **SHEILA B.** | 2001 | 30 | Moss Landing Marine Laboratories, California State University | Coastal research and marine education | WC |
| **ED RICKETTS** | 1978 | 35 | Moss Landing Marine Laboratories, California State University | Coastal research and marine education | WC |
| **JOHN H. MARTIN** | 1985 | 56 | Moss Landing Marine Laboratories, California State University | Coastal research and marine education | WC |
| **ELAKHA** | 2000 | 54 | Oregon State University | Coastal research and marine education | WC |
| **QUESTUARY** | 1975 | 38 | Romberg Tiburon Center for Environmental Studies, San Francisco State University | Coastal research and marine education | WC |
| **FLIP** | 1962 | 355 | Scripps Institution of Oceanography | Oceanography | WC |
| **CHARLES A. KANE** | 1993 | 101 | Seattle Maritime Academy | Maritime education | WC |
| **ANOVA** | NA | 31 | Shannon Point Marine Center Western Washington University | Coastal research and marine education | WC |
| **SEAWATCH** | 1977 | 65 | Southern California Marine Institution | Coastal research and marine education | WC |
| **YELLOWFIN** | 1987 | 76 | Southern California Marine Institution | Oceanography and marine education | WC |
| **VANTUNA** | 1969 | 85 | Southern California Marine Institution | Oceanography and marine education | WC |
| **NAIA** | 1984 | 25 | University of California Santa Cruz | Coastal research and marine education | WC |
| **ESTES RADON** | 2000 | | University of California Santa Cruz | Coastal research and marine education | WC |
| **PARAGON** | 2002 | 32 | University of California Santa Cruz | Coastal research and marine education | WC |
| **DAVID JOHNSTON** | 1980 | 43 | University of California Santa Cruz | Coastal research and marine education | WC |
| **CUSTOM** | 2001 | 37 | University of California, Davis | Coastal research and marine education | WC |
| **PLUTEUS** | 1970 | 42 | University of Oregon | Coastal research and marine education | WC |
| **SEA WATCH** | 1957 | NA | University of Southern California | Coastal research and marine education | WC |
| **C.E. MILLER** | 1962 | 50 | University of Washington | Coastal research and marine education | WC |

## SUPPLEMENT 4-3: Academic Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| **J.E. HENDERSON** | 1959 | 70 | University of Washington Applied Physics Lab | Oceanography and marine education | WC |
| **KAHOLO** | | 42 | Hawaii Pacific University | Coastal research and marine education | WP |
| **KILA** | 1977 | 104 | University of Hawaii/SOEST | Oceanography | WP |
| **KA'IMIKAI-O-KANALOA** | 1978 | 222 | University of Hawaii/SOEST | Oceanography submersible support | WP |

*Regions: GL – Great Lakes; NE – Northeast; MA – Mid Atlantic; SA – South Atlantic; C – Caribbean; GM – Gulf of Mexico; WC – West Coast; AK – Alaska; WP – Western Pacific
NA - Information was not available

## SUPPLEMENT 4-4: Federal Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| RELENTLESS II | NA | 21 | MMS | Marine mammal survey | GM |
| NINA | 1962 | 42 | MMS | Ocean Engineering | GM |
| LAUNCH 1273 | 1983 | 37 | MMS | Coastal research | AK |
| USNS JOHN MCDONNELL | NA | 208 | Navy | Oceanography Survey | NA |
| USNS KANE | NA | 285 | Navy | Oceanography Survey | NA |
| USNS SILAS BENT | NA | 285 | Navy | Oceanography Survey | NA |
| USNS BOWDITCH | NA | 329 | Navy | Oceanography Survey | NA |
| USNS BRUCE C. HEEZEN | NA | 329 | Navy | Oceanography Survey | NA |
| USNS HENSON | NA | 329 | Navy | Oceanography Survey | NA |
| USNS PATHFINDER | NA | 329 | Navy | Oceanography Survey | NA |
| USNS SUMNER | NA | 329 | Navy | Oceanography Survey | NA |
| KA'IMIMOANA | 1996 | 224 | NOAA | Oceanography research | WP |
| OSCAR ELTON SETTE | 1987 | 224 | NOAA | Fisheries research | WP |
| VINDICATOR/HI'IALAKAI | 1984 | 224 | NOAA | Fisheries research coral reef mapping | WP |
| XANTU | NA | 28 | NOAA | Marine sanctuary support | WC |
| SEA OTTER | NA | 57 | NOAA | Fisheries Research | WC |
| SHEARWATER | NA | 62 | NOAA | Marine sanctuary support | WC |
| DAVID STARR JORDAN | 1965 | 171 | NOAA | Fisheries research | WC |
| MILLER FREEMAN | 1967 | 215 | NOAA | Fisheries research | WC |
| INDOMITABLE/MCARTHUR | 1985 | 224 | NOAA | Oceanography and atmospheric research | WC |
| RAINIER | 1968 | 231 | NOAA | Nautical charting | WC |
| JANE YARN | NA | 65 | NOAA | Marine sanctuary support | SE |
| POINT LOBOS | NA | 82 | NOAA | Marine sanctuary support | SE |
| POINT MONROER | NA | 82 | NOAA | Marine sanctuary support | SE |
| NANCY FOSTER | 1990 | 186 | NOAA | Coastal research | SE |
| RONALD H. BROWN | 1996 | 274 | NOAA | Oceanography and atmospheric research | SE |
| DELAWARE II | 1968 | 155 | NOAA | Fisheries Research | NE |
| ALBATROSS IV | 1962 | 187 | NOAA | Fisheries research | NE |
| LAIDLEY | NA | 54 | NOAA | Coastal research | MA |
| BAY HYDROGRAPHER | NA | 55 | NOAA | Nautical Charting | MA |
| GLORIA MICHELE | NA | 72 | NOAA | Fisheries surveys. | MA |
| RUDE | 1966 | 90 | NOAA | Nautical charting | MA |
| JOHN N. COBB | 1950 | 93 | NOAA | Fisheries research | MA |
| WHITING | 1963 | 163 | NOAA | Fisheries research | MA |
| LITTLEHALES | 1991 | 208 | NOAA | Nautical charting | MA |
| CARETTA | NA | 58 | NOAA | Fisheries Research | GM |
| OREGON II | 1967 | 170 | NOAA | Fisheries research | GM |

## SUPPLEMENT 4-4: Federal Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| GORDON GUNTER | 1989 | 224 | NOAA | Fisheries research | GM |
| FAIRWEATHER | 1967 | 231 | NOAA | Nautical charting | GM |
| SHENEHON | 1952 | 66 | NOAA | Coastal research | GL |
| ARCTIC WHALER | 1981 | 25 | NOAA | Coastal research | AK |
| OSCAR DYSON | 2004 | 209 | NOAA | Fisheries research | AK |
| NATHANIEL B. PALMER | 1991 | 309 | NSF | Polar research, icebreaker | SO |
| LAWRENCE M. GOULD | 1997 | 250 | NSF | Polar research, icebreaker | SO |
| SAXATIUS | NA | NA | Smithsonian Environmental Research Center | Coastal research | MA |
| SUNBURST | NA | NA | Smithsonian Marine Station Fort Pierce | Coastal research | SE |
| USCGC POLAR SEA | 1976 | 399 | USCG | Polar research, icebreaker | AK |
| USCGC POLAR STAR | 1976 | 399 | USCG | Polar research, icebreaker | AK |
| USCGC HEALY | 1998 | 420 | USCG | Polar research, icebreaker | AK |
| LEAR | NA | 35 | EPA | Environmental research and survey | MA |
| PETER W. ANDERSON | 1978 | 165 | EPA | Environmental research and survey | MA |
| MUDPUPPY | 1988 | 32 | EPA | Environmental research and survey | GL |
| LAKE EXPLORER | 1963 | 82 | EPA | Environmental research and survey | GL |
| LAKE GUARDIAN | 1980 | 180 | EPA | Environmental research and survey | GL |
| TOGUE | 1975 | 73 | USFWS | Fisheries research | GL |
| POLARIS | 1927 | 96 | USGS | Environmental research and survey | WC |
| RAFAEL | NA | 25 | USGS | Coastal geophysical survey | NE |
| G.K. GILBERT | 1993 | 50 | USGS | Coastal geophysical survey | GM |
| MUSKY II | 1960 | 45 | USGS | Coastal and fisheries research | GL |
| KAHO | 1961 | 65 | USGS | Coastal and fisheries research | GL |
| GRAYLING | 1977 | 75 | USGS | Coastal and fisheries research | GL |
| KIYI | 1999 | 107 | USGS | Coastal and fisheries research | GL |
| KARLUK | 1975 | 42 | USGS | Coastal geophysical survey | AK |

*Regions: GL – Great Lakes; NE – Northeast; MA – Mid Atlantic; SA – South Atlantic; C – Caribbean; GM – Gulf of Mexico; WC – West Coast; AK – Alaska; WP – Western Pacific
NA – Information was not available

## SUPPLEMENT 4-5: State Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| **MEDEIA** | NA | 110 | Alaska Department of Fish and Game | Fisheries research | AK |
| **MONTAGUE** | NA | 58 | Alaska Department of Fish and Game | Fisheries research | AK |
| **GULF COAST TRAWLER** | NA | 87 | California Dept Fish and Game | Fisheries research | WC |
| **GUMAR** | NA | 45 | California Dept Fish and Game | Fisheries research | WC |
| **MUNSEN** | NA | 32 | California Dept Fish and Game | Fisheries research | WC |
| **C.C.G.S. LIMNOS** | 1968 | 147 | Dept Fisheries and Ocean Canadian Coast Guard | Fisheries research | GL |
| **C.C.G.S. SHARK** | 1971 | 51 | Dept Fisheries and Ocean Canadian Coast Guard | Water quality monitoring | GL |
| **SCULPIN** | NA | 32 | Illinois Natural History Survey | Fisheries research | GL |
| **O. MYKISS** | 1988 | 34 | Indiana Department Natural Resources Lake Michigan Research | Fisheries research | GL |
| **QUEEN OF BAYFIELD** | 1941 | 40 | Lake Superior Chippewa-Red Cliff Fisheries Department | Fisheries research | GL |
| **CHANNEL CAT** | 1968 | 46 | Michigan Department of Natural Resources | Fisheries research | GL |
| **CHINOOK** | 1947 | 50 | Michigan Department of Natural Resources | Fisheries research | GL |
| **FIN AND FEATHER** | 1967 | 38 | Michigan Department of Natural Resources | Fisheries research | GL |
| **JUDY** | 1950 | 40 | Michigan Department of Natural Resources | Fisheries research | GL |
| **STEELHEAD** | 1967 | 63 | Michigan Department of Natural Resources | Fisheries research | GL |
| **ARGO** | 1986 | 42 | N.Y. Department Environmental Conservation Lake Erie Fisheries Unit | Fisheries research | GL |
| **OSPREY** | 1991 | 51 | NYC Dept. of Environmental Protection | Water quality monitoring | GL |
| **GS-1** | 1953 | 48 | Ohio Department of Natural Resources | Fisheries research | GL |
| **GS-3** | 1994 | 25 | Ohio Department of Natural Resources | Coastal research | GL |
| **EXPLORER** | 1999 | 53 | Ohio Division of Wildlife | Fisheries research | GL |
| **GRANDON** | 1990 | 47 | Ohio Division of Wildlife | Fisheries research | GL |
| **ATIGAMAYG** | 1954 | 57 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| **CENTENIAL 92** | 1992 | 30 | Ontario Ministry of Natural Resources | Natural resouces enforcement protection | GL |
| **ERIE EXPLORER** | 1982 | 62 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| **GUARDIAN II** | 1983 | 66 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| **JAMES AULD** | 1983 | 45 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| **K.H. LOFTUS** | 1990 | 42 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| **KEENOSAY** | 1989 | 58 | Ontario Ministry of Natural Resources | Fisheries research | GL |

## SUPPLEMENT 4-5: State Research Vessels

| Name | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| NAMAYCUSH | 1954 | 49 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| STEELCRAFT | 1945 | 45 | Ontario Ministry of Natural Resources | Water quality monitoring | GL |
| WANDA GOLDIE | 1950 | 50 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| WHISKEY JACK | 1975 | 27 | Ontario Ministry of Natural Resources | Fisheries research | GL |
| MONITOR VI | 1989 | 28 | Ontario MOE | Water quality monitoring | GL |
| AQUALAB | 1990 | 30 | Toronto Metropolitan and region Conservation Authority | Water quality monitoring | GL |
| BARNEY DEVINE | 1937 | 50 | Wisconsin Department of Natural Resources | Fisheries research | GL |
| HACK NOYES | 1946 | 56 | Wisconsin Department of Natural Resources | Fisheries research | GL |
| FIRST STATE | 2002 | 62 | Delaware Division of Fish and Wildlife | Fisheries research | MA |
| NATALE COLOSI | 1988 | 25 | Interstate Environmental Commission (NY, NJ, CT0 | NA | MA |
| KERHIN | 1980 | 51 | Maryland Dept Natural Resources | Coastal research | MA |
| LIONEL A. WALFORD | 1986 | 55 | New Jersey Marine Sciences Consortium | Coastal research | MA |
| SETH GREEN | 1984 | 47 | New York Department of Environmental Conservation | Fisheries research | MA |
| HARBOR SURVEY | 1960 | 53 | NYC Dept. of Environmental Protection | Water quality monitoring | MA |
| PERCA | 1959 | 50 | Pennsylvania Fish and Boat Commission | Fisheries research | MA |
| JOHN DEMPSEY | 1990 | 50 | Connecticut Department of Environmental Protection | Fisheries research | NE |
| PATRICIA LYNN | NA | 27 | Connecticut Department of Environmental Protection | Fisheries research | NE |
| TORTUGAS | 1979 | 30 | Florida Marine Research Institute | Fish and wildlife conservation and coral reef monitoring | SE |
| ANITA | NA | 51 | Marine Resources Research Institute, South Carolina Dept. Natural Resources | Coastal and fisheries research | SE |
| CAROLINA PRIDE | NA | 51 | Marine Resources Research Institute, South Carolina Dept. Natural Resources | Coastal and fisheries research | SE |
| LADY LISA | NA | 75 | Marine Resources Research Institute, South Carolina Dept. Natural Resources | Coastal and fisheries research | SE |
| PALMETTO | 1982 | 110 | Marine Resources Research Institute, South Carolina Dept. Natural Resources | Fisheries research | SE |

*Regions: GL – Great Lakes; NE – Northeast; MA – Mid Atlantic; SA – South Atlantic; C – Caribbean; GM – Gulf of Mexico; WC – West Coast; AK – Alaska; WP – Western Pacific
NA – Information was not available

## SUPPLEMENT 4-6: Commercial Research Vessels

| NAME | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| HERON | 1962 | NA | Alaska Research Vessel Charters | Coastal research | AK |
| MARITIME MAID | 1971 | 66 | Maritime Helicopters | Coastal research | AK |
| ORION | 1979 | 54 | Orion Inc. | Coastal research | AK |
| MORNING STAR | NA | NA | United Catcher Boats | Fisheries research | AK |
| MISTRAL | 1998 | 30 | Zephyr Marine | Coastal research | AK |
| ZEPHYR | 1987 | 44 | Zephyr Marine | Coastal research | AK |
| GREAT PACIFIC | NA | NA | NA | Coastal research | AK |
| ARCTIC DISCOVERER | 1988 | 180 | EZRA Inc. | Coastal research | GL |
| NEPTUNE | 1970 | 69 | Hydrographic Survey Co. | Coastal research | GL |
| CAPT. W.A. BISSO JR. | 1965 | 150 | Bisso Marine Co. Inc. | Geophysical survey | GM |
| BULL'S EYE | 1996 | 28 | Bisso Marine Co. Inc. | Coastal research | GM |
| EAGLE EYE II | 1980 | 36 | Bisso Marine Co. Inc. | Coastal research | GM |
| DAVID MCCALL II | 1979 | 110 | Gulf Ocean Services, Inc | Geophysical survey | GM |
| L'ARPENTEUR | 1981 | 30 | John Chance Land Surveys, Inc. | Geophysical survey | GM |
| GEODETIC SURVEYOR | 1981 | 122 | John Chance Land Surveys, Inc. | Coastal research | GM |
| SEIS SURVEYOR | 1985 | 150 | John Chance Land Surveys, Inc. | Geophysical survey | GM |
| UNIVERSAL SURVEYOR | NA | NA | John Chance Land Surveys, Inc. | Geophysical survey | GM |
| REFLECTION | 1972 | 105 | KC Offshore | Geophysical survey | GM |
| ALBUQUERQUE | 1982 | 132 | KC Offshore LLC | Coastal research | GM |
| HECK | 1967 | 90 | Marex Oceanographic Services | Coastal research | GM |
| BEACON | 1996 | 120 | Marex Oceanographic Services | Geophysical survey | GM |
| PLUS ULTRA | 1998 | 190 | Marex Oceanographic Services | Coastal research | GM |
| ATLANTIC EXPLORER | 1980 | 203 | Marex Oceanographic Services | Survey and sampling | GM |
| BESSIE CHOUEST | 1992 | 213 | PGS Exploration (U.S.) Inc. | Geophysical survey | GM |
| ELDA CHOUEST | 1992 | 213 | PGS Exploration (U.S.) Inc. | Geophysical survey | GM |
| EDISON CHOUEST | 1993 | 221 | PGS Exploration (U.S.) Inc. | Geophysical survey | GM |
| GARY CHOUEST | 1994 | 225 | PGS Exploration (U.S.) Inc. | Geophysical survey | GM |
| NEW VENTURE | 1992 | 250 | PGS Exploration (U.S.) Inc. | Geophysical survey | GM |
| OCEAN EXPLORER | 1993 | 266 | PGS Exploration (U.S.) Inc. | Geophysical survey | GM |
| FLING | 1974 | 97 | Rinn Boats Inc. | Coastal research | GM |
| SPREE | 1976 | 97 | Spree Ventures Inc. | Coastal research | GM |
| J.W. POWELL | 1964 | 142 | TDI-Brooks International, Inc | Coastal research | GM |
| ROSS SEAL | 1989 | 176 | Veritas Geophysical Services | Geophysical survey | GM |
| ACADIAN SEARCHER | 1996 | 217 | Veritas Geophysical Services | Geophysical survey | GM |
| POLAR PRINCESS | 1996 | 225 | Veritas Geophysical Services | Geophysical survey | GM |
| POLAR SEARCH | 1993 | 250 | Veritas Geophysical Services | Geophysical survey | GM |
| VERITAS VIKING | 1998 | 306 | Veritas Geophysical Services | Geophysical survey | GM |
| WESTERN VOYAGER | 1973 | 83 | Western Geophysical Co. | Geophysical survey | GM |
| ARCTIC STAR | 1944 | 99 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN ALEUTIAN | 1982 | 136 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN POLARIS | 1982 | 136 | Western Geophysical Co. | Geophysical survey | GM |

## SUPPLEMENT 4-6: Commercial Research Vessels

| NAME | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| WESTERN SHORE | 1982 | 144 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN ORIENT | 1981 | 146 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN WAVE | 1983 | 151 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN PACIFIC | 1979 | 185 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN ANCHORAGE | 1977 | 190 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN HORIZON | 1982 | 200 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN INLET | 1981 | 200 | Western Geophysical Co. | Geophysical survey | GM |
| KENDA | 1985 | 220 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN PATRIOT | 1993 | 222 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN LEGEND | 1991 | 235 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN PRIDE | 1991 | 235 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN ATLAS | 1988 | 266 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN MONARCH | 1991 | 303 | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN REGENT | 1992 | 303 | Western Geophysical Co. | Geophysical survey | GM |
| OGS EXPLORA | 1973 | NA | Western Geophysical Co. | Geophysical survey | GM |
| SABERTOOTH | NA | NA | Western Geophysical Co. | Geophysical survey | GM |
| TUCANO | 1985 | NA | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN ENDEAVOR | NA | NA | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN FRONTIER | NA | NA | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN MAGELLAN | NA | NA | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN METEOR | 1995 | NA | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN NEPTUNE | 1999 | NA | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN SPIRIT | 1993 | NA | Western Geophysical Co. | Geophysical survey | GM |
| WESTERN TRIDENT | 1999 | NA | Western Geophysical Co. | Geophysical survey | GM |
| ATLANTIC TWIN | 1965 | 90 | Alpine Ocean Seismic Survey | Geophysical survey | MA |
| ATLANTIC SURVEYOR | 1978 | 96 | Divemasters Inc. | Coastal research | MA |
| ALOHA | NA | 143 | IUC International Ltd. | Coastal research | MA |
| NORTHSTAR 4 | NA | 50 | Northstar Marine Inc. | Coastal research | MA |
| AQUAMONITOR | NA | 45 | Batelle | Coastal research | NE |
| BOSTON PILOT | NA | 70 | Boston Pilot | Coastal research | NE |
| CYPRINODON | 1992 | 32 | C.R. Environmental Inc. | Coastal research | NE |
| CHRISTOPHER ANDREW | 1976 | 62 | C.R. Environmental Inc. | Coastal research | NE |
| ISABEL S | 1988 | 91 | C.R. Environmental Inc. | Fisheries research | NE |
| COBIA | NA | 20 | C.R. Environmental, Inc | Coastal research | NE |
| C-HAWK | NA | 22 | C.R. Environmental, Inc | Coastal research | NE |
| JEANZO | NA | 14 | C.R. Environmental, Inc. | Coastal research | NE |
| JONZO | NA | 16 | C.R. Environmental, Inc. | Coastal research | NE |
| DRAGON | NA | 34 | C.R. Environmental, Inc. | Coastal research | NE |

## SUPPLEMENT 4-6: Commercial Research Vessels

| NAME | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| SAKONNET | NA | 36 | C.R. Environmental, Inc. | Geophysical survey | NE |
| LADY JANE | NA | 40 | C.R. Environmental, Inc. | Coastal research | NE |
| FAST TRACK | NA | 42 | C.R. Environmental, Inc. | Coastal research | NE |
| COURIER | NA | 43 | C.R. Environmental, Inc. | Coastal research | NE |
| LADY IRENE | NA | 45 | C.R. Environmental, Inc. | Coastal research | NE |
| SUSAN & CAITLYN | NA | 54 | C.R. Environmental, Inc. | Coastal research | NE |
| GLENA & JACOB | NA | 62 | C.R. Environmental, Inc. | Coastal research | NE |
| ANDREA J. | NA | 70 | C.R. Environmental, Inc. | Coastal research | NE |
| INHERITANCE | NA | 70 | C.R. Environmental, Inc. | Coastal research | NE |
| AMERICAN HERITAGE | NA | 72 | C.R. Environmental, Inc. | Coastal research | NE |
| TRIPOLINA | NA | 80 | C.R. Environmental, Inc. | Coastal research | NE |
| RESOLUTE | NA | 90 | C.R. Environmental, Inc. | Coastal research | NE |
| MARY K. | NA | 96 | C.R. Environmental, Inc. | Coastal research | NE |
| MORA K. | NA | 99 | C.R. Environmental, Inc. | Fisheries research | NE |
| CELTIC | NA | 100 | C.R. Environmental, Inc. | Coastal research | NE |
| MARY ANNE | NA | 100 | C.R. Environmental, Inc. | Coastal research | NE |
| WARRIOR | NA | 100 | C.R. Environmental, Inc. | Coastal research | NE |
| NORDIC PRIDE | NA | 105 | C.R. Environmental, Inc. | Fisheries research | NE |
| ARAHO | NA | 120 | C.R. Environmental, Inc. | Coastal research | NE |
| AMELIA MARY | NA | 64 | Coady Marine | Coastal research | NE |
| ROLLING THUNDER | NA | 39 | Downeast Marine Resources, Inc. | Coastal research | NE |
| CAROLYN CHOUEST | NA | NA | Edison Chouset | Submerisble support | NE |
| NAVAHO | NA | 53 | International Wildlife Coalition | Coastal research | NE |
| AZORIAN | 2002 | 42 | Marine Research Services | Coastal research | NE |
| LEE | NA | 35 | NA | Coastal research | NE |
| MAGIC | NA | 35 | NA | Coastal research | NE |
| PAUL DEROCHER | NA | 40 | NA | Coastal research | NE |
| OCEAN REPORTER | NA | 43 | NA | Coastal research | NE |
| PROVIDENCE | NA | 50 | NA | Coastal research | NE |
| ALBATROSS | NA | 52 | NA | Coastal research | NE |
| CAP'N BERT | NA | 53 | NA | Coastal research | NE |
| WEATHERBIRD | NA | 65 | NA | Coastal research | NE |
| EDGERTON | NA | 68 | NA | Coastal research | NE |
| DIANE G. | NA | 103 | NA | Coastal research | NE |
| ENVIRO-LAB II | NA | 55 | Project Oceanology | Coastal research | NE |
| ENVIRO-LAB III | NA | 65 | Project Oceanology | Coastal research | NE |
| QUEST | NA | 43 | Quest Marine Services | Coastal research | NE |
| SUB SIG II | 1976 | 118 | Raytheon Co. | Coastal research | NE |
| ARTEMIS | NA | 30 | Athena Technologies, Inc. | Geophysical survey | SE |
| LADY ATHENA | NA | 46 | Athena Technologies, Inc. | Geophysical survey | SE |
| BARB-N-T | 1992 | 34 | Barb Marine Consulting | Coastal research | SE |
| CORDELL EXPLORER | 1975 | 42 | Cordell Expeditions | Coastal research | SE |
| THUNDERFORCE | 1980 | 85 | M&S Enterprises Inc. | Coastal research | SE |
| THUNDERSTAR | 1968 | 65 | M&S Enterprises Inc. | Coastal research | SE |
| BONNIE MARIETTA | 1981 | 38 | Mark M. Tognazzini | Fisheries research | SE |

## SUPPLEMENT 4-6: Commercial Research Vessels

| NAME | Year | Length (ft) | Institution | Mission | Region* |
|---|---|---|---|---|---|
| SEAHAWK | NA | 83 | Technology Inc. | Coastal research | SE |
| BLUE RUNNER | NA | 35 | | Coastal research | SE |
| ECHO | NA | 41 | | Coastal research | SE |
| SCOTSMAN | 1989 | 57 | | Coastal research | WC |
| JOHN B. PRESTON | 1990 | 30 | | Geophysical survey | WC |
| SAMSON | 1942 | 121 | | Geophysical survey | WC |
| AMERICAN PATRIOT | 1962 | 165 | | Coastal research | WC |
| GLORITA | 1968 | 147 | | Geophysical survey | WC |
| SHANA RAE | 1986 | 51 | Vessels Inc. | Geophysical survey | WC |
| WM. A. MCGAW | 1984 | 106 | | Coastal research | WC |
| NOR'WESTER | 1982 | 45 | | Coastal research | WC |
| TRANSQUEST | 1967 | 108 | | Coastal research | WC |
| BRENDAN D II | 1974 | 36 | | Coastal research | WC |
| MUIR MILACH | NA | NA | | Fisheries research | WC |
| WHITE LIGHTNING | 1981 | 75 | | Coastal research | WC |
| WHITE SQUALL | 1964 | 45 | | Coastal research | WC |

*Regions: GL – Great Lakes; NE – Northeast; MA – Mid Atlantic; SA – South Atlantic; C – Caribbean; GM – Gulf of Mexico; WC – West Coast; AK – Alaska; WP – Western Pacific
NA – Information was not available

## SUPPLEMENT 4-7: Coastal Observing Systems

| Observing System | Region* | Number of Stations | |
|---|---|---|---|
| **ACMP**<br>**Alliance Citizen Monitoring Program** | MA | NA | monitoring sampling using over 145 trained volunteers to support the protection and restoration of the bay. |
| **Alaska GLOBEC**<br>**Gulf of Alaska Global Ocean Ecosystem Dynamics Monitoring Program** | AK | | A University of Alaska Fairbanks School of Fisheries and Ocean Sciences program that monitors the effects of climate variability and climate change on the Gulf of Alaska shelf ecosystem, and incorporates results into diagnostic and prognostic models. Samples are collected at a station at the mouth of Resurrection Bay and along the Seaward Line. |
| **AMH**<br>**Acoustic Monitoring Hydrophones** | AK, WC | 7 | (three other arrays are discussed in the global system). The first array, deployed in the Gulf of Alaska, has six hydrophones to monitors the movement of large cetaceans. The second array consist of an abandoned cabled installation at the Pioneer Seamount (off the central California coast) retrofitted with a hydrophone system to passively monitor the ocean for natural and man-made sounds. |
| **CalCOFI**<br>**California Cooperative Oceanic Fisheries Investigations** | WC | > 60 | A program of the Scripps Institution of Oceanography Integrative Oceanography Division, California Department of Fish and Game, and NMFS SWFSC, established in 1949 that conducts quarterly cruises to monitor physics, chemistry, biology, and meteorology of the California Current ecosystem. |
| **Caribbean Time Series** | C | 1 | A University of Puerto Rico Department of Marine Sciences monitoring program, sponsored by NASA, and established in 1994. The program collects monthly oceanographic samples at a station 26 miles south of Puerto Rico. |
| **CBMSM**<br>**Chesapeake Bay Mouth Survey Monthly** | MA | 20 | An Old Dominion University's Center for Coastal Physical Oceanography program that conducts monthly CTD casts during spring high tide cruises at stations at the mouth of Chesapeake Bay. The program was initiated in 1992 with the goal of developing climatology of the ocean processes at the mouth of Chesapeake Bay. |
| **CBOS**<br>**Chesapeake Bay Observing System** | MA | 7 | A federal (NOAA, EPA, Navy), state (Virginia; Maryland) and academic (University of Maryland) joint program with permanent weather and oceanographic data monitoring sensors in the Chesapeake Bay. Periodic aircraft remote sensing images supplement the field information. |
| **CDIP**<br>**Coastal Data Information Program** | GL, MA, SA, WC, WP | > 100 | A joint program of the Integrative Oceanography Division of Scripps Institution of Oceanography, US Army Corps of Engineers, and California Department of Boating and Waterways that primarily focuses on wave data measurements. It analyzes, archives, and disseminates coastal environmental data for use by coastal engineers, planners, managers, scientist, and mariners. |
| **COMPS**<br>**West Florida Coastal Ocean Monitoring and Prediction System** | SA, GM | > 50 | This system, coordinated by the University of South Florida, encompasses numerous observation stations from various federal and state agencies, academia, and local jurisdictions. Buoys deployed mostly off West Florida for monitoring and modeling in support of multiple management and research programs. Remote sensing images supplement the field information. |
| **COOL/LEO 15**<br><br>**Observation Laboratory/Long term Ecosystem Observatory** | MA | NA | This is a network of coastal observing systems coordinated by Rutgers University Institute of Marine Science with the goal to develop real-time capability for environmental assessment and forecasting. The network includes the Long-term Ecosystem Observatory at 15 meters depth (LEO-15) off the coast at Tuckerton, New Jersey. Partners in the program include multiple federal, state, academic, and non-government organizations. |

## SUPPLEMENT 4-7: Coastal Observing Systems

| Observing System | Region* | Number of Stations | |
|---|---|---|---|
| **CORIE Columbia River Estuary Real-time Observation and Forecasting System** | | 19 | Pilot environmental observation and forecasting system for the Columbia River, Oregon by the Center for Coastal and Land Margin Research of the Oregon Graduate Institute. The project integrates a real-time sensor network, a data management system and advanced numerical models. |
| **DART Deep Ocean Assessment and Reporting of Tsunamis** | WC, AK | | A NOAA PMEL project that has the goal of early detection and real-time reporting of tsunamis in the open ocean. There are three stations located near Alaska-Aleutian Seismic Zone; two stations off the Washington-Oregon coast near the Cascadian Subduction Zone; and a sixth station in the eastern equatorial region to measure tsunamis that may be generated in the Peru-Chile Seismic Zone and propagate into the north Pacific. |
| **FOCI Fisheries Oceanography Coordination Investigations** | AK | > 50 | environment on the abundance of various commercially valuable fish and shellfish stocks in Alaskan waters and the role of these species in the ecosystem. In collaboration with the Stellar Sea Lion programs, Lagrangian drifters are deployed to determine the annual circulation variability in the North Pacific and Eastern Bering Sea regions. |
| **GEM Gulf of Alaska Ecosystem Monitoring and Research** | AK | NA | The GEM program, established by the Exxon Valdez Oil Spill Trustee Council, is in the early stages of implementation. Pilot monitoring programs begin in 2003 with full implementation expected by 2007. |
| **Gulf of Maine Ocean Observing System** | NE | 15 | National pilot program to provide hourly oceanographic data from the Gulf of Maine to the public, resource managers, education, and scientific community. In addition to buoy data, the systems expect to incorporate a CODAR system in 2003. The program is a collaboration of the University of Maine, WHOI, Bigelow Lab, NOAA, and Navy. |
| **Hawaii Ocean Time series Program** | WP | 5 | This program is coordinated by the University of Hawaii and is supported by NSF. The program collects oceanographic data to better understand the heat, freshwater, and chemical fluxes at a North Pacific oligotrophic site |
| **Monterey Bay Innovative Coastal Ocean Observing Network** | WC | 6 | Component of NOPP to provide a real-time ocean observation of Monterey Bay. System relies on new ocean measurement technologies, along with data collected from moorings, tomographic arrays, high frequency radars, ship cruises, and satellites. Major partners include Navy NPS and NRL, University of Michigan, University of Southern Mississippi, California State University-Monterey Bay, MBARI, HOBI Labs, and Codar Ocean Sensors, Ltd. |
| **Indiana Coastal Information System** | GL | 1 | System developed for the Indiana Department of Natural Resources that uses real-time data from a NOAA buoy (45007) in a model. The system allows a web user to analyze water circulation patterns, water velocities, and other data around the Indiana Harbor and Ship Canal using the Army Corps of Engineers TABS-MD numerical modeling system. |
| **Indiana Shoreline Erosion Observation System** | GL | NA | This is a system of the Indiana Department of Natural Resources. The system relies on biannual aerial photography of Lake Michigan shoreline to assess coastal erosion and its potential impacts along the coast. The program has been in operation since 1987. In addition, the system records the impacts of unique events, such as severe storm. |
| **LUMCON Louisiana Universities Marine Consortium Environmental Monitoring** | GM | 4 | The LUMCON array collects real-time weather and aquatic parameters to support research on ocean/river interactions, human and industrial environmental impacts, processes influencing coastal change, living resources, and biological systems. |

## SUPPLEMENT 4-7: Coastal Observing Systems

| Observing System | Region* | Number of Stations | |
|---|---|---|---|
| **MOOS**<br>**MBARI Observing System** | WC | 5 | MOOS is an observing system that collects oceanographic data in real-time from moorings, drifters, and ship cruises from one of the deepest underwater canyons in the U.S. The system is supplemented with information from ROV, AUV, and remote sensing technology. |
| **MVCO**<br>**Martha's Vineyard Coastal Observatory** | NE | 1 | The underwater coastal observatory is a WHOI project funded by NSF and ONR. The observatory is located one mile offshore of Martha's Vineyard and provides coastal oceanographic and weather data (real-time and archived) to educators and public. The system relies on underwater cables for power and data transmission. |
| **NDBC**<br><br>**Center** | GL, NE, MA, SA, C, GM, WC, AK, WP | > 130 | This is a NOAA National Weather Service International program. Most the stations are located in the coastal and offshore waters of the U.S. The program relies on moored buoys, onshore/nearshore platforms (C-MAN stations) and drifting buoys for oceanographic and meteorological observations. In the Caribbean, the system relies on French buoys. |
| **NEMP**<br>**Neuse Estuary** | SA | 10 | NEMP is a project of the North Carolina State University Center for Applied Aquatic Ecology that established a system of weather and water data collection platforms deployed along the Neuse River. This system supports, among various projects, the study of *Pfisteria* events in the Neuse River. |
| **NERR**<br>**National Estuarine** | GL, NE, MA, SA, C, GM, WC, AK | > 50 | This monitoring program measures changes in estuarine water quality, habitat and land in 25 estuarine reserves. The reserves are located along the Nation's coastline, including the Great Lakes. Water quality samples are collected continuously at 30-minute intervals using an YSI™ datalogger in at least two stations in every reserve. |
| **NGLI**<br>**Northern Gulf of Mexico** | GM | > 20 | This is a multi-agency program established through a partnership between the Navy and the EPA. The goal of the program is devising model forecasts and observational data for military training and coastal resource management. In situ observing system consists of shipboard surveys, subsurface moorings, moored buoys, fixed piling platforms, and drifting buoys. |
| **NJ CMN**<br>**New Jersey**<br><br>**Network** | MA | 3 | This is a coastal observation system operated by Davidson Laboratory of Stevens Institute of Technology. It provides digital images of the beach and nearshore ocean and oceanographic and meteorological data (real-time and archived), including shallow water (5m) wave characteristics. |
| **NWLON**<br>**National Water Level** | GL, NE, MA, SA, C, GM, WC, AK, WP | 175 | A NOAA NOS Center for Operational Oceanographic Products and Services program that provides a network of water level measurement stations along the Nation's coastline, including the Great Lakes and territories. Some stations have been in operation for more than 20 years. |
| **PORTS**<br>**Physical Oceanographic** | GL, NE, MA, GM, WC, AK | 68 | A NOAA NOS Center for Operational Oceanographic Products and Services program that consists of a monitoring network to improve safety and efficiency of maritime commerce and coastal resource management. The program provides shipmasters and pilots with accurate real-time information required for preventing groundings and collisions. |
| **SABSOON**<br>**South Atlantic Bight**<br><br>**Observational Network** | SA | 8 | Real-time observational network of offshore platforms coordinated by Skidaway Institute of Oceanography and maintained by the Navy. The network provides data from large-scale oceanographic processes on the U.S. southeastern continental shelf and supports the development of a database of ocean-atmosphere interactions. Partners include various federal and state agencies and academic institutions. |
| **SALMON**<br><br>**and observation Network** | AK | 2 | University of Alaska maintains two moored instrument platforms located 30 miles south of Seward. Project collaborates with Alaska GLOBEC program to develop an understanding of the relationship between physical forcing and ecosystem trophic levels. |

## SUPPLEMENT 4-7: Coastal Observing Systems

| Observing System | Region* | Number of Stations | |
|---|---|---|---|
| **SBCSMB Santa Barbara Channel- Santa Maria Basin** | WC | 4 | Research program of the Scripps Institution of Oceanography and MMS to study the circulation in the Santa Barbara Channel- Santa Maria Basin offshore area. Four long-term moorings have been deployed since1992. System also uses ADCP installed on NDBC buoys. |
| **SCCWRP Southern California Project Authority** | WC | > 300 | The SCCWRP is a joint program of public agencies and regulators that conducts marine environmental monitoring and research of the effects of wastewater and other discharges on the health of the Southern California coastal environment. |
| **SEAKEYS/C MAN Research Related to Management of the Florida Keys Seascape** | SA GM | 7 | This is a Florida Institute of Oceanography project in coordination with NOAA to collect additional oceanographic measurements beyond the normal data collected at 6 C-MAN stations from the Florida Keys area and a station in northwest Florida Bay. The project provides long-term ecosystem monitoring and supports coral reefs research. |
| **SFOMC South Florida Ocean Measurement Center** | | NA | This is a partnership program among Navy and academic institutions to deploy physical oceanographic instrument from mid Florida to the Bahamas and Florida Keys. |
| **TABS Texas Automated Buoy System** | | 16 | This is a program operated for the Texas General Land Office by the Geochemical and Environmental Research Group at Texas A&M University. The system consists of ten TABS buoys, four NDBC buoys, and two C-MAN stations. This is the only program in the Nation designed to provide real-time surface current data to support oil spill prevention and response. |
| **TCOON Texas Coastal Ocean Observation Network** | GM | | This is a network of water level gauges operated by the Conrad Blucher Institute for Surveying and Science at Texas A&M-Corpus Christi. Goal of network is to establish water level datums and to provide various oceanographic measurements. Partners include various federal and state agencies and academic institutions. |
| **USACE FRF U.S. Army Corps of Engineers Field Research Facility** | SA | 1 | Facility of the Coastal Hydraulics Laboratory at Duck, NC that collects physical oceanographic measurements on a daily basis. |
| **USACE Waves U.S. Army Corps of Engineers Wave Gauges** | GL, MA, SA, C, GM, WC, WP | 34 | This is a system of the US Army Corps of Engineers Prototype Measurement and Analysis Branch of the Coastal Hydraulics Laboratory that collects, processes, analyzes, and reports on wave data nationwide. |
| **U.S. Geological Survey Streamflow and Stage Data** | GL, NE, MA, SA, C, GM, WC, AK, WP | NA | The USGS streamflow gauging system has been in operation since 1887. It provides real-time hydrologic data from thousands of stations across the Nation. The system operates in partnership with more than 700 federal, state, and local agencies. Most of the stations are inland, but many are located near estuaries and provide valuable information for coastal hydrodynamic models. |
| **WAVCIS Wave Current Surge Information System** | GM | 6 | A Louisiana State University monitoring program that provides real-time wave and meteorological data for the Louisiana coast. |

*Regions: GL – Great Lakes; NE – Northeast; MA – Mid Atlantic; SA – South Atlantic; C – Caribbean; GM – Gulf of Mexico; WC – West Coast; AK – Alaska; WP – Western Pacific
NA – Information was not available

## SUPPLEMENT 4-8: Ocean Observing Systems

| Observing System | | Number of Station | Description |
|---|---|---|---|
| **AMH**<br>**Acoustic monitoring hydrophones**[i] | | 18 hydrophones | This NOAA PMEL project has three six-hydrophones arrays located outside of the Nation's EEZ to monitor earthquake activity (2 other arrays are discussed in the coastal observatories system). An array was deployed in the east Pacific Rise. The two other arrays were deployed in 1999 near the Mid Atlantic Ridge. |
| **Argo Floats** | AO, PO, IO, SO | 720 operational floats as of March 2003 | deploy a global array of 3,000 profiling floats at a resolution of 3° x 3° using ships of opportunity. The floats provide profiles of temperature and salinity for the upper 2 km of the ocean. The Argo array is component of Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS), Climate Variability and Predictability Experiment (CLIVAR), and Global Ocean Data Assimilation Experiment (GODAE). The U.S. plans call for supporting one-half of the global array. Implementation of the program is through a consortium consisting of Scripps Institution of Oceanography, WHOI, University of Washington, and NOAA AOML<br>and PMEL. |
| **BATS**<br>**Bermuda Atlantic Time-series Study** | AO | 2 | monthly sampling (biweekly during bloom season) at a station 85 km southeast of Bermuda. The program investigates the seasonal and interannual variability in ocean biogeochemistry. |
| **BTM**<br>**Bermuda Test-bed Mooring** | AO | 1 | BTM is a project of the Bermuda Biological Station for Research, funded by NSF in 1994, that established a mooring station southeast of Bermuda. The mooring provides a platform for developing, testing, calibrating and intercomparing instruments for time series analysis. Several physical, chemical and biological measuring instruments from various institutions are currently deployed. |
| **Carbon Retention in a Colored Ocean** | AO | NA | CARIACO is a project of University of South Florida initiated in 1995 that studies primary productivity, physical forcing and vertical particle flux in the Cariaco Basin. |
| **Carbon Dioxide Measuring Systems**[ii] | PO | NA | sinks of carbon dioxide in the oceans. Data are collected on cruises onboard NOAA vessels and from selected TAO moorings. |
| **GDA**<br>**Global Drifter Array** | AO, PO, IO | > 400-500 annually | This is a program of NOAA AOML GOOS Center that maintains an accurate and globally dense set of Argos-tracked Lagrangian drifters. The drifters provide in-situ observations of SST and surface circulation. The GDA is part of an international program designed to improve climate prediction. The U.S. deploys the drifters using the VOS Program, research vessels and U.S Navy aircraft. The AOML tracks these drifters daily<br>via satellite. |
| | PO | 1 | H2O is an observatory located halfway from Hawaii to California between the Murray and Molokai Fracture Zones. The observatory, installed on a retired AT&T submarine telephone cable, consists of a sea floor junction box and scientific sensors located at 5000 m depth. Initial instrumentation set at the site included a broadband three-component seismometer, a short period geophone, a standard hydrophone, and a pressure sensor. In the future the system may be enhanced with the addition of biological sensors and a magnetic observatory. NSF provides support to H2O including funds<br>for 1 FTE. |
| **HD XBT**<br>**High density Expendable Bathy Thermograph Global Array** | AO, PO | 9 lines | HD XBT is a program of NOAA AOML GOOS Center with nine high-density XBT lines (3 lines in the Atlantic and 6 lines in the Pacific). These lines require the aid of VOS willing to have a scientist aboard to deploy XBTs. The system provides temperature profiles down to a depth of about 760 m every 50 km in the open ocean and between 10-30 km near boundary currents. Scripps Institution of Oceanography manages the high-density XBT lines in the Pacific ocean, while AOML manages the Atlantic lines. |

## SUPPLEMENT 4-8: Ocean Observing Systems

| Observing System | | Number of Station | Description |
|---|---|---|---|
| **Hydrostation S** | AO | 1 | This is a program of the Bermuda Biological Station for Research that conduct biweekly samples at Hydrostation S, an oceanographic station located 26 km southeast of Bermuda. Hydrostation S, established in 1954, is the longest oceanographic time series sampling program. |
| **OFP Oceanic Flux Program** | | 1 | OFP is project of the Bermuda Biological Station for Research initiated in 1978 that has sediment traps located at 3500 m depth. In 1984, the station was moved 75 km southeast of Bermuda and traps were added at 500 and 1500 m depth. Bimonthly collections were conducted from 1978 to 1989. Since 1989 the collections are made on a bi-weekly basis. |
| **ORS Ocean Reference Stations** | AO | | This is a joint program of NOAA AOML and WHOI that includes five different oceanic stations. AOML manages the Florida Straits cable program that monitors the Florida Current transport via a submarine telephone cable. AOML also manages the Abaco 26.5°N line, a yearly repeated Conductivity-Temperature-Depth/Lowered Acoustic Doppler Current Profiler high-density flux resolving line. WHOI manages two surface flux moorings collecting air-sea data in the western Atlantic and the southeastern Atlantic, and the Denmark Straits observations. |
| **PIRATA Pilot Research Moored Array in the Tropical Atlantic** | AO | 10 | of Atlas mooring in the tropical Atlantic. The moorings collect oceanographic and meteorological data and transmit to shore in real-time via the Argos satellite system. NOAA PMEL manages the U.S. component of the array. |
| **TAO/TRITON Tropical Atmosphere-Ocean/Triangle Trans Ocean Buoy Network** | PO | 68 | This is an International program (U.S. and Japan) consisting of temperature and current meter Atlas moorings in the Tropical Pacific. TAO array is also used as a platform for biological and chemical measurements. The U.S. maintains the array from the west coast of the Americas to 165 E. In 1999, the moorings |
| **The Oleander Section** | | 1 line | This is a project of the University of Rhode Island Graduate School of Oceanography that started in 1992 and is using the commercial freighter CMV OLEANDER to measure upper ocean currents (top 100 to 300 m) between New Jersey and Bermuda using an ADCP. |
| **TTPN Trans-Pacific Profiler Network** | PO | | The NOAA Aeronomy Laboratory operates the TPPN in collaboration with the NOAA Cooperative Institute for Research in Environmental Sciences. The system is an equatorial network of Doppler radars spanning the data-sparse region of the tropical Pacific Ocean, from Peru to Indonesia. The instruments measure wind profile of both horizontal and vertical motions at heights from the surface to 5-15 kilometers. In addition to the wind profile, information about precipitation and atmospheric turbulence is also obtained. The TPPN observations contribute to the understanding and predictability of El Nino events and to the understanding of interannual climate fluctuations that have their origin in the tropics. |
| **USIABP U.S. Inter-Agency Artic Buoy Program** | AR | 36 | support the International Artic Buoy Program. International partners include Russia, Canada, Norway, Germany, and Japan. Data are transmitted over ARGOS satellites. Nominal sensors include air temperature, surface pressure, and ice drift. |
| **VOS Voluntary Observing System** | AO, PO, IO | NA | VOS, a program of NOAA AOML GOOS Center, relies on a global fleet of about 400 domestic and foreign commercial vessels that collect sea surface meteorological, sub-surface XBT, and shipboard temperature and salinity observations. The VOS vessels also deploy drifting buoys and profiling floats, and sometimes tow continuous plankton recorders. |
| **Expendable Bathy Thermograph Global Array** | AO, PO, IO | 26 lines, 15,000 XBT | This is a program of NOAA AOML GOOS Center that utilizes approximately 70 VOS vessels to deploy XBT to monitor three ocean basins on a monthly basis. The XBT program collects, quality controls, and transmits in real-time subsurface oceanographic observations. The estimated 2002 budget was $1.7 million. |

*Regions: AO – Atlantic; PA – Pacific Ocean; IO – Indic Ocean; SO – Southern Ocean; AR – Arctic Ocean
NA – Information was not available

## SUPPLEMENT 4-9: Ocean Observing System Sensors

| Measurement | Sensor Type | Model # | Resolution | Range | Accuracy |
|---|---|---|---|---|---|
| **Wind speed** | | R. M. Young: 05103 | 0.2 m $s^{-1}$ | 1-20 m $s^{-1}$ (0.4 - 36 m $s^{-1}$) | |
| **Wind direction** | Vane | R. M. Young: 05103 | 1.4° | | 5° - 7.8° |
| | Fluxgate compass | E.G.and G. or KVH: 63764 or LP101-5 | 1.4° | | |
| **Air temperature** | Pt-100 RTD | Rotronic Instrument Corp.: MP-100 | 0.04°C Std 0.01° C NX | (0-40°C) | ±0.2°C |
| **Relative humidity** | Capacitance | | 0.4 %RH realtime 0.02 %RH delay mode | 55-95 %RH (0-100 %RH) | ±2 %RH for 6 mo. ±4 %RH for 1 yr. |
| | Capacitance | R. M. Young: 50203-34 | 0.2 mm $hr^{-1}$ | | ±0.4 mm $hr^{-1}$ on 10 min filtered data |
| **Downwelling shortwave radiation (Next Generation ATLAS Moorings)** | | Eppley Laboratory: PSP-TAO, Delrin case | 0.4 W $m^{-2}$ | 200-1000 W $m^{-2}$ (0-1600 W $m^{-2}$) | |
| **Downwelling longwave radiation** | Pyrgeometer | Eppley Laboratory: PIR-TAO, Delrin case, 3-output (1) | 0.1 W $m^{-2}$ 0.03° C | @ 20°C (thermopile only) | ±1% |
| **Barometric pressure** | transducer | Paroscientific: MET1-2 | 0.1 hPa | 800-1100 hPa | ±0.01% of reading |
| **Sea surface and subsurface temperature** | Generation ATLAS sensor | Yellow Springs Instruments: Thermistor 46006 | 0.001°C | 6-32°C (0-40°C) | ±0.01°C |
| **Sea surface and subsurface temperature** | | Sea Bird Electronics: SBE16, SBE37 | 0.001°C | 1-31°C (-5-35°C) | ±0.003°C |
| **Salinity** | conductivity cell | Sea Bird Electronics: SBE16 (Seacat) | 0.0001 S $m^{-1}$ | 3-6 S $m^{-1}$ (0-6 S $m^{-1}$) | |
| | | SBE37 (Microcat) | 0.00001 S $m^{-1}$ | | |
| | | Sea Bird cell with ATLAS module | 0.002 S m | | |
| **Water pressure** | Transducer | Paine: 211-30-660-01 | | 400-800 psi (0-1000 psi) | ±0.25% full scale (1000psi) |
| **Ocean current (profile)** | ADCP | band, 150 kHz | 0.1 cm $s^{-1}$ 0.006 | (0-256 cm $s^{-1}$) | ±5 cm $s^{-1}$, |
| **Ocean current (single point)** | Dopper Current Meter | SonTek: Argonaut | 0.1 cm $s^{-1}$ 0.1° | | ±1 percent of measured velocity, ±0.5 cm $s^{-1}$ |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Great Lakes Region** | | | | | | | | | | |
| **Great Lakes Center SUNY College at Buffalo, NY** | 3 research vessels ranging in size from 26'-46'<br>Over 180 tanks from 5 to 900 gallons for fish and plankton culturing | 1966 | | | | | N/A | | | |
| **Frantz Theodore Stone Laboratory Ohio State University, OH** | 5 boats ranging from 22'-42'<br>Several small motor and row boats<br>1 ROV | 1895 | | | | | N/A | | | |
| **Large Lakes Observatory University of Minnesota, MN** | 1 86' R/V Blue Heron | 1938 | | | | | N/A | | | |
| **The Ocean Engineering Laboratory University of Michigan, MI** | 1 22' survey vessel<br>1 15' Motomar inflatable raft | N/A | | | | | N/A | | | |
| **Great Lakes Water Institute University of Wisconsin-Milwaukee, WI** | 1 22' boat – 0 years old<br>1 71' research vessel – 50 years old*<br>1 ROV<br>Gamma and alpha counters<br>Monitoring buoys – 7 years old<br>Authomous profiling & thermister<br>Mass spectrometer – 5 years old | 1973 | | | | | N/A | | | |
| **Northeast Region** | | | | | | | | | | |
| **UNH Marine Program, University of New Hampshire, NH & College of Agriculture and Life Sciences Cornell University, NY** | Shoals Marine Laboratory<br>• Numerous inflatables and whalers<br>• 1 19' sailboat<br>• 1 36' research vessel<br>• 1 47' research vessel | 1973 | | | | | N/A | | | |
| **Marine Sciences Institute University of Connecticut, CT** | 1 76' research vessel<br>1 25' research vessel<br>3 small boats (16'-22')<br><br>John S. Rankin Laboratory<br>• 2,400 ft$^2$ facility can process up to 600GPM of seawater | 1957 | | | | | N/A | | | |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Marine Science Center, Northeastern University, MA** | The Edwards Laboratory<br>• 3 small boats<br>• 3 boats ranging in size from 12′ to 20′<br>• 1 50′ research vessel (built 1963, refurbished 2003) | 1968 | N/A | | | | | | | |
| **Graduate School of Marine Sciences and Technology, University of Massachusetts System, Dartmouth MA** | 1 AUV<br>1 50′ research vessel – 18 years old<br>Mass spectrometer – 15 years old<br>4 off-campus research facilities/field stations | 1991 | N/A | 0 | 0 | 5 | 0 | 3 | 0 | 0 |
| **Biology Department, Salem State College, MA** | 1 16′ boat – 3 years old<br>Northeastern Massachusetts Aquaculture Center<br>• Includes the 510 $m^2$ Cat Cove Marine Laboratory and 3.25-hectare Smith Pool | 1854 | 31 | N/A | N/A | 4 | 4 | 7 | 1 | 0 |
| **Woods Hole Oceanographic Institution, MA** | 1 submersible – 20 years old<br>1 AUV – 10 years old<br>1 ROV – 10 years old*<br>1 46′ boat – 20 years old* | 1930 | N/A | 10 | 14 | 55 | 54 | 31 | 0 | 0 |
| **Massachusetts Institute of Technology, MA** | Ocean Engineering Department<br>• 2 AUVs (ages 1 and 8**)<br>• 1 ROV – 1 year old | 1885 | N/A | 26 | 8 | 12 | 2 | 1 | 2 | 7 |
| **Marine Program University of New Hampshire, NH** | 1 50′ research vehicle – 9 years old<br>Several laboratories<br>20,000-25,000$ft^2$ research facility planned | 1976 | N/A | | | | | | | |
| **Graduate School of Oceanography University of Rhode Island, RI** | 1 research vessel – 15 years old<br>Mass spectrometer – 5 years old | 1930s | N/A | 10 | 8 | 21 | 6 | 3 | 3 | 0 |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Mid Atlantic Region** | | | | | | | | | | |
| **Columbia University, NY** | Lamont-Doherty Earth Observatory<br>• 1 239' research<br>• Seismology & geoscience databases | 1949 | N/A | 2 | 8 | 17 | 2 | 12 | 25 | 4 |
| **Institute for Marine and Coastal Sciences Rutgers University, NJ** | Meadowlands Environmental Research Institute<br>3 field stations<br>Seawater & Flume Facility<br>National Undersea Research Program<br>Rutgers Ocean Data Access Network<br>Clean Ocean & Shore Trust<br>1 30' research vessel – 12 years old<br>1 48' research vessel – 7 years old<br>1 AUV – 0.25 years old | 1993*** | 5 | 2 | 3 | 16 | 9 | 12 | 4 | 1 |
| **Ocean Engineering, Stevens Institute of Technology, NJ** | 1 26' research vessel – 10 years old<br>1 26' research vessel – 11 years old | 1935 | 4 | 4 | 3 | 3 | 1 | 4 | 0 | 7 |
| **Graduate College of Marine Studies University of Delaware, DE** | Multiple mass spectrometers – various ages | 1970 | N/A | 10 | 8 | 21 | 8 | 7 | 0 | 0 |
| **Marine Sciences Research Center State University of New York, Stony Brook, NY** | 1 28' boat – 13 years old<br>1 80" boat – 16 years old<br>AA Spectrophotometer – 15 years old<br>ICPM Spectrophotometer | 1957 | N/A | 19 | 12 | 20 | 15 | 5 | 2 | 0 |
| **U.S. Merchant Marine Academy Kings Point, NY** | 2 boats – ages 17 and 35 | 1938 | 199 | N/A | | 32 | 20 | 14 | 5 | 7 |
| **University of Maryland Center for Environmental Science, MD** | 1 50' and 1 65' boat – both 35 years old** | 1925 | N/A | 114 | 12 | 20 | 6 | 4 | 0 | 8 |
| **U.S. Coast Guard Academy, CT** | 1 30' R/V<br>State of the art laboratories | 1876 | 25 | N/A | | 0 | 2 | 2 | 2 | 0 |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Department of Oceanography & Department of Ocean Engineering U.S. Naval Academy, MD** | 1 108′ research vessel – 10 years old** | 1845 | 0 | 6 | 3 | 16 | 4 | 3 | 0 | 0 |
| **Dept of Ocean, Earth and Atmospheric Science Old Dominion University, VA** | 1 55′ research vessel<br>Various small vessels<br>Virtual Environments Lab – internationally known simulation lab | 1969 | 0 | 6 | 3 | 16 | 4 | 3 | 0 | 0 |
| **Virginia Institute of Marine Science The College of William & Mary, VA** | 29 boats ranging in size from 14′ to 24′ and ages 1 to 20 years old<br>11 boats ranging in size from 25′ to 65′ and from 0.25 to 30 years old | 1961 | N/A | 18 | 11 | 25 | 25 | 11 | 0 | 16 |
| **South Atlantic Region** | | | | | | | | | | |
| **Department of Ocean Engineering, Florida Atlantic University, FL** | 3 AUVs (ranging in age from 2-5)*<br>1 34′ boat – 24 years old<br>1 65′ boat – 11 years old | 1965 | 12 | 26 | 0 | 8 | 4 | 2 | 3 | 2 |
| **Marine Laboratory at Seahorse Key University of Florida, FL** | 1 42′ R/V<br>5 boats ranging from 16′-21′<br>Numerous small boats & canoes | 1951 | N/A | | | | | | | |
| **Rosenstiel School, Marine and Atmospheric Science, University of Miami, FL** | 1 96′ R/V catamaran<br>On-campus research museum<br>Mass spectrometers, X-ray spectrographs, gas chromatographs, & a scanning electron microscope | 1926 | N/A | 16 | 13 | 54 | 24 | 15 | 2 | 2 |
| **Florida Institute of Technology, FL** | 1 60′ R/V<br>Several 14′-29′ boats for nearshore research<br>Several laboratories for marine-related studies<br>Vero Beach coastal facility for marine-related studies | 1981 | 56 | 25 | 2 | 8 | 8 | 6 | 1 | 0 |
| **College of Marine Science University of South Florida, FL** | 4 Centers of specialized study<br>14 laboratories, including Ocean Modeling & Prediction Laboratory<br>4 Ocean Modeling, Ocean Sensors, & Real Time Data vehicles<br>1 71′ R/V<br>1 110′ R/V | 1960 | N/A | 16 | 8 | 16 | 6 | 6 | 0 | 43 |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Skidaway Institute of Oceanography, GA** | 1 96′ R/V<br>1 72′ R/V<br>Several small research vessels<br>Flume facility<br>Saltmarsh Ecosystem Research Facility<br>Seawater culture/ experiment facilities | 1903 | N/A | | | | | | | |
| **Department of Marine, Earth & Atmospheric, Science North Carolina State University, NC** | Satellite coastal research facility | 1887 | 6 | 2 | 4 | 7 | 4 | 1 | 0 | 4 |
| **Institute of Marine Sciences, University of North Carolina - Chapel Hill, NC** | Satellite coastal research facility | 1891 | N/A | 3 | 2 | 4 | 2 | 4 | 6 | 15 |
| **Duke University Marine Laboratory, Duke University, NC** | Satellite coastal research facility<br>1 135′ R/V<br>1 50′ R/V<br>Numerous small boats/canoes | 1938 | N/A | | | | | | | |
| **Diving and Water Safety East Carolina University, NC** | 1 24′ boat – 9 years old**<br>4 boats ranging from 25′-65′ and 10-49 years old | N/A | N/A | | | | | | | |
| **Grice Marine Laboratory College of Charleston, SC** | 4 boats ranging in size from 16′ to 17′ and 5 to 22 years old<br>1 22′ boat – 20 years old<br>DNA sequencer – 0.25 years old | 1955 | 27 | 10 | 0 | 5 | 9 | 9 | 65 | 2 |
| **UNCW Center for Marine Science, University of North Carolina at Wilmington** | 1 41′ research vessel – 3 years old<br>1 70′ research vessel – 15 years old<br>2 ROVs – 15 years old<br>NMR Spectroscopy – 18 years old** | 1947 | 5 | 1 | 2 | 4 | 2 | 4 | 6 | 15 |
| **Marine Biomedicine and Environmental Sciences, Medical University of South Carolina, SC** | Graduate studies in marine & estuary biosciences in relation to human health<br>Hollings Marine Laboratory (under construction) | N/A | N/A | | | | | | | |
| **Baruch Institute for Marine Biology & Coastal Research, University of South Carolina, SC** | 15 boats ranging from small aluminum and 13′ to 21′ whalers and ages 9 to 25 years old | 1969 | 59 | 6 | 1 | 16 | 11 | 9 | 8 | 5 |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Caribbean Region** | | | | | | | | | | |
| **Department of Marine Sciences, University of Puerto Rico, PR** | R/Vs ranging from 35'-127'<br>Numerous small boats | 1954 | N/A | 15 | 6 | 17 | 2 | 1 | 0 | 1 |
| **University of the Virgin Islands, VI** | Center for Marine & Environmental Studies - cooperative educational arrangement<br>Two campuses (St. Croix, St. Thomas)<br>Recently installed internet capabilities | 1962 | N/A | | | | | | | |
| **Gulf of Mexico Region** | | | | | | | | | | |
| **Fisheries & Allied Aquaculture Center Auburn University, AL** | 117' and 1 24 ' boat – 0-3 years old<br>1 32' boat – 20 years old | 1930s | 6 | 22 | 10 | 10 | 6 | 3 | 6 | 1 |
| **Department of Oceanography & Coastal Studies, Louisiana State University, LA** | Remote sensing receiver – 10 years old* | 1991 | N/A | 5 | 8 | 17 | 7 | 5 | 18 | 4 |
| **College of Marine Sciences The University of Southern Mississippi, MS** | 4 research vessels ranging in size from 38 to 125 feet and 20 to 53 years old<br>1 ROV – 7 years old | 1996 | N/A | 22 | 4 | 12 | 5 | 6 | 0 | 0 |
| **Center for Coastal Studies, Texas A&M University - Corpus Christi, TX** | 5 laboratories<br>Off-campus field station | 1984 | N/A | | | 1 | 0 | 0 | 5 | 0 |
| **Department of Oceanography Texas A&M University, Corpus Christi, TX** | 1 ROV – 25 years old<br>Flow Cytometer – 5 years old<br>Mass Spectrometer – 7 years old | 1949 | N/A | 9 | 6 | 16 | 5 | 2 | 0 | 0 |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| - | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Texas A&M University Graduate School, College Station, TX** | • Waterways Experiment Station in Vicksburg, MS part of curriculum<br>• Hydromechanics laboratory (contains wave tanks)<br>• Civil engineering laboratory (contains wave tanks)<br>• Offshore Technology Research Center<br>• Center for Dredging Studies<br>• Center for Texas Shores and Beaches<br>• New coastal engineering laboratory under construction | 1876 | 0 | 9 | 6 | 16 | 5 | 2 | 0 | 0 |
| **Texas A&M University, Galveston, TX** | • 1 393' R/V – USTS Texas Clipper II<br>• New engineering facility under construction<br>• Multiple laboratories for the different marine-related departments<br>• Full Bridge mission simulator | 1876 | 30 | N/A | N/A | 0 | 0 | 0 | 11 | 0 |
| **Marine Biomedical Institute, Galveston, University of Texas Medical Branch, TX** | 1 65' trawler<br>2 aluminum boats (15' & 21')<br>Leading neuroscience research facility | 1969 | N/A | | | | | | | |
| **Marine Science Institute University of Texas – Austin, TX** | 1 38' boat – 12 years old<br>1 57' boat – 21 years old | 1946 | N/A | 6 | 2 | 6 | 2 | 5 | 0 | 0 |
| **Institute of Geophysics University of Texas-Austin, TX** | Ocean-Bottom Seismometer Program<br>1 103' R/V (32 years old – renovated in 1997)<br>1 57' R/V | 1972 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **West Coast Region** | | | | | | | | | | |
| **Marine Science Institute, Marine Biotechnology Center, University of California-Santa Barbara, CA** | 4 research centers<br>Flow injection analyzer, isotope ratio mass spectrometer, CHN analyzer, & Atomic Adsorption Spectrometer | 1969 | N/A | | | | | | | |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **Scripps Institute of Oceanography, University California, CA** | 1 boat >25′ – 40 years old**<br>1 ATV – 11 years old<br>Marine genomics equipment | 1903 | N/A | 6 | 26 | 65 | 15 | 9 | 7 | 0 |
| **Institute of Marine Sciences University California Santa Cruz, CA** | 2 22′ boats ages 0 and 4<br>3 boats range from 25′-32′ and ages 0-18 | 1965 | 104 | 10 | 8 | 20 | 5 | 10 | | 0 |
| **Bodega Marine Laboratory, University of California-Davis, CA** | 1 37′ boat – 0.25 years old | 1984 | N/A | | 3 | 2 | 0 | 0 | 0 | 0 |
| **Hancock Institute of Marine Studies Wrigley Institute for Environmental Studies University of Southern California, CA** | 1 boat – 45 years old**<br>Gene sequencing facility (1 year old)<br>Mass spectrometer – 3 years old | 1965 | 23 | 0 | 3 | 12 | 3 | 1 | 8 | 0 |
| **Earth Systems & Science Policy California State University, Monterey, CA** | years old | 1994 | 42 | N/A | | 2 | 6 | 1 | 10 | 0 |
| **Moss Landing Marine Laboratories, California State University, CA** | 3 boats ranging in age from 1-30** | 1966 | N/A | 11 | 10 | 8 | 0 | 1 | 5 | 0 |
| **Hopkins Marine Station, Stanford University, CA** | 1 25′ R/V<br>Numerous small boats | | 0 | 0 | 4 | 5 | 1 | 1 | 1 | 0 |
| **Romberg Tiburon Center for Environmental Studies San Francisco State University, CA** | 1 12′ boat – 20 years old**<br>1 39′ boat – 15 years old | 1978 | 0 | 6 | 0 | 3 | 1 | 1 | 7 | 1 |
| **Fisheries Biology/Oceanograp hy Humboldt State University, CA** | 3 boats ranging in size from 12′ to 18′ and 2 to 15 years<br>1 90′ R/V | 1940 | 26 | 2 | 0 | 6 | 0 | 0 | 13 | 0 |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff | |
| **College of Oceanic & Atmospheric Sciences Oregon State University, OR** | 1 57' boat – 2 years old<br>1 AUV<br>Supercomputer (8years old**) and gigabit networking infrastructure (1 year old)<br>Satellite direct broadcast receiving system – 1 year old<br>Inductively-coupled mass spectrometer<br>Organic gas chromatography – 5 years old | 1924 | N/A | 15 | 3 | 37 | 18 | 9 | 0 | 0 | |
| **Marine Biology University of Oregon, OR** | 1 14' boat – 0 years old<br>1 20' boat – 6 years old<br>1 42' boat – 32 years old | 1924 | N/A | 1 | 0 | 3 | 2 | 0 | 0 | 0 | |
| **Schools of Aquatic & Fisheries Science & Oceanography, University of Washington, WA** | Ion coupled plasma mass spectrometer – 11 years old**<br>Stable isotope mass spectrometer – 6 years old | 1981 | 31 | 35 | 15 | 21 | 16 | 10 | 11 | 1 | |
| **Applied Physics Laboratory University of Washington, WA** | 2 AUVs (ages 1 and 40)<br>2 50' research vessels – ages 25 and 35 | 1943 | N/A | | | | | | | | |
| **Friday Harbor Laboratories University of Washington, WA** | 1 58' R/V<br>Numerous small boats<br>Lab equipment includes:<br>• High performance liquid chromatograph<br>• Spectrophotometers<br>• Electrophysical equipment | | N/A | | | | | | | | |
| **Alaska Region** | | | | | | | | | | | |
| **School of Fisheries & Ocean Sciences University of Alaska-Fairbanks, AK** | 1 26' boat (age – N/A)<br>Arctic Region Supercomputing Center (age – N/A)<br>Mass Spectrometers (age – N/A) | 1917 | 2 | 19 | 4 | 24 | 10 | 11 | 0 | | |
| **Western Pacific Region** | | | | | | | | | | | |
| **University of Guam Marine Laboratory University of Guam, Guam** | 4 R/V ranging in size from 14' – 21' (age – N/A) | 1970 | N/A | | | | | | | | |

## SUPPLEMENT 5-1: Academic Marine Facilities

| Institution/Laboratory | Unique Aspects* | Year Established | # Degrees Awarded | | | # Faculty Members | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A/BS/BA | MS MA | PhD | Full Professors | Associate Professors | Assistant Professor | Instructors/ Adjunct | Other Staff |
| **School of Ocean & Earth Science Technology University of Hawaii, HI** | Hawaii Institute of Marine Biology<br>1 research vessel – 23 years old<br>1 submersible – 29 years old<br>1 ROV – 18 years old<br>High resolution alpha spectrometer system – 6 years old<br>Stable isotope mass spectrometers – 10 years old | 1988 | 14 | 16 | 3 | 90 | 40 | 54 | 51 | 8 |

N/A – Data were not available.
Data for this supplement are based on (1) CORE report data for AY2001 and (2) web research to supplement unique aspects.
Sixty-nine schools were selected for this table to illustrate the diversity of ocean science educational facilities in the United States. This list is only a sampling of the opportunities available for ocean science education.
* Non-UNOLS vessels only
** Denotes a replacement plan is in place
***Institute of Marine and Coastal Sciences at Rutgers is 10 years old, however, laboratory facilities at the University date back to 1972.

**SUPPLEMENT 5-2:**
**Original Members of the Joint Oceanographic Institutions**

| Name of Institution | Overview |
|---|---|
| **Columbia University, Lamont-Doherty Earth Observatory** | Affiliated with Columbia University, the Observatory operates the 239-foot research vessel, Maurice Ewing, which travels the world.<br><br>The Observatory actively participates in the JOIDES Ocean Drilling Program and houses the world's largest collections of deep and sediment cores.<br><br>Some of the most comprehensive and accessible databases in seismology and geosciences are on-site.<br><br>The Observatory has fully equipped laboratories for rock mechanics, paleomagnetics, high-pressure experiments, and a wide range of isotope geochemistry, as well as its own library, electronics shop, and instrument laboratory. |
| **Oregon State University, College of Oceanic and Atmospheric Sciences (OSU)** | One of the leading oceanic and atmospheric science institutions in the Nation.<br><br>A research institution with a number of state-of-the-art facilities. Some of these facilities provide services to the oceanographic and scientific community beyond Oregon State University. All are available for graduate student research of the College. |
| **Texas A&M University, College of Geosciences (TAMU)** | This institution is one of the largest and most comprehensive academic concentrations of geosciences students, faculty, and research activity in the world, and is a key element of TAMU's Land Grant, Sea Grant, and Space Grant missions.<br><br>The College of Geosciences is home to the Center for Tectonophysics, the Geochemical and Environmental Research Group, and the Texas Center for Climate Studies, and is the science operator for the Ocean Drilling Program. |
| **University of California at San Diego, Scripps Institution of Oceanography (UCSD-SIO)** | Scripps is one of the oldest and largest centers for global science research and graduate training in the world. More than 300 research programs are now conducted at Scripps, aimed at gaining comprehensive understanding of the oceans, atmosphere and structure of the Earth.<br><br>In 1995, the National Research Council ranked Scripps first in faculty quality among oceanography programs nationwide. |
| **University of Hawaii, School of Ocean & Earth Science & Technology (U. Hawaii)** | This division of the University of Hawaii was established to realign strengthen the education and research resources within the University.<br><br>The school offers formal and informal graduate and undergraduate programs in several disciplines, all enhanced by research programs and resources.<br><br>The institution has several specialized laboratories and equipment that make it state of the art for education and research. |
| **University of Miami, Rosentiel School of Marine & Atmospheric Sciences (U. Miami)** | research institute of its kind in the continental United States.<br><br>The school specializes in satellite oceanography, experimental fish hatchery, sedimentary geology, marine geophysics, ocean acoustics, and marine and atmospheric chemistry.<br><br>The school is also known as one of the National Institute of Environmental Health Sciences sites for the Marine and Freshwater Biomedical Sciences Center. |
| **University of Rhode Island, Graduate School of Oceanography (URI)** | One of the largest and most widely known graduate schools of oceanography in the Nation, and one of the original group of National Sea Grant Colleges.<br><br>As a center for marine studies, the school is located ideally on the shore of the West Passage of Narragansett Bay.<br><br>environmental education and science communications. |

## SUPPLEMENT 5-2:
## Original Members of the Joint Oceanographic Institutions

| Name of Institution | Overview |
|---|---|
| **University of Texas at Austin, Institute for Geophysics (UTIG)** | Known internationally as a leading academic institution in geology and geophysics. Its location along the Gulf of Mexico facilitates the study of these disciplines.<br><br>The school has an extensive outreach program that focuses on geophysical issues. |
| **University of Washington, School of Oceanography (UW)** | A national leader in oceanographic research and graduate and undergraduate instruction.<br><br>The school incorporates extensive study aboard research vessels into all levels of academics.<br><br>Many staff and students participate in formal and informal outreach activities that include the award-winning REVEL program. |
| **Woods Hole Oceanographic Institution (WHOI)** | The largest independent, not-for-profit oceanographic research institution in the Nation. Woods Hole also provides graduate educational opportunities for the ocean sciences.<br><br>The premier facilities at the institution are the research vessels, which are floating laboratories. |

## SUPPLEMENT 5-3: Federal and State Maritime Academies

| Name and Location of Academy | Degrees/Certifications | Degree Programs Offered | Unique Attributes of Institution |
|---|---|---|---|
| **U.S. Merchant Marine Academy, Kings Point, NY** | Marine Officer, and Appointment as officer in a reserve U.S. Armed Force | Marine Transportation, Maritime Operations and Technology, Logistics and Intermodal Transportation, Marine Engineering, Marine Engineering Systems, Marine Engineering and Shipyard Management, or Dual License | Only Federal maritime academy; home to the Global Maritime and Transportation School |
| **California Maritime Academy, Vallejo, CA** | Affiliated with California State University; 4-year, Licensed as a Third Mate, Third Assistant Engineer, Certified Plant Engineer | Nautical Industrial Technology; Marine Engineering Technology; Mechanical Engineering; Business Administration | Well known for direct, hands-on approach; first maritime academy to admit females; expanded curriculum in 1996 to offer a facilities technology engineering degree; Business degree program expanding; Home to the Institute for Maritime Technology Research |
| **Great Lakes Maritime Academy, Traverse City, MI** | Affiliated with Northwestern Michigan College; Bachelors in Business; A.A.S. in Maritime Technology | Deck Program; Engineering Program; Business Administration | Designed as a regional maritime academy; the only one affiliated with a community college |
| **Maine Maritime Academy, Castine, ME** | Several A.S. and B.S. degrees offered in Major Programs | Marine Engineering Operations; Marine Engineering Technology; Marine Systems Engineering; Power Engineering Technology; Marine Transportation Operations Small Vessel Operations; Marine Biology; Marine Science; Interdisciplinary Studies | Academy has the most vessels of any U.S. maritime college |
| **Massachusetts Maritime Academy, Cape Cod, MA** | B.S.; Licensed Merchant Marine; Naval Officer's Commission | International Maritime Business; Marine Engineering; Marine Transportation; Facilities and Environmental Engineering; Marine Safety and Environmental Protection | Nation's oldest co-ed maritime college; students required to spend portion of academic program at sea or in cooperatives or internships |
| **State University of New York Maritime College, Throggs Neck, NY** | Bachelor of Science; Bachelor of Engineering; Licensure as a Third Officer (mate or engineer) for Merchant Marine | Marine Transportation/Business Administration; International Transportation and Trade; Engineering; Humanities; Naval Architecture; Marine Environmental Science | Blend of classroom instruction as well as three summers of international travel aboard college's training vessel, the *EMPIRE STATE VI* |
| **Texas Maritime Academy, Galveston, TX** | Affiliated with Texas A&M; Bachelor of Science; Bachelor of Arts; Licensed Merchant Marine Officer (Third Mate's License or Third Assistant Engineers License-depending on major) | Marine Biology; Marine Sciences; Marine Transportation; Marine Engineering Technology | Blend of classroom instruction as well as three summers aboard the *TEXAS CLIPPER II*, the Academy training vessel |

## SUPPLEMENT 5-4: Maritime Graduate and Continuing Education Institutions

| Name and Location of Academy | Degrees/Certifications and Programs Offered | Unique Attributes of Institution |
|---|---|---|
| **Seattle Maritime Academy, Seattle, WA** | Affiliated with Seattle Community College; Coast Guard-Approved Certification Programs in Marine Deck Technology and Marine Engineering Technology;<br>Training in a variety of marine subjects and topics; Provides training under contract to private companies, government agencies, military units, and unions;<br>Offer about 45 courses annually | Mission is to serve the maritime community and the industry of the Pacific Northwest through vocational education, technical training and licensure;<br>Courses directed towards commercial fishing, the Merchant Marine, and the workboat industry |
| **Calhoon Marine Engineers' Beneficial Association Engineering School, Easton, MD** | STCW-95 courses and certification; focus on core business of maritime education, service to the MEBA members, and advancement of excellence to the MEBA contracted companies for over 30 years;<br>Over 25 courses to the USCG licensed deck and engineering officers;<br>Take high school graduates through three years of intense study, including one full year at sea | Quality Management System, as certified by Det Norske Veritas (DNV) and recognized by the American Council on Education, ensures faculty and students maintain high standards;<br>U.S.'s first joint maritime industry-labor training institution;<br>Provides state-of-the-art training to an average of 1,600 sailing members annually |
| **Marine Institute of Technology and Graduate Studies, Linthicum Heights, MD** | Home to International Longshoremens' Association/Carrier's Container Council Crane Training Center;<br>Applicable programs meet USCG, STCW-95, American Pilots' Association, and DNV standards;<br>Provides training to military and civilian mariners from around the world | Non-profit continuing education center for professional mariners;<br>Two full-mission ship bridge simulators; eight ship interactive blind pilotage simulators equipped with ARPA, radars, ECDIS, bridge control, and DSC-VHF communications; etc. |
| **Simulation, Training, Assessment, and Research Center, Toledo, Ohio and Dania Beach, FL** | More USCG and other approved courses than any other simulation training center;<br>Extensive simulation and in-house modeling capabilities;<br><br>Medical courses; STCW-95 courses; Bridge simulator courses; Waterfront courses; Engineering courses | World's first 360 degree field of view Full Mission bridge simulator, as well as a 247 degree field of view bridge simulator;<br>Slow speed and medium speed diesel engine room simulators;<br>Full mission diesel electric simulator;<br>Liquid cargo, radar/ARPA, and GMDSS simulators;<br>Courses tailored to individual needs and fully integrated into ISM and company policies |
| **Elkins Marine Training International, Petaluma, CA** | Training for STCW-95 compliance;<br>Training and certifications in Global Maritime Distress and Safety (GMDSS), STCW-95 General Operators Certificate for GMDSS, Restricted Operators Certificate for GMDSS, Basic Safety Training, Personal Survival, Basic Marine Firefighting, Elementary First Aid, Tanker Familiarization, Tankership Dangerous Liquids and Advanced Firefighting | Training facility is a joint venture between FBT Training Unlimited (U.S. company) and Marineworks, LTD, (London, U.K. company);<br>Training mariners and aviation specialists for over 50 years |
| **Pacific Marine Institute, Seattle, WA** | Wide array of marine safety and watchstanding oriented courses;<br>Entry-Level Career Program; Able Seaman to Mate Program; Mate to Master Program | Nonprofit continuing education center for professional civilian and military mariners |

## SUPPLEMENT 5-4: Maritime Graduate and Continuing Education Institutions

| Name and Location of Academy | Degrees/Certifications and Programs Offered | Unique Attributes of Institution |
|---|---|---|
| **Port Canaveral Maritime Academy, Port Canaveral, FL** | USCG-approved STCW-95 Basic and Combined Basic and Advanced Fire Fighting courses, Basic Safety Training; Personal Safety and Social Responsibilities; Individual courses include Personal Survival Techniques and Basic First Aid/CPR | State-of-the-art maritime fire training facility with simulation capabilities; environmentally safe machines as part of simulators |
| **Resolve Fire and Hazard Response, Port Everglades, FL** | Fire training in a realistic yet safe environment; Wide variety of safety training programs to meet training needs of all mariners with a concentration on firefighting | Widely recognized as one of the finest training centers of its type in the world;<br><br>Facility uses environmentally friendly propane gas |

## SUPPLEMENT 5-5: National Marine Sanctuaries, By Region

| Sanctuary | Area (square miles) | Designation | Unique Characteristics | Education |
|---|---|---|---|---|
| **South Atlantic** | | | | |
| **Florida Keys, Florida** | 2,800 | 1990 | Known worldwide for extensive offshore coral reefs | Several educational programs include *Coral Reef Classroom* (middle school), *Community Connection*, and Coral Shore High School Mentor Program |
| **Gerry E. Studds Stellwagen Bank, Massachusetts** | 842 | 1992 | Over 1 million visitors a year, many for whale watching; challenging to manage sanctuary due to numerous competing resources | Educational programs include whale watching programs, exhibits on site and at aquariums, and interactive Web sites |
| **Thunder Bay, Michigan** | | 2000 | Most recently designated sanctuary and only one for the Great Lakes; approximately 160 shipwrecks are contained in the sanctuary | Educational programs focus on bringing video links of shipwrecks to the visitors center, classrooms, and beyond; ongoing shipwreck exploration |
| **Gray's Reef, Georgia** | 17 | 1981 | One of the most popular recreation areas in Georgia; largest sandstone reef in southeastern U.S. | Sanctuary sponsors community outreach marine programs, presentations, and exhibits; several educational publications, teacher programs, and distant learning programs bring the reef to the classroom |
| **Monitor, North Carolina** | 1 | 1975 | First designated sanctuary; purpose is to preserve this Civil War wreckage; recovery efforts of important artifacts continues; Located 16 miles off the coast in 240 feet of water | The major goal of the education program is developing programs and products that bring the *Monitor* to the public since it is not possible for the public to visit. Brochures, posters, publications, slide and video programs, public presentations, professional papers, and the internet are all educational tools |
| **Gulf of Mexico** | | | | |
| **Flower Garden Banks, Texas and Louisiana** | ~ 42 | | Northernmost coral reefs in the U.S.; premier diving destination and scientist research area for people worldwide | Education opportunities include exhibits and hands-on activities at trade shows and conferences, presentations in conjunction with workshops offered by other entities, brochures, videos, posters, newsletters, trained Naturalists on Board, Ocean Discovery Days and formal workshops |
| **West Pacific** | | | | |
| **Fagatele Bay, American Samoa** | 0.25 | 1986 | Smallest and most remote sanctuary; only tropical coral reef sanctuary | Educational programs include the Enviro Discoveries Marine Science Summer Camp, and Le Tausagi (village outreach) |
| **Hawaiian Islands Humpback Whale, Hawaii** | N/A | 1992 | Scientists estimate two-thirds of the North Pacific Humpback Whales migrate to Hawaii for breed, calve, and nurse young | Extensive programs to educate the public about this species |
| **North Pacific** | | | | |
| **Monterey Bay, California** | | 1992 | The sanctuary is managed to balance recreational and commercial uses with protection of resources; varies between undeveloped and settlements of small towns | Provide public outreach through exhibits, publications, programs, events and services; provide sanctuary education for students and teachers |

## SUPPLEMENT 5-5: National Marine Sanctuaries, By Region

| Sanctuary | Area (square miles) | Designation | Unique Characteristics | Education |
|---|---|---|---|---|
| **Olympic Coast, Washington** | > 3,300 | | Sanctuary provides habitat for one of the most diverse marine mammal faunas in North America and is a critical link to the Pacific flyway; largely undeveloped shoreline | Help develop education programs for schools, with emphasis on teacher training and student field investigations; provides teacher and student training in field research methods and hands-on field investigations, and assists teachers conducting field trips; on-site interpretive programs are carried out with area parks |
| **Gulf of the Farallones, California** | 1,255 | 1981 | Serves as a wildlife refuge; visitors enjoy easy access to shoreline areas | Coastal Ecosystem Education Program (K-12), Intertidal Trash Bash (3-5), Sanctuary Explorers Summer Camp (8-13 yrs.), Resource Library (educators), School Program (K-8) |
| **Channel Islands, California** | 1,252 | 1980 | Over 27 species of whales and dolphins visit or inhabit the sanctuary; combination of warm and cool currents create an exceptional breeding ground for numerous plants and animals | Los Marineros educational program includes lectures, presentations, and student field trips to local marine sites |
| **Cordell Bank, California** | 526 | 1989 | One of the most biologically productive areas of the West Coast; over most of it the water is about 200 feet deep | Educational programs at the Sanctuary range from displays, brochures, classroom visits, student summits, outreach events, lecture series, outings, teacher trainings, and guided boat tours |

## SUPPLEMENT 5-6: National Estuarine Reserves, By Region

| Estuarine Reserve | Year | Acreage | Unique Characteristics | Education |
|---|---|---|---|---|
| **Great Lakes** | | | | |
| **Old Woman Creek, Ohio** | 1980 | 571 | Smallest reserve in NERRS; only Great Lakes-type freshwater estuary in NERRS | Educational efforts focus on using audio-visual presentations, field trips and tours, lectures, workshops and training seminars to increase awareness of coastal wetlands and watersheds |
| **New England** | | | | |
| **Great Bay, New Hampshire** | 1989 | 5,280 | The University of New Hampshire's Jackson Estuarine Lab is within the reserve | Educational activities focus on slide shows, tours, lecture series, and outreach programs for school children and general public; several hands on activities and programs |
| **Narragansett Bay, Rhode Island** | 1980 | 3,845 | Home to the densest herd of white tailed deer in the northeast | Educational programs include interpretive hikes, tours, and a learning center; a touch tank and education building are available on a seasonal basis |
| **Waquoit Bay, Massachusetts** | 1988 | 2,500 | Washburn Island, in the western part of Waquoit Bay, is one of the last undeveloped coastal properties on Cape Cod, Bordering Waquoit Bay on the south is South Cape Beach, Waquoit Bay is the dominant feature of the Reserve and includes 825 acres | Reserve staff hold workshops for coastal decision makers; community courses offers on a variety of topics; staff work with local schools through teacher training to develop curriculum with a coastal focus |
| **Wells, Maine** | 1986 | | The Wells Reserve is dominated by salt marsh, but also encompasses fields, forests, and beaches, a variety of habitats supporting diverse plant and animal communities | The reserve educates the general public through lectures, guided tours, workshops, and field trips focusing on the reserves natural history and current research; Estuary participates in the Estuary-Net Project |
| **South Atlantic** | | | | |
| **Apalachicola Reserve, Florida** | 1979 | 246,000 | One of the most productive estuarine systems in the Northern Hemisphere | Outreach education includes Estuarine Habitats (K-5) and Project Estuary (6-12); field activities; educational exhibits; and the coastal management workshop series |
| **ACE Basin, South Carolina** | 1992 | 134,710 | One of the largest undeveloped estuaries on the East Coast | A variety of educational programs for educators, coastal decision makers, lawmakers, students, and the general public; programs include a touch tank program for children, educational cruises, and a marsh classroom adventure program |
| **Jacques Cousteau, New Jersey** | 1998 | 114,665 | The only reserve in the system named after an individual; only reserve to expand its boundaries into the Atlantic Ocean | Staff conduct a variety of workshops for local government officials and decision makers; staff also provide professional training, educational tours, teacher training, and K-12 curriculums specific to New Jersey coastal issues |
| **Rookery Bay, Florida** | 1978 | 110,000 | One of the largest mangrove-forested regions in the new world. Rookery Bay represents one of the few remaining undisturbed mangrove estuaries in North America | study programs for students, adult education programs, training workshops for professionals, and outreach programs for the local community |
| **Guana Tolomato Matanzas, Florida** | 1999 | 55,000 | Newest reserve in NERRS | As a new reserve, the educational program is under development |
| **Sapelo Island Reserve, Georgia** | 1976 | 17,950 | A typical barrier island natural community, from the diversified wildlife of the forested uplands to the vast expanses of *Spartina* salt marsh and the complex beach and dunes system. | Educational programs for schoolchildren and the public focus on the facets of Georgia's coastal and estuarine ecology; interactive and narrative programs; and curriculums designed for teachers |

## SUPPLEMENT 5-6: National Estuarine Reserves, By Region

| Estuarine Reserve | Designation Year | Acreage | Unique Characteristics | Education |
|---|---|---|---|---|
| **North Inlet-Winyah Bay, South Carolina** | 1992 | 12,237 | As the estuary with the third largest watershed on the east coast, Winyah Bay has been greatly influenced by agriculture, industry and other human activities | Reserve educational opportunities serve audiences of all ages; short courses, seminars, tours, and open houses are held year round; evening lectures, forums, and seminars directed towards adult audiences complement the numerous family oriented ecology programs |
| **North Carolina** | 1985, 1991 | 10,000 | Currituck Banks, Rachel Carson, Zeke's Island, and Masonboro Island make up reserve | Educational activities include workshops and outreach programs for school groups; Estuary Live, an internet field trip program, is used worldwide |
| **Delaware** | 1993 | | The Blackbird Creek component is dominated by freshwater wetlands, ponds, and forested habitats. The St. Jones component is dominated by salt marshes and open water habitats of the Delaware Bay | Reserve offers a wide variety of educational programs to the general public, school groups, organizations, and educators; examples include a guided wetland walk, St. Jones River boat tours, and coastal decision-maker workshops |
| **Hudson River, New York** | 1982 | 4,838 | Piedmont Marsh is the largest brackish wetland on the Hudson River | Educational programs draw on research conducted at the reserve; 16 seasonal field programs offered targeting adult audiences with focus on regional ecology |
| **Chesapeake Bay, Maryland** | 1985, 1990 | 4,820 | Multi-component reserve reflects the diversity | Reserve serves as living classroom for audiences of all ages; a wide variety of educational programs; annual celebration of Estuaries Day |
| **Chesapeake Bay, Virginia** | 1991 | 4,435 | The range of habitats in the reserve are famous worldwide for their commercial, recreational, and aesthetic resources | Technical training and education programs; general education programs for students (grades 6-college), educator, and public audiences enhance awareness and understanding of estuary |
| **Gulf of Mexico** | | | | |
| **Grand Bay, Mississippi** | 1998 | 18,400 | One of the most biologically productive estuarine reserves in the Gulf Coast region | of Mexico as a center for estuarine conservation, research, education and public interpretation |
| **Weeks Bay, Alabama** | 1986 | 6,000 | Much of the land surrounding Weeks Bay is composed of forested wetlands and swamps, as well as some areas of upland pine-oak forest | Numerous education programs include "Touch Lab" (targets K-6), guided trail walks, and an estuary tour on the Reserve's boat |
| **North Pacific** | | | | |
| **Kachemak Bay, Alaska** | 1999 | 385,000 | Largest reserve in NERRS | Reserve is in the process of constructing a visitor facility with educational exhibits |
| **South Pacific** | | | | |
| **Padilla Bay, Washington** | 1980 | 11,000 | The bay is filled with sediment from the Skagit River, making the bottom very shallow, flat, and muddy. Almost the whole bay is intertidal. This condition allows unusually large eelgrass meadows to grow. There are nearly 8,000 acres of eelgrass in Padilla Bay | The education program supports K-12 and adult audiences with four curricula, classroom and field studies; the staff holds coastal decision maker workshops; "Fish Feeding" program is an interpretive tour of the Reserve's saltwater aquarium |
| **South Slough Reserve, Oregon** | 1974 | 4,700 | Connecting to the ocean through the Coos estuary mouth, near Charleston, Ore., South Slough provides an outstanding natural laboratory | range of audiences; coastal decision maker workshops have been developed |
| **Tijuana River, California** | 1982 | 2,500 | One of the few salt marshes remaining in Southern California, where over 90 percent of wetland habitat has been lost to development | Education programs are bilingual and include K-12 programs, interpretive walks, beach clean-ups, coastal decision maker workshops, and teacher training courses |

## SUPPLEMENT 5-6: National Estuarine Reserves, By Region

| Estuarine Reserve | Designation Year | Acreage | Unique Characteristics | Education |
|---|---|---|---|---|
| **Elkhorn Slough, California** | 1979 | 1,400 | One of the few undisturbed coastal wetlands in California | Extensive research carried out at reserve involving university students; education program designed to help teachers become proficient environmental educators; the coastal training program is in place to educate the public about coastal resources |
| **Caribbean** | | | | |
| **Jobos Bay, Puerto Rico** | 1981 | 2,883 | Second largest estuarine reserve area in Puerto Rico; plays a leading role in the International Coral Reef Initiative | Reserve engaged in cooperative programs with University of Puerto Rico, Sea Grant Program, and other educational institutions |

## SUPPLEMENT 5-7: Federal Seashore/Lakeshore/Coral Reef Parks

| Park Name | Designation | Acreage | 2001/2002 Attendance | Education |
|---|---|---|---|---|
| **National Seashore/Lakeshore Parks** | | | | |
| **South Pacific** | | | | |
| **Point Reyes National Seashore, California** | 1962 | 71,068 | 2,294,544 | Provides extensive education opportunities that include teacher workshops, ranger-led curriculum, high school summer internships, interactive Web site, and overnight educational opportunities |
| **Gulf of Mexico** | | | | |
| **Padre Island National Seashore, Texas** | 1962 | 663,890 | 130,434 | Sea turtle education and release program; and an adopt-a-beach program |
| **Gulf Islands National Seashore, Florida and Mississippi** | 1971 | 137,458 | 4,428,944 | 19th century forts; and nature trails |
| **Mid Atlantic** | | | | |
| **Assateague Island National Seashore, North Carolina** | 1965 | 39,733 | 1,874,661 | Wild horses roam the seashore freely; numerous educational programs targeting ages 4 and up – focus is beach conservation and marine species education |
| **Cape Hatteras National Seashore, North Carolina** | 1937 | 31,263 | 3,331,952 | Wealth of history related to shipwrecks, lighthouses and the U.S. Lifesaving Service; seasonal education programs given by rangers |
| **Cape Lookout National Seashore, North Carolina** | 1966 | 28,243 | 561,976 | Three barrier islands that are part of seashore contain significant historical and natural features; On-site programs include: Lighthouse Keepers/Life Savers, Barrier Island Visitors, Barrier Island Ecology, and Salt Marsh Critters |
| **Fire Island National Seashore, New York** | 1980 | 19,579 | 646,812 | Numerous visitor centers on site have a variety of educational and interactive programs |
| **South Atlantic** | | | | |
| **Canaveral National Seashore, Florida** | 1975 | 57,662 | 1,141,654 | Seashore has a junior ranger program for ages 6-12; numerous educational programs include Beach Discovery Hunt, Seaside Discovery, and high school magnet programs |
| **Cumberland Island National Seashore, Georgia** | 1972 | 36,415 | 43,816 | Seashore is well known for its sea turtles, shore birds, dune fields, maritime forest, salt marshes, and historic structures; various educational programs for school children are given year round |

## SUPPLEMENT 5-7: Federal Seashore/Lakeshore/Coral Reef Parks

| Park Name | Designation | Acreage | 2001/2002 Attendance | Education |
|---|---|---|---|---|
| **New England** | | | | |
| **Cape Cod National Seashore, Massachusetts** | 1961 | 43,605 | 4,495,452 | Seashore contains a variety of historical structures; several one-day and overnight educational opportunities |
| **Great Lakes** | | | | |
| **Apostle Islands National Lakeshore, Wisconsin** | 1970 | 69,372 | 186,232 | The Apostle Islands archipelago includes 22 islands and is located in far northwestern Wisconsin, off the Bayfield Peninsula; educational programs include service learning and wilderness study |
| **Pictured Rocks National Lakeshore, Michigan** | 1966 | 73,228 | 420,320 | The first national lakeshore designated; the park has two information centers as well as two interpretive centers; seasonal education programs offered |
| **Sleeping Bear Dunes National Lakeshore, Michigan** | 1970 | 71,176 | 1,126,176 | Many cultural and natural resources; Seashore has a junior ranger program for ages 6-12 |
| **Indiana Dunes, National Lakeshore, Indiana** | 1966 | 15,063 | 1,175,043 | Partnership between the National Lakeshore and the Indiana Dunes Environmental Education Consortium to enhance educational programs; overnight programs for grades 4–6 students; various year round educational programs |
| **National Coral Reef Parks** | | | | |
| **South Atlantic** | | | | |
| **Biscayne National Park, Florida** | 1980 | 172,924 | 486,402 | Educational camping program in place; a "Discovery Room" is in development for hands-on interaction |
| **Dry Tortugas National Park, Florida** | 1992 | 64,701 | 73,469 | Seven islands along with the coral reef make up the park; ranger-guided programs; visitor center at Fort Jefferson |
| **Caribbean** | | | | |
| **Virgin Islands National Park, Virgin Islands** | 1956 | 14,689 | 713,462 | Virgin Islands Environmental Resource Station educates through snorkeling expeditions, guided tours, exhibitions, and presentations |
| **Salt River Bay National Park and Ecological Preserve, Virgin Islands** | 1992 | 948 | N/A | Park contains numerous monuments of historical significance |

## SUPPLEMENT 5-7: Federal Seashore/Lakeshore/Coral Reef Parks

| Park Name | Designation | Acreage | 2001/2002 Attendance | Education |
|---|---|---|---|---|
| **Buck Island Reef National Monument, Virgin Islands** | N/A | N/A | N/A | Famous underwater trail; park is open to visitors for walking, snorkeling, and diving; much-acclaimed underwater interpretive trails |
| **Gulf of Mexico** | | | | |
| **Guadalupe Mountains National Park, Texas** | 1966 | 86,416 | 208,098 | Park contains some of the most extensive Permian limestone fossil reef; several educational and interpretive programs |
| **Western Pacific** | | | | |
| **Kalaupapa National Historic Park, Hawaii** | 1980 | 10,779 | 96,143 | Visitor center with interactive exhibits; no regular interpretive programs due to the restricted nature of visitation to the park |
| **National Park of American Samoa** | 1993 | 9,000 | N/A | One of the most remote national parks in the U.S.; park preserves the only mixed-species paleotropic rainforest in the U.S.; Home Stay program allows visitors to live with native Samoans |
| **Kaloko-Honokohau National Historic Park, Hawaii** | 1978 | 1,161 | 50,003 | undeveloped; education programs focus on native plant and animal life, habitat & ecosystems within the park, and cultural history; programs focus on 3rd and 4th grade students, but can be modified for other age groups if notified |
| **War in the Pacific National Historical Park, Asan, Guam** | N/A | 2,037 | 147,273 | Park suffered major damage from Super Typhoon Pongsona in December 2002; most of the park is closed until further notice |