U.S. INTEGRATED OCEAN OBSERVING SYSTEM

COST ANALYSIS REQUIREMENTS DESCRIPTION

VERSION 2.0

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Preface

Analysts need extensive information about an acquisition program in order to develop realistic cost estimates for budgeting. This information is provided in a document known as the Cost Analysis Requirements Description (CARD). Prepared by the program office, the CARD, among other things, documents assumptions; presents technical, functional, and physical descriptions of program elements; specifies the number of items to be procured; provides a schedule for development and acquisition; describes the support concept and operational needs in terms of fuel, power, chemicals, labor, facilities, tools, security, and so on; and defines the life-cycle length. The more detailed the CARD in terms of costable quantities, the more accurate the estimates will be.

The CARD presents a common view of a program from a cost perspective; that view is used as the basis for developing program office estimates, independent cost estimates, and other agency-required cost estimates. It is not very useful for other purposes, such as program planning or requirements analysis, because it does not contain a complete picture of those areas.

A CARD is a living document, usually prepared by or with program engineers. As the program matures from identification of a mission need, to identification of alternatives, to publication of a request for proposals, the CARD must be updated to incorporate additional detail and to present the most accurate picture of the program. At any point in time, some parts of the CARD may contain details about cost elements that are well known and defined, while other parts may be subject to program decisions, engineering research, or undefined external requirements. A CARD may contain elements from or reference requirements documents, test and evaluation master plans, program plans, the concept of operations and the integrated logistics plan, and so on.

In the absence of specific guidance from the Government Accountability Office, this CARD for the U.S. Integrated Ocean Observing System follows the structure required by the Department of Defense. It provides the data available as of March 2011; in sections for which data are not yet available, the CARD specifies what data should be added.

Section 1.
System Overview

1.1 SYSTEM PURPOSE

1.1.1 U.S. IOOS Background

Oceans are critically important to our society and affect the lives of all Americans regardless of whether they reside along the coasts. Oceans provide critical sources of dietary protein, and they generate services such as tourism, recreational opportunities, and employment. They are the birthplace of weather systems and modifiers of weather and climate; they are highways for marine commerce and a buffer for national security; and they are a major reservoir of natural resources, havens for recreation, and virtual schoolrooms for educators and laboratories for scientists.[1]

Changes are occurring in the oceans that have profound effects on our society—from rising sea levels and coastal flooding to harmful algal blooms, dead zones, ocean acidification, and fish kills. Our ability to understand the magnitude of ocean changes, including their causes and consequences, and to effectively manage the impacts on marine ecosystems and living resources depends on the ability to rapidly detect and predict changes in the ocean and coastal environments. Due to the disparate nature of our national observing capabilities, a comprehensive view of the ocean environment does not currently exist. Resource and emergency managers, land use planners, and others do not have access to sufficient, timely ocean information to support their decisions.[2]

Historically, the United States has responded to these challenges individually and in an ad hoc uncoordinated fashion. Hundreds of federal, state, and local programs collect information on our nation's oceans and coasts. Many of these programs collect, distribute, and archive the same data (e.g., temperature and salinity) but in different ways. This disparity results in data that cannot be combined or analyzed together, are not easily accessible, and may never be known to exist. Consequently, time and resources are wasted converting disparate data and potentially duplicating data collections. Data from existing observing systems would be much more useful and timely if it were linked and presented in an integrated, standardized way.[3]

[1] 2008 IOOS Report to Congress, p. 3.
[2] 2008 IOOS Report to Congress, p. 3.
[3] 2008 IOOS Report to Congress, p. 3.

The Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009 mandated the establishment of a national integrated system of ocean, coastal, and Great Lakes observing systems to improve the nation's capability to measure, track, explain, and predict events related to weather and climate.[4] The U.S. Integrated Ocean Observing System (IOOS®) will address this requirement. U.S. IOOS will gather physical, geological, chemical, and biological information on our oceans and coasts—conditions that affect, and are affected by, humans and their activities. This coordinated network of people and technology generates and disseminates continuous data, information, models, products, and services on our coastal waters, Great Lakes, and oceans.[5]

With U.S. IOOS, the nation can more effectively monitor and address the increasing demands on our coasts and oceans. Improved capabilities could provide better predictions of hazardous events; allow more accurate measurement or prediction of risks of illness, injury, and death; route ships more cost effectively through U.S. waterways; and improve search, rescue, and emergency response efforts.[6]

The following descriptions provide additional context for U.S. IOOS:[7]

- As a functional capability, U.S. IOOS provides for the common, interoperable exchange of, and access to, ocean observing data among U.S. IOOS data collectors, data providers, data managers, and data users.
- As a system, U.S. IOOS is an adaptive, federated network of ocean observation, data management and communications, and modeling and analysis capabilities.
- As a process, U.S. IOOS is a social network of organizations and people supporting and using the U.S. IOOS.

1.1.2 U.S. IOOS Mission

The core mission of U.S. IOOS is the systematic provision of ready access to marine environmental data and data products—in an interoperable, reliable, timely, and user-specified manner—to end users/customers in order to serve seven critical and expanding societal needs:

- Improve predictions of climate change and weather, and their effects on coastal communities and the nation
- Improve the safety and efficiency of maritime operations
- More effectively mitigate the effects of natural hazards

[4] 2011 IOOS Report to Congress (draft).

[5] 2008 IOOS Report to Congress, p. 1.

[6] 2008 IOOS Report to Congress, p. 4.

[7] U.S. IOOS Office, *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, Version 1.0, November 2010, p. 1-3.

- Improve national and homeland security
- Reduce public health risks
- More effectively protect and restore healthy coastal ecosystems
- Enable the sustained use of ocean and coastal resources.[8]

These seven critical societal needs shape U.S. IOOS direction. To help achieve this mission, representatives of the U.S. IOOS community of practice reached a consensus—at the March 2002 Ocean.US Workshop held at Airlie House in Warrenton, VA—about 20 ocean observing core variables "required to detect and/or predict changes in a maximum number of phenomena of interest to user groups."[9] Subsequent efforts identified six additional core variables.[10] The 26 U.S. IOOS core variables are as follows (asterisks denote the six core variables added after the Airlie House conference):[11]

- Acidity (pH) *
- Bathymetry
- Bottom character
- Colored dissolved organic matter *
- Contaminants
- Dissolved nutrients
- Dissolved oxygen
- Fish abundance
- Fish species
- Heat flux
- Ice distribution
- Ocean color
- Optical properties
- Partial pressure of carbon dioxide (pCO2) *
- Pathogens
- Phytoplankton species
- Salinity
- Sea Level
- Stream flow *
- Surface currents
- Surface waves
- Temperature
- Total suspended matter *
- Wind speed and direction *
- Zooplankton abundance
- Zooplankton species.

[8] National Office for Integrated and Sustained Ocean Observations, *The First U.S. Integrated Ocean Observing System (IOOS) Development Plan*, Ocean.US Publication 9, January 2006, p. viii.

[9] The workshop was convened to focus, prioritize, and plan the IOOS program path. Participants included Ocean US (a federally funded office) personnel, oceanographic researchers from academia, and representatives from other federal agencies such as NOAA. See National Office for Integrated and Sustained Ocean Observations, *Building Consensus: Toward An Integrated and Sustained Ocean Observing System*, Ocean.US Workshop Proceedings, March 10–15, 2002, p. 6.

[10] Adapted from Integrated Global Observing Strategy, *Coastal Theme Report*, January 2006, and from Intergovernmental Oceanographic Commission, *An Implementation Strategy for the Coastal Module of the Global Ocean Observing System*, 2005.

[11] U.S. IOOS Office, *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, Version 1.0, November 2010, p. 1-5.

These core variables represent the high-level ocean observing requirements of U.S. IOOS.[12] These variables, ranging from small to significant technological challenges in measurement, were identified as the most critical data sets and are required on a national scale. U.S. IOOS will build a national capacity to deliver these data and ensure their continuity and sustainability over the long term.[13] The continued establishment of national core variables will be provided through formal interagency coordination, and partnership engagement, by the IOOC in accordance with the provisions of the ICOOS Act.[14]

1.1.3 System Functional Relationships

U.S. IOOS is a networked system based on partnerships between federal, regional, and private-sector entities. The system represents a partnership of 17 federal agencies, 11 regional associations (RAs) for coastal and ocean observations, a validation and verification testing capability, a federal committee providing interagency coordination and oversight, and a U.S. IOOS Program Office to coordinate and facilitate U.S. IOOS activities. These organizations share responsibility for the design, operation, and improvement of the national and regional network of observations, linking marine data in a compatible and easy-to-use manner for the wide variety of U.S. IOOS customers.[15] They also form the organization framework for the CARD and subsequent U.S. IOOS cost estimation.

As a collaboration of national and regional entities working together, U.S. IOOS will improve coordination of observation strategies and systems, identify gaps in the nation’s ocean observing capacity, and facilitate the exchange of information to help decision makers address pressing policy issues. By collecting and bringing together data in a way that ensures the information can be used with other data sets, U.S. IOOS will make a broader suite of data available to scientists, allowing them to develop a more complete characterization of our oceans and coasts. U.S. IOOS will be a nationally important infrastructure enabling many different users to monitor and predict changes in coastal and ocean environments and ecosystems. This infrastructure is critical for understanding and for responding and adapting to the effects of severe weather, global-to-regional climate variability, and natural hazards.[16]

In addition, U.S. IOOS is the oceans-and-coasts component of the U.S. Integrated Earth Observation System and serves as the U.S. contribution to the Global Ocean Observing System (GOOS) and to the Global Earth Observation System of Sys-

[12] U.S. IOOS Office, *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, Version 1.0, November 2010, p. 1-5.

[13] 2008 IOOS Report to Congress, p. 8.

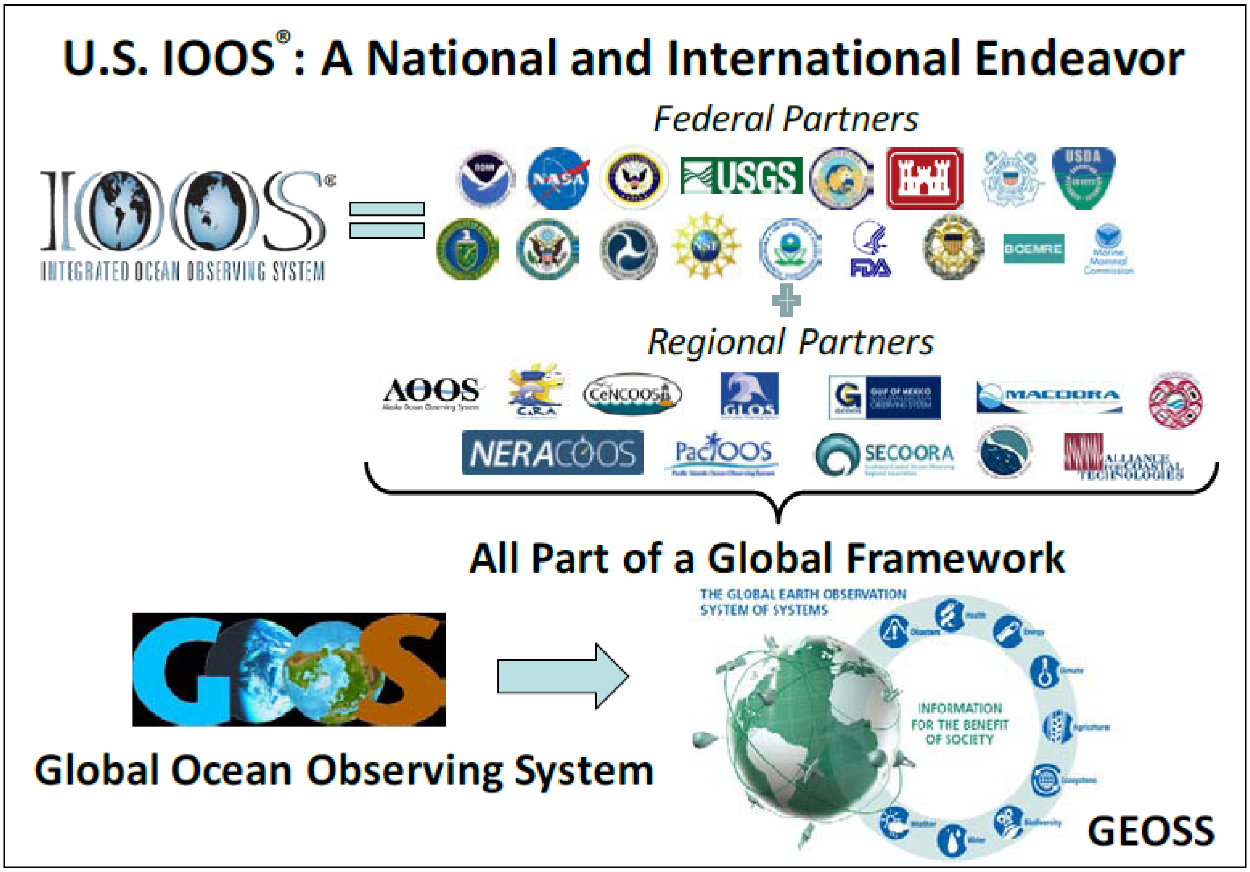
[14] U.S. IOOS Office, *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, Version 1.0, November 2010, p. 1-5.

[15] 2011 IOOS Report to Congress (draft v14), p. 2.

[16] 2008 IOOS Report to Congress, p. 5.

tems (GEOSS)[17]. As such, the U.S. IOOS marine environmental data enterprise is designed as an integral part of the overall U.S. and global environmental data enterprises. The composite of these activities and associations form the basis for both the global and coastal component of U.S. IOOS, as depicted in Figure 1-1.[18]

Figure 1-1. U.S. IOOS National and International Relationships



The U.S. IOOS program structure can be described by its three major components, listed in Table 1-1. This component structure provides the organizational framework for the system as addressed in the CARD. The CARD anticipates cost estimates will be developed for the three components and specifies the required approach (composition/content). The CARD provides the necessary information for an independent cost estimate of the U.S. IOOS central function, fulfilled by the Program Office, federal and non-federal partners and their contributions. Each of three components is described in more detail in the following subsections.

[17] Strategic Plan For the U.S. Integrated Earth Observation System Interagency Working Group on Earth Observations, NSTC Committee on Environment and Natural Resources. Whitehouse: Washington D.C., 2005.

[18] U.S. IOOS Office, *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, Version 1.0, November 2010, p. 1-4.

Table 1-1. Major Components of the U.S. IOOS Program

Major U.S. IOOS component	Description
Central function	Central Functions are activities that are focused on the design, implementation, and administration of IOOS. The U.S. IOOS Program Office undertakes the central functions necessary to manage and operate the national system. The specific activities of the central function are described in detail in *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability.*
Federal agencies/ assets	Federal partners that contribute any of the following: • Operations and maintenance (O&M) of existing assets of the system, owned by federal agencies • Acquisition and O&M of new federal assets for the system • Operation facilities, observation equipment, modeling and software, data management and communication, and other essential components.
Non-federal entities/ assets	Other partners that contribute any of the following: • O&M of assets of all non-federal entities with an existing relationship with the U.S. IOOS Program Office • Leveraged assets or data that are accessible to, but not owned by, U.S. IOOS non-federal entities • Acquisition and O&M of new non-federal assets for the system • Operation facilities, observation equipment, modeling and software, data management and communication, and other essential components.

1.1.3.1 CENTRAL FUNCTIONS

The NOAA IOOS Program was established in February 2007 to support, manage, and coordinate U.S. IOOS implementation efforts distributed across the agency. The NOAA IOOS Program is responsible for developing the national framework for data integration across NOAA and IOOS regions that will then be extended nationwide. NOAA is the lead federal agency for the development and oversight of the RAs and their Regional Coastal Ocean Observing Systems (RCOOSs), working to ensure the development of consistent and complementary federal and regional contributions.[19]

NOAA’s IOOS implementation relies on the contributions of multiple programs, the operations of which can be categorized into six subsystems: three functional and three cross-cutting. The subsystems are listed below and described in more detail in Section 1.2:

- Functional subsystems
  - Observing subsystem
  - Data management and communication (DMAC) subsystem

[19] 2008 IOOS Report to Congress, p. 5-6.

- Modeling and analysis subsystem
- Cross-cutting subsystems
  - Governance and management subsystem
  - Research and development (R&D) subsystem
  - Training and education subsystem.

U.S. Integrated Ocean Observing System: A Blueprint for Full Capability, hereafter referred to as the Blueprint, decomposes the six U.S. IOOS subsystems into 37 distinct core functional activities. The activities, listed in Table 1-2, are the minimum capabilities required for an effective U.S. IOOS and represent, at a high level, the contribution required of U.S. IOOS to produce a cohesive suite of data, information, products, and services related to our coastal waters, Great Lakes, and oceans.[20]

Table 1-2. U.S. IOOS Core Functional Activities

U.S. IOOS subsystem	Core functional activities
Observing systems	Observing subsystem management Surveys Optimization studies Asset management
DMAC	Registration of data providers Management of data providers Deregistration of data providers Standards management Utility services management Utility services development Data services and component development Data services and component management Configuration control
Modeling and analysis	Customer needs Sponsored models MOU management Publication of standards
Governance and management	User councils Financial management Policy Plans and operations Human resources Acquisition and grants Marketing, outreach, and engagement IT support

[20] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. 2-8–2-9.

Table 1-2. U.S. IOOS Core Functional Activities

U.S. IOOS subsystem	Core functional activities
Research and development	R&D requirements determination Coordination of R&D programs R&D pilot projects Technical assessments Technology enhancements Technology transition
Training and education	Training and education strategy and plans development Training and curriculum development Training and education pilot projects Training and education assessments Collaboration with education delivery managers Professional certifications

1.1.3.2 Federal Agencies

Federal partners of U.S. IOOS are drawn from a variety of departments and agencies, none of which has the capacity or resources to fully implement U.S. IOOS on a national scale, but all of which share a piece of the overall mission. Effective and consistent collaboration among these various organizations is essential to support the planning, coordination, and development of U.S. IOOS.[21]

Currently, 17 federal organizations are named as U.S. IOOS partners. These organizations, identified in Table 1-3, provide critical elements of the IOOS including development and management of relevant observing systems, data systems, modeling, research, active support, funding, guidance, and advice to the program. The first 11 federal partners listed are also part of the Interagency Ocean Observation Committee (IOOC) and are denoted on the table with an asterisk. These members play a direct oversight role in the development of U.S. IOOS.[22]

[21] 2011 IOOS Report to Congress (draft v14), p. 2.
[22] 2011 IOOS Report to Congress (draft v14), pp. 2–3.

Table 1-3. U.S. IOOS Federal Partner Agencies

Logo	Federal partner
	National Oceanic and Atmospheric Administration (NOAA) *
	National Science Foundation (NSF) *
	National Aeronautics and Space Administration (NASA) *
	Environmental Protection Agency (EPA) *
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) *
	Marine Mammal Commission (MMC) *
	Office of Naval Research (ONR) *
	Joint Chiefs of Staff (JCS) *
	U.S. Army Corps of Engineers (USACE) *
	U.S. Coast Guard (USCG) *
USGS	U.S. Geological Survey (USGS) *
	U.S. Department of Agriculture, Cooperative State Research, Education, and Extension Service (CSREES)
	U.S. Department of Energy (DOE)
	U.S. Department of State (DOS)
	U.S. Department of Transportation (DOT)
FDA	U.S. Food and Drug Administration (FDA)
	U.S. Arctic Research Commission (USARC)

Source: http://www.ioos.gov/partners/national.html.
Note: An asterisk denotes IOOC membership.

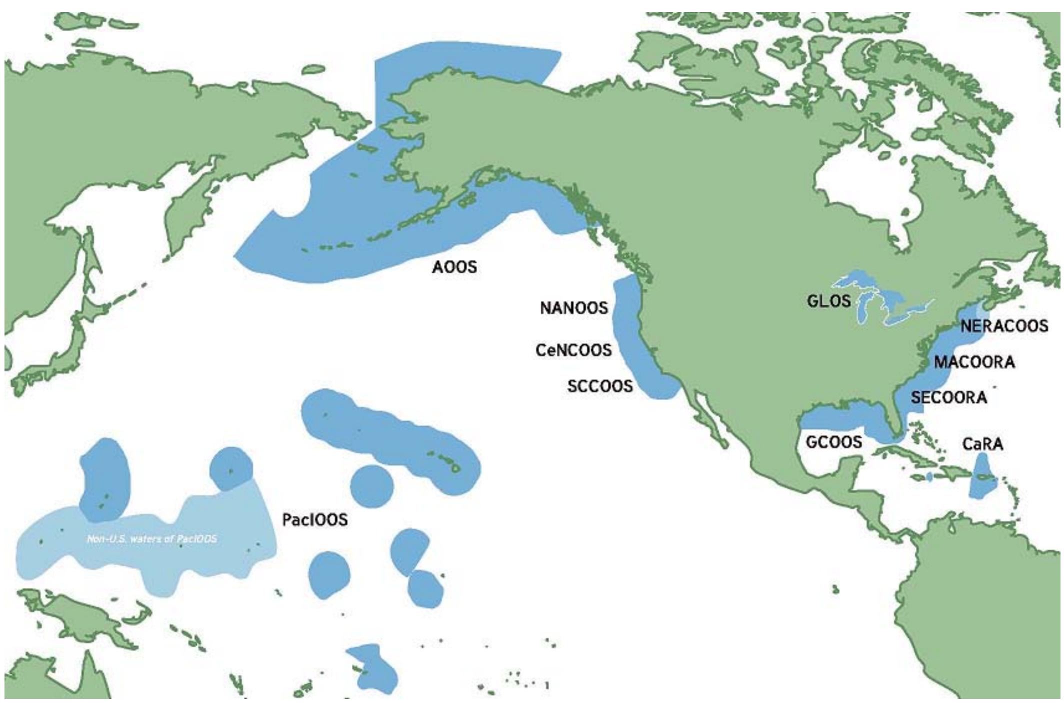
1.1.3.3 NON-FEDERAL ENTITIES

Regional capabilities are essential to building and supporting U.S. IOOS. They provide increased observation density, distinctive knowledge, and technological competencies related to local environments (sea ice, coral reefs, Great Lakes, etc.), and they support local user needs, for example by providing current local information to users. Eleven RAs and their associated RCOOSs, each a nongovernmental organization (NGO) managed by a board of directors, provide the regional link to U.S. IOOS and serve in the capacity of regional information coordination entities (RICEs) as described in the ICOOS Act.[23] They "provide a forum for convening regional experts, agencies, industry, and users to discuss mutual needs, leverage assets, and share expert knowledge."[24]

1.1.3.3.1 Regional Associations

RAs provide the primary framework to coordinate ocean observing activities and are responsible for the design and coordinated operation of RCOOSs within their respective geographical areas. The RAs also coordinate operations and cooperate with adjacent RAs so the data and products are seamless to the users, like the ocean they observe. Figure 1-2 shows where the U.S. IOOS RA partners are located. RAs work with user communities at the state and local levels to ensure that the regional system is designed to be as useful as possible and that U.S. IOOS develops on the basis of a strong customer focus and connection.

Figure 1-2. Regional Association Partners in U.S. IOOS



[23] 2011 IOOS Report to Congress (draft v14), p. 4.

[24] NFRA Report, *Providing Coastal Information in a Changing Climate*.

Table 1-4 contains details about the RAs' primary geographic coverage areas.

Table 1-4. U.S. IOOS Regional Associations and Geographic Coverage

Logo	Regional association	Primary geographic coverage
	Alaska Ocean Observing System (AOOS)	Gulf of Alaska, Bering Sea and Aleutian Islands, and the Arctic
	Caribbean Regional Association for Ocean Observing (CaRA)	Puerto Rico, U.S. Virgin Islands, and the Island of Navassa
	Central and Northern Coastal Ocean Observing System (CeNCOOS)	Central and Northern California
	Gulf of Mexico Ocean Coastal Observing System (GCOOS)	Gulf Coast of Florida to Texas
	Great Lakes Observing System (GLOS)	The Great Lakes, its interconnecting waterways, and the St. Lawrence River
	Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Cape Cod, MA, to Cape Hatteras, NC
	Northwest Association of Networked Ocean Observing Systems (NANOOS)	Washington, Oregon, and northern California
	Northeastern Regional Association of Coastal Ocean Observing (NERACOOS)	Maine to Massachusetts, including the Canadian provinces of New Brunswick and Nova Scotia
	Pacific Islands Ocean Observing System (PacIOOS)	Hawaii, U.S. territories in the Pacific, and the Freely Associated States in the Pacific
	Southern California Coastal Ocean Observing System (SCCOOS)	Southern California Bight
	Southeast Coastal Ocean Observing Regional Association (SECOORA)	North Carolina to the Atlantic coast of Florida

Source: 2008 IOOS Report to Congress, p. 7-8.

1.1.3.3.2 Validation and Verification Testing Organization

The final partner in the federal and regional area is the Alliance for Coastal Technologies (ACT). ACT is a NOAA-funded partnership of research institutions, resource managers, and private-sector companies dedicated to fostering the development and adoption of effective and reliable sensors and sensor platforms for environmental monitoring and the long-term stewardship of coastal ocean resources. It provides the validation and verification of observing sensors, ensuring their accuracy.[25]

[25] 2011 IOOS Report to Congress (draft v14), p. 5.

1.2 SYSTEM CONFIGURATION

U.S. IOOS has three functional and three cross-cutting subsystems. The functional subsystems provide the technical capability to readily access marine environment data and data products within a fully capable U.S. IOOS, to support of user needs. Each consists of a set of functions, hardware, software, and infrastructure managed by a variety of programs and entities.[26] These functional descriptions facilitate coordination across similar activities in IOOS. The functional subsystems and their definitions are as follows: [27]

- *Observing subsystem.* This subsystem comprises the collection of sensor and non-sensor marine environment measurements and their transmission from regional and national platforms. Accordingly, the observing subsystem is responsible for data quality assurance/quality control (QA/QC) and for initial metadata generation for the measurements being made and transmitted. U.S. IOOS observing subsystem data collectors transmit their data from the sensor (hardware or human) to data providers such as ocean data assembly centers (DACs) and ocean data archive centers.[28] The state of development of this subsystem is driven largely by the identified set of core oceanographic variables.[29] This document categorizes the observing subsystem into three subcategories based on the data collection method: in situ, remote, and transitory.

- *DMAC subsystem.* This subsystem comprises the information technology (IT) infrastructure that enables the interoperable transmission of marine environment data from a data provider (U.S. IOOS observing subsystem) to a data/services customer (e.g., U.S. IOOS modeling and analysis subsystem). Similarly, this subsystem makes available DMAC-compliant data products (products derived from data such as model outputs) to end users, including U.S. IOOS customers and data product repositories. It also maintains catalogs of data and registries of observation systems that facilitate customer discovery of desired observation data. The U.S. IOOS Program Office will be responsible for coordinating the availability of the material/equipment solution, both hardware and software, for DMAC subsystem fielding and operations. This will entail leveraging existing capabilities when possible and developing, deploying, and supporting new DMAC capabilities when necessary.[30]

- *Modeling and analysis subsystem.* This subsystem comprises the U.S. IOOS-provided data, data products (products derived from IOOS data), and services used by U.S. IOOS users/customers. It includes creation of

[26] National Office for Integrated and Sustained Ocean Observations, *IOOS Data Management and Communications Concept of Operations*, Version 1.5, January 2009, p. 1-1.

[27] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. 1-6.

[28] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capa*bility, p. 1-6.

[29] 2008 IOOS Report to Congress, p. 8.

[30] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. 1-6.

data products such as models and use of provided models to fulfill the seven societal mission goals. These users are federal and non-federal organizations and agencies, industry, academia, the research community, NGOs, tribal entities, professional organizations, and the general public. Intermediate users/customers synthesize and evaluate those data, products, and services to forecast the state of the marine environment and provide the results via reports, alerts, model outputs, or tailored analytical products to various end users/customers. This subsystem also provides the mechanism by which intermediate and end users make their requirements for IOOS data and data products known.[31]

The U.S. IOOS cross-cutting subsystems enhance the utility of the U.S. IOOS functional subsystems. The cross-cutting subsystems include entities, processes, and tools that provide products and services to ensure sustainment of, and improvements to, the overall system and its usage. The cross-cutting subsystems and their definitions are as follows:[32]

- *Governance and management subsystem.* This subsystem comprises the collection of functions and activities that support U.S. IOOS in terms of policy, plans, guidance, resources, processes, tools, and infrastructure.[33]
- *Research & Development subsystem.* This subsystem comprises the functions and activities required to gather requirements for research and development analyze and prioritize those requirements, and facilitate cooperation among partners with R&D capabilities to satisfy identified requirements. It also includes processes to manage R&D pilot projects, conduct technology assessments, field technology enhancements, and transition technology solutions from the laboratory to the field. U.S. IOOS is not anticipated to directly run R&D laboratories or facilities, but can engage such institutions to act as agents of U.S. IOOS to perform designated R&D activities.[34]
- *Training and education subsystem.* This subsystem comprises the entities, processes, and tools required to (1) develop and sustain a broad spectrum of educators and trainers who use U.S. IOOS information to achieve their education and training objectives and (2) create the workforce needed to develop and sustain the U.S. IOOS and produce U.S. IOOS information products, services, and tools.[35]

The following subsections describe in detail the subsystems and their categories, their components, and their contributions to the overall program.

[31] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. 1-6.
[32] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. 1-8.
[33] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capab*ility, p. 1-8.
[34] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. 1-8–1-9.
[35] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. 1-9.

1.2.1 Observing Subsystem

As described in the U.S. IOOS Blueprint, the observing system subsystem will

> serve as the source of U.S. IOOS-provided data. U.S. IOOS accesses the data from databases such as data assembly centers (which collect ocean observation data, make metadata available, and control data quality), archives (where ocean observation data previously available from a DAC are maintained for long-term access), and sponsored models (models and other analytical tools that take raw or refined ocean observation data and provide a value added output that is of such significance to the U.S. IOOS community that the output is specifically served through U.S. IOOS).[36]

The observing subsystem is the foundation of IOOS and consists of two interdependent components: the federal and non-federal observing systems. The observing subsystem will monitor changes on global, national, and regional scales.[37] Ocean and coastal observation data are critical for understanding ocean and atmospheric environments and are essential for predicting changes that may threaten our nation's economy, public health, and safety.

Observing is executed through the following functions:

- Observing subsystem management
- Surveys
- Optimization studies
- Asset management.

We describe each of these functions below. We then describe the specific assets—in situ observing assets, remote observing assets, and transitory observing assets—that contribute observations.

1.2.1.1 Observing Subsystem Management

As described in the U.S. IOOS Blueprint, this function will

> oversee and manage the observing functional subsystem of U.S. IOOS.[38]

1.2.1.1.1 Central Function

Observing subsystem management is a requisite central function. Table 1-5 decomposes this function into subactivities.

[36] *U.S. Integrated Ocean Observing System: A Blueprint for Full Ca*pability, p. F-5.
[37] 2008 IOOS Report to Congress, p. 8.
[38] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-5.

Table 1-5. Observing Subsystem Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Requirements definition	Gather observing system requirements, perform analysis, and recommend plans to address the requirements. (Note: see Section 3 for more information on requirements.)
Observing systems sharing agreements	Broker agreements to share observing platforms and/or sensor outputs.
Unfulfilled requirements management	Manage data/services customer and observing subsystem requirements that could not be satisfied by existing data providers (U.S. IOOS or non-U.S. IOOS), existing model outputs (U.S. IOOS and non-U.S. IOOS), or DMAC services (existing, modified, or planned).

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-5–F-6.

1.2.1.1.2 Federal Assets

Many observing assets are or will be provided by federal participants. Federal partners will have to participate in the formation and execution of sharing agreements for observing systems and to continue managing those observing systems. The level of effort needed for observing subsystem management will be directly tied to the federal observing assets participating in U.S. IOOS and managed by federal entities. Many federally provided observing assets are managed by RAs.

1.2.1.1.3 Non-Federal Assets

Many observing assets are provided or managed by RAs. The level of effort associated with observing subsystem management is described in terms of current staffing and facilities and appears in Sections 4 and 9 of this document.

1.2.1.2 SURVEYS

As described in the U.S. IOOS Blueprint, this function will

> conduct surveys of ocean observing capability and assets across the ocean observing subsystem, including U.S. IOOS partners and non-U.S. IOOS assets.[39]

1.2.1.2.1 Central Function

The U.S. IOOS Program Office is currently surveying federal and non-federal observing systems.

Plans to update and conduct future surveys should also be described here, in terms of the information that will be requested and the level of effort by number of persons estimated to be involved in the effort, over a stated period of time.

[39] *U.S. Integrated Ocean Observing System: A Blueprint for Full Ca*pability, p. F-6.

1.2.1.2.2 Federal Assets

Federal partners are being asked to self-identify observing assets in the existing survey. The information they provide should be described here.

1.2.1.2.3 Non-Federal Assets

The non-federal RAs have published web-based descriptions of their observing assets. Appendix A contains a table listing and describing information on RA assets available to support U.S. IOOS. Other efforts to survey assets will be retained with RA leadership.

1.2.1.3 OPTIMIZATION STUDIES

As described in the U.S. IOOS Blueprint, this function will

> utilize survey data and conduct optimization studies to identify actions that will improve ocean observations to meet current requirements or future plans.[40]

U.S. IOOS is charged with identifying efficiencies in ocean observation. U.S. IOOS sees to make prudent use of taxpayer funds by encouraging and forming partnerships to promote ocean observing with extant assets. U.S. IOOS will optimize its program dollars in concert with federal and non federal partners to avoid duplicative functions.

1.2.1.3.1 Central Function

The U.S. IOOS Program Office will use the survey results to derive a picture of the existing assets and data collection activities. Following that survey, the U.S. IOOS Program Office will develop optimization studies.

The nature of those optimization studies, including number of people involved, the offices and interests represented, and the length of time associated with those surveys, should be described here.

1.2.1.3.2 Federal Assets

The optimization studies will be done primarily by the U.S. IOOS Program Office, with assistance from the RAs. Participation from federal partners in optimization planning may occur one on one with cooperating agencies like NASA’s Jet Propulsion Laboratory, EPA, and USGS, and at the budget programming level with OMB and congressional staffs.

[40] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-6.

1.2.1.3.3 Non-Federal Assets

The non-federal RAs are key contributors in optimization. To an extent, the RAs optimize each budget request to take account of existing capabilities and leverage new ones, while maintaining existing assets. The primary and secondary points of contact for each RA are also charged with gap analysis and optimization. While an initial gap analysis is expected to take 1 year, subsequent optimization will be an ongoing activity, as stakeholder needs change with a changing world, technological innovations enable more effective and efficient data collection and quality assurance/checking and data transmission.

1.2.1.4 ASSET MANAGEMENT

As described in the U.S. IOOS Blueprint, this function will

> manage U.S. IOOS-owned observing system assets. These processes relate to items that are part of the U.S. IOOS property book or for which U.S. IOOS bears life-cycle management responsibilities.[41]

Additionally, U.S. IOOS shares responsibility for acquiring, fielding, and managing assets owned by federal or non-federal partners. U.S. IOOS collectively manages the data and data products of U.S. IOOS assets and cooperating assets; so U.S. IOOS shares oversight of the assets in a contributory fashion. As an example, if an asset belonging to a federal partner is damaged or destroyed by natural phenomena, and that asset contributes data to U.S. IOOS, IOOS will report the outage and assist with monitoring the restoration of the asset and its data flow.

1.2.1.4.1 Central Function

Asset management is a requisite central function. Table 1-6 decomposes this function into subactivities.

Table 1-6. Asset Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Accountability	Add and manage assets in the U.S. IOOS property book.
Life-cycle management	Manage the full life cycle of assets from development and procurement through retirement.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-6.

1.2.1.4.2 Federal Assets

Current and future federal assets contributing to U.S. IOOS will continue to be managed by the offices that currently manage them. Some federal assets are managed by RAs. The management of federal assets that will be added to U.S. IOOS

[41] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-6.

to enable full capability have not yet been identified, and their management cannot be described until they are identified by the gap analysis. (See Section 8 of this document for the development plan to "full capability.") Federal assets are being identified through a process of inventory, blueprint assessment, survey, and gap analysis. Federal assets will be added to this document as they are identified.

Additionally, the number of people, the offices they represent, and the level of effort needed to manage the observing assets should be described in Section 4 of this document.

1.2.1.4.3 Non-Federal Assets

The RAs manage observing assets. They provide planning, oversight, and data input and output from the assets under their supervision. The RAs collect information about observing assets that may be added to their supervision and maintain information about the observing assets available in other RAs.

1.2.1.5 In Situ Observing Assets

In situ observing assets include fixed sensors, buoys,[42] and platforms that remain in place to collect myriad coastal and ocean observation data required to inform foundational climate research, operational forecasting and warnings of immediate hazards, and regulatory decisions.[43] For example, the following principal NOAA line offices are involved in developing and managing in situ ocean observation systems:[44]

- Office of Oceanic and Atmospheric Research (OAR)
- National Weather Service (NWS)
- National Environmental Satellite Data and Information Service (NESDIS)
- National Ocean Service (NOS)
- National Marine Fisheries Service (NMFS)
- Office of Marine and Aviation Operations (OMAO).

In addition, these NOAA entities are also responsible for developing and managing in situ ocean observation systems:

- Atlantic Oceanographic and Meteorological Laboratory
- National Data Buoy Center (NDBC).

[42] 2008 IOOS Report to Congress, p. 8.

[43] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 1-1.

[44] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-1–2-2.

These offices' in situ observing systems can be categorized as either operational or research systems. NAO 216-105, *Policy on Transition of Research to Applications*, issued July 31, 2008, defines operations as "sustained, systematic, reliable, and robust mission activities with an institutional commitment to deliver specified products and services." It defines research as "systematic study directed toward a more complete scientific knowledge or understanding of the subject studied."[45] This CARD uses these definitions to distinguish between operations and research.

For example, within NOAA, to qualify as an operational in situ ocean observing system, the system must meet the definition set forth in NAO 216-105 and also be a system that (1) has either been operated by or transitioned to and is now operated by the NDBC or (2) is operated by a different NOAA organization (e.g., the Center for Operational Oceanographic Products and Services) and has been identified in the NOAA Observing System Architecture (NOSA) as operational. The following are examples of NOAA operational systems:[46]

- Coastal weather buoys
- Deep-Ocean Assessment and Reporting of Tsunamis® (DART®) buoys
- Tropical Atmospheric Ocean (TAO) buoys
- Coastal-Marine Automated Network (C-MAN)
- National Water Level Observation Network (NWLON)
- National Current Observation Program (NCOP)
- National Estuarine Research Reserve System (NERRS) System-wide Monitoring Program (SWMP).

A research system may possess operational characteristics (sustained, systematic, reliable, and robust) but is still directed toward providing more complete scientific knowledge or understanding of the subject under study and therefore has not transitioned to operational status.[47] The NOAA research systems are as follows:[48]

- Argo floats
- Ocean Reference Stations–Surface (ORS-S)
- Ocean Reference Stations–Bottom (ORS-B)
- Prediction and Research Moored Array in the Atlantic (PIRATA)
- Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction (RAMA)

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[45] *Buoy Recapitalization Strategic Plan: Review of Current P*rocesses, August 2009, p. 2-2.
[46] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. A-1.
[47] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-3.
[48] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. A-1–A-2.

- Fisheries Oceanography Coordinated Investigations (FOCI)
- Integrated Coral Observing Network (ICON)
- Real-Time Environmental Coastal Observation Network (ReCON)
- Marine Optical Buoy (MOBY)
- Coral Reef Ecosystem Integrated Observing System (CREIOS)
- Chesapeake Bay Interpretive Buoy System (CBIBS).

Appendix B describes the operational and research systems listed above.

In addition to federal assets managed by the line offices, NOAA maintains an IOOS Regional Observation Registry that documents the significant growth of the IOOS regional contribution. As of 2008, the registry records data from 723 observation platforms from 9 of the 11 regions and is actively working to develop records for the less mature regions.[49]

The following subsections further describe in situ observation subsystems. The following in-situ categories are described:

- 1.2.1.5.1 Moorings and Buoys
- 1.2.1.5.2 Fixed Stations
- 1.2.1.5.3 Undersea Imagery

The in-situ section is followed by the remote sensing section.

1.2.1.5.1 Moorings and Buoys

To collect long-term views of processes at work in the ocean, scientists and engineers have devised ways to leave instruments out in the environment. Moored observatories—secured by wires, buoys, weights, and floats—are platforms that allow observation of how the ocean and seafloor change. Common moorings use anchors and cables or ropes to secure boats, channel markers, and other floating objects in fixed places in our waterways. Fixed oceanographic moorings—also known as “Eulerian” platforms—work on the same principles, but the lines can be thousands of meters long and may or may not poke above the surface of the water. Scientific instruments can be attached to the mooring line, mounted on a surface buoy, or made to climb up and down the underwater line.

Above the water, moored buoys (see Figure 1-3) may be mounted with meteorological sensors, communications systems such as satellite or radio transmitters and receivers, and solar panels. Below the water line, buoys hold various instru-

[49] 2008 IOOS Report to Congress, p. 9.

ments, including current meters, temperature and pressure sensors, sediment traps, chemical sensors, power supplies, data recorders, and acoustic modems.[50]

Figure 1-3. Examples of Moored Buoys

1.2.1.5.1.1 Central Function

Buoy observing systems contribute to the purpose of gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.5.1.2 Federal Assets

Table 1-7 shows the currently identified inventory of federal buoys contributing to U.S. IOOS.

Table 1-7. Moored Buoy Inventory by Federal Managing Entity

Managing entity	Number contributing to U.S. IOOS
National Data Buoy Center	93
National Data Buoy Center (DART)	3
National Estuarine Research Reserve System	3
National Ocean Service CO-OPS	5
National Weather Service	1
NOAA	12
PMEL	1
U.S. Army Corps of Engineers	7
National Marine Mammal Laboratory/NOAA	18
U.S. Geological Survey	4

Source: Regional Association websites listed in Appendix A.

[50] Woods Hole Oceanographic Institute, http://www.whoi.edu/page.do?pid=10316, February 27, 2011.

1.2.1.5.1.3 Non-Federal Assets

Table 1-8 provides the currently known inventory of non-federal buoys contributing or expected to contribute to U.S. IOOS.

Table 1-8. Moored Buoy Inventory by Non-Federal Managing/Integrating Entity

Managing entity	Inventory
AOOS	137
CariCOOS	4
CeNCOOS	19
GCOOS	14
GLOS	6
MACOORA	0
NANOOS	27
NERACOOS	20
PacIOOS	63
SCCOOS (CDIP)	15
SECOORA	26

Source: Regional Association websites listed in Appendix A.

1.2.1.5.2 Fixed Stations

Fixed stations—broadly defined in this document as any observing station that is not a buoy—are monitoring platforms deployed at strategically located sites on beaches, marshlands, near-shore areas, or permanent structures such as meteorological stations and lighthouses. These stations are outfitted with observing instruments to gather a variety of marine environment data such as water quality, temperature, salinity, and chlorophyll. The following are among the NOAA observational systems that collect data via fixed stations:

- C-MAN
- NERRS
- NWLON
- PORTS
- ICON
- RECON.

1.2.1.5.2.1 Central Function

Fixed-station systems contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.5.2.2 Federal Assets

Table 1-9 provides the currently identified inventory of federal fixed stations that contribute to U.S. IOOS.

Table 1-9. Fixed Station Inventory by Federal Managing Entity

Managing entity	Inventory
National Data Buoy Center	58
National Estuarine Research Reserve System	59
National Ocean Service	21
National Ocean Service CO-OPS	121
National Park Service	3
National Weather Service	264
NOAA-AOML	1
U.S. Geological Survey	772

Source: Regional Association websites listed in Appendix A.

1.2.1.5.2.3 Non-Federal Assets

Table 1-10 provides the current inventory of non-federal fixed stations that contribute to U.S. IOOS.

Table 1-10. Fixed Station Inventory by Managing RA

Managing RA	Inventory
AOOS	0
CariCOOS	12
CeNCOOS	7
GCOOS	52
GLOS	0
MACOORA	27
NANOOS	28
NERACOOS	0
PacIOOS	22
SCCOOS	66
SECOORA	124

Source: Regional Association websites listed in Appendix A.

1.2.1.5.3 Undersea Imagery

Undersea imagery consists of transmitting live images from the seafloor to scientists ashore and to classrooms, newsrooms, and living rooms. In a new model of exploring the ocean through telepresence, most scientists work from shore while remote vehicles or platforms capture images, which are then analyzed back on land. Telepresence was developed with the support of Dr. Robert Ballard and the Inner Space Center at the University of Rhode Island.

In 2010, NOAA ship *Okeanos Explorer*'s built-in multibeam sonar mapped a huge undersea volcano while cameras on the ship's remotely operated vehicle took high-definition images of the feature called Kawio Barat, referring to the ocean area west of Kawio Islands (see Figure 1-4). Indonesian and U.S. scientists believe that investigating previously unexplored ocean areas will yield new phenomena and provide information that will improve our understanding of ocean ecosystems, ocean acidification, and climate change impacts. Jim Holden, U.S. chief scientist for the first leg of the joint expedition and a microbiologist from the University of Massachusetts in Amherst, who is operating from an Exploration Command Center in Jakarta, Indonesia, said, "The more we understand these undersea features and the communities of life they support, the better we can manage and protect the ocean and its resources."

Figure 1-4. Perspective View of the Kawio Barat (West Kawio) Seamount

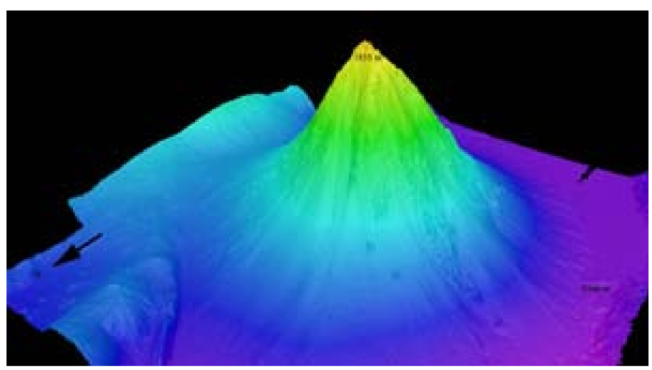


Image courtesy of INDEX 2010: "Indonesia-USA Deep-Sea Exploration of the Sangihe Talaud Region."

Scientists chose Kawio Barat as the first target for the expedition on the basis of satellite information and data collected by a joint Indonesian-Australian team in 2004. The immense underwater feature served as an ideal initial target to calibrate onboard tools and technologies being used on the ship's maiden voyage.

1.2.1.5.3.1 Central Function

Undersea imagery systems contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.5.3.2 Federal Assets

The federal partners will be asked to self-identify their observing assets. The description of their observing assets in this category should appear here. A partial list of the assets already identified are listed here. Appendix B contains details about the data collected, notably key parameters.

Currently, the federal inventory of undersea imagery assets consists of the following NOAA-owned assets:

- *Okeanos Explorer*, a 224-foot former Naval surveillance T-AGOS Class ship
- Two remotely operated vehicles, attached by a tether, capable of operating to depths of 6,000 meters
- Five Exploration Command Centers ashore, receiving live images and other data from the seafloor over satellite and high-speed Internet pathways.[51]

1.2.1.5.3.3 Non-Federal Assets

RAs support remote sensing by providing scientists to watch and interpret live imagery, around the clock if necessary. These opportunities for study of live undersea imagery are of short duration, e.g., for a week at a time, and represent a fraction of the non-federal assets' commitment. Additionally, there are some sustained towed vehicles that have been collecting data for a period of a year, and the data is being integrated by RAs.

1.2.1.6 REMOTE OBSERVING ASSETS

Remote observing assets include satellite-, aircraft-, and land-based sensors, power sources, and transmitters.[52] The following remote categories are described:

- 1.2.1.6.1 High Frequency Radar
- 1.2.1.6.2 Satellites
- 1.2.1.5.3 Aircraft

The remote section is followed by the transitory observing section.

[51] NOAA website, http://oceanexplorer.noaa.gov/okeanos/.

[52] 2008 IOOS Report to Congress, p. 8.

1.2.1.6.1 High-Frequency Radar Arrays

The expanded implementation of the observing technology known as high-frequency radar (HFR) is an example of successful and effective partnership among federal and regional IOOS components with benefits at the national and local levels. HFR systems (see Figure 1-5) collect data about ocean currents, including speed and direction, in near-real time. This information is needed to support a range of applications such as search and rescue (SAR), oil spill response, and assessment of beach water quality. This broad range of uses has motivated development of and support for a national network of surface-current mapping systems as part of U.S. IOOS.[53]

Figure 1-5. HFR System

Source: http://www.ioos.gov/.

This critical data resource benefits Harmful Algae Bloom (HAB) forecasting and Integrated Ecosystem Assessment (IEA) development and will greatly expand the number of observations available to support oil spill/pollutant tracking and SAR operations. The tens of thousands of HFR-derived current observations each hour from such a network would provide the data required to develop fine-scale resolution "nowcast" and forecast maps of currents in coastal waters, as well as large bays. Archived data will be delivered to coastal ecosystem managers and others needing long-term data sets for planning and decision making.[54]

Sparsely located measurements provide a partial, less detailed description of the speed and direction of coastal currents, information that is essential for oil spill and point-source pollution tracking and prediction, SAR, marine navigation, HAB forecasts, marine protected area and ecosystem management, effects of climate change on coastal ecosystems, and coastal zone management. As an example, the U.S. Coast Guard, which uses surface-current data from HFR sites at its SAR operations center for the mid-Atlantic coast, estimated that access to HFR data in all

[53] See http://www.ioos.gov/program/projects.html.

[54] 2008 IOOS Report to Congress, p. 34.

U.S. coastal waters would save 26 to 45 more lives annually and reduce the $30 million per year currently spent on rescue flights.[55]

In order for coastal forecasting to achieve the effectiveness and timeliness of weather forecasting and nowcasting, scientists require access to more densely distributed, near-real-time current measurements. HFR provides the most cost-effective solution to augment the existing system of in situ measurements and extend its geographic coverage. Recognizing the value of this technology, state, regional, and academic partners have already invested significant resources to purchase radar systems for their regions ($14 million in California alone). If data from these existing radars were integrated and made available to the public, the total number of surface current measurements would increase from about 100 to 200 per hour from in situ methods, such as moored buoys, to about 60,000 HFR observations per hour. U.S. IOOS will maximize the benefit of these investments and develop a national, near-real-time surface-current capability by supporting the compilation, integration, and distribution of data from HFR stations around the United States. This increased capacity would cost more than $10 billion if monitored using only moored buoys.[56]

Conventional in situ methods provide sparse single-point measurements, at a great distance from one another along the U.S. coast, while HFR provides two-dimensional maps of oceanic flow over a much larger area. Each pair of HFRs can cover a current measurement area of 6,000 square miles, equivalent to a square of about 77 miles on each side. Maps produced from existing HFR observations cover a significant percentage of the Atlantic, Pacific, and Gulf coasts—…and… the U.S. Exclusive Economic Zone (EEZ)—but these outputs are not yet fully integrated.[57][58]

In addition to the expanded geographic coverage, HFR has the capacity to observe surface currents at a very fine (1 km) resolution for short-range stations and 3 km for long-range stations. Considering requirements for surface currents data along the U.S. coast, as submitted by NOAA programs in FY07, HFR can meet 50 percent of the unmet requirements for improved horizontal resolution. NOAA's compiled observing requirements also indicate that HFR meets or exceeds existing resolution capability for all programs currently receiving surface-current data from other in situ or remote observing systems. An independent study by the U.S. Coast Guard demonstrated that HFR had the lowest uncertainty of any source currently in use for predicted currents. The USCG uses these data primarily for SAR. However, reducing uncertainty when analyzing where and how quickly an oil spill will travel (as well as bacteria, sewage effluents, HABs, etc) is just as important.[59]

[55] 2008 IOOS Report to Congress, p. 34.

[56] 2008 IOOS Report to Congress, pp. 34–35.

[57] 2008 IOOS Report to Congress, p. 35.

[58] 50% coverage assertion in report to Congress may refer only to EEZ surrounding the contiguous 48 states.

[59] 2008 IOOS Report to Congress, p. 35.

1.2.1.6.1.1 Central Function

The U.S. IOOS Program will support development of a comprehensive coastal surface-current monitoring capability with high-density, near-real-time, round-the-clock coverage of the nation's coastal waters, provided by a national network of HFRs. The network will complement the existing network of in situ observations, providing timely monitoring and distribution of coastal current data to federal, state, and local governments, as well as to the general public. HFR is recognized nationally as an important technology to provide real-time data on surface currents to support safe navigation of vessels; SAR; and monitoring of oil spills, sewage outfalls and bacterial contamination, HABs, rip current forecasts, and other environmental hazards. A number of federal agencies, including NOAA, U.S. Coast Guard, Bureau of Ocean Energy Management Regulation and Enforcement, U.S. Fish and Wildlife Service, and U.S. Geological Survey, use HFR to address federal mission responsibilities related to these and other issues. Also, given local health and safety implications, 8 of the 11 IOOS regions highlighted HFR as a high, near-term priority. The three remaining regions listed HFR as a medium priority due to technical implementation and logistical challenges, as well as other competing requirements, but recognized its importance and utility for a number of applications.[60]

HFR systems contribute to the subsystem purpose of gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the U.S. IOOS Blueprint.

1.2.1.6.1.2 Federal Assets

NOAA CO-OPS owns and operates one HFR system in Cape Henry, VA.

1.2.1.6.1.3 Non-Federal Assets

The U.S. IOOS Program is engaging RCOOS partners to identify the greatest needs for increased surface current observations. All of the regions' conceptual designs contain requirements for HFR capability. Requirements vary by region depending on existing capacity and monitoring priorities. Some regions require long-range HFRs that provide 6,000 square miles of ocean coverage with data points every 3.5 miles, while others that already have access to long-range HFRs may need finer resolution from standard-range HFRs.

Existing HFR capacity was developed largely at the state and regional levels to address targeted local needs. As a result, these data were not readily accessible on a national scale or delivered according to consistent data quality standards. The U.S. IOOS objective is to ensure sustained, quality-controlled delivery of this critical data resource to federal and regional partners, as well as many other state, local, and industry users, to maximize the value of this ocean observing investment. HFR provides a unique combination of increased surface-current observations,

[60] 2008 IOOS Report to Congress, pp. 33–34.

wide geographic coverage, fine-scale data resolution, and low data uncertainty. Although U.S. IOOS does not own and operate these HFR systems as federal assets, IOOS will support regional efforts to maintain these systems and expedite national data delivery and integration for a sustained, national surface current monitoring capability that addresses the needs of a range of users nationwide.[61]

Over the past 3 years, the U.S. IOOS Program Office has made significant progress in developing a national HFR data server to provide access to these vast surface current data resources. The server architecture is scalable to accept data from additional HFR systems at minimal additional server cost. To ensure data from the radar systems around the country are high quality, compatible, and able to be integrated, the U.S. IOOS Program has funded efforts to develop HFR data and metadata standards, as well as standard operating procedures and quality control methods. In addition, backup systems were implemented to ensure continuity in the event of a server failure or other problem. A national HFR capability serving SAR, oil-spill response, and other real-time emergency applications must be reliable and available for round-the-clock operations. NOAA's first priority in advancing the development of a national current-measuring capability is to integrate the data from the existing HFRs and to work with the U.S. IOOS regional partners to sustain these systems.[62]

To achieve a more comprehensive network, such as the network that exists for weather forecasting, the system must be augmented with more HFRs to fill gaps in economically and ecologically important coastal areas. The NOAA IOOS Program will support regional efforts to fill gaps in areas without HFR coverage or where even higher density observations are needed to fulfill a specific mission.[63]

Currently, 143 HFR systems contribute data to U.S. IOOS, but may or may not have been funded by U.S. IOOS. Table 1-11 shows the operating entity and the inventory of HFR systems they manage.

[61] 2008 IOOS Report to Congress, p. 34.

[62] 2008 IOOS Report to Congress, pp. 36–37.

[63] 2008 IOOS Report to Congress, p. 37.

Table 1-11. HFR Inventory by Non-Federal Managing Entity

Managing entity	Inventory
Bodega Marine Laboratory	6
BP (formerly British Petroleum)	1
Canadian Coast Guard	2
Humboldt State University	1
NOAA CO-OPS	1
National Park Service	11
Old Dominion University	5
Oregon State University	13
Rutgers University	14
SC	1
San Francisco State University	12
Scripps Institution of Oceanography	11
SIT	1
SSkidaway Institute of Oceanography	2
San Luis Obispo California Polytechnic State University	9
University of Alaska, Fairbanks	10
University of Connecticut	2
University of California, Santa Barbara	9
University of Delaware	2
University of Hawaii	3
University of Maine	3
University of Massachusetts, Dartmouth	1
University of Miami	4
University of North Carolina	2
Universidad de Puerto Rico	2
University of Rhode Island	3
University of South Carolina	4
University of South Florida	5
University of Southern Mississippi	3

Source: NOAA, Jack Harlan.

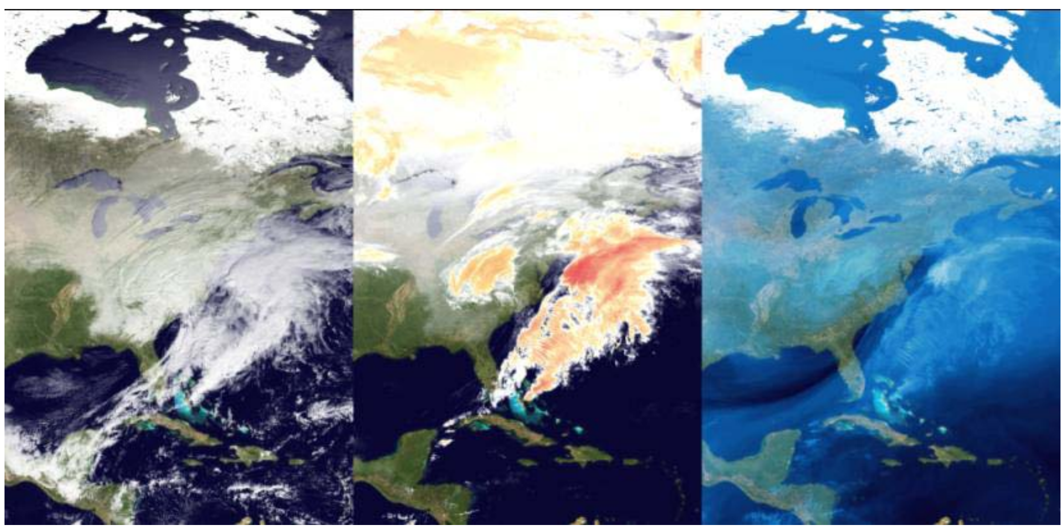
1.2.1.6.2 Satellites

Satellites provide continuous and consistent long-term observations. Data from satellites are used to measure the temperature of the ocean, track storms, monitor coral reefs, HABs, fires, volcanic ash, and many other environmental variables. Monitoring the Earth from space contributes to understanding how the Earth works and its impact on much of our daily lives.

For example, within NOAA the backbone of the satellites consists of the Geostationary Operational Environmental Satellite (GOES) and Polar-orbiting Operational Environmental Satellite (POES) systems.[64]

The GOES system provides the kind of continuous monitoring necessary for intensive data analysis. The satellites circle the Earth in a geosynchronous orbit, which means they orbit the equatorial plane of the Earth at a speed matching the Earth's rotation. This allows them to hover continuously over one position on the surface. The geosynchronous plane is about 35,800 km (22,300 miles) above the Earth, high enough to allow the satellites a full-disc view of the Earth. The GOES system is the primary tool used by weather forecasters to monitor severe weather. The system provides enormous flexibility to meteorologists because of its multiple sensors, vast array of data products, and the frequency of its imagery. Figure 1-6 shows images in three different channels (visible, infrared, and infrared water vapor) of a storm approaching the Northeast United States.[65]

Figure 1-6. Sample Multi-Sensing Imaging from GOES System



Because the satellites stay above a fixed spot on the surface, they provide a constant vigil for the atmospheric "triggers" for severe weather conditions such as tornadoes, flash floods, hail storms, and hurricanes. When these conditions develop, the satellites monitor storm development and track their movements.

GOES imagery is also used to estimate rainfall during thunderstorms and hurricanes for flash flood warnings and to estimate snowfall accumulations and overall extent of snow cover. Such data help meteorologists issue winter storm warnings and spring snow melt advisories. Satellite sensors also detect ice fields and map the movements of sea and lake ice.[66]

[64] *Strategic Satellite Plan FY2010–2019*, December 2007, p. iii.

[65] See http://www.nnvl.noaa.gov/MediaDetail.php?MediaID=635&MediaTypeID=1.

[66] See http://www.oso.noaa.gov/goes/index.htm.

The POES system offers the advantage of daily global coverage, by making nearly polar orbits roughly 14.1 times daily. Because the number of orbits per day is not an integer, the suborbital tracks do not repeat daily, although the local solar time of each satellite's passage is essentially unchanged for any latitude. Currently in orbit are a morning and an afternoon satellite, providing global coverage four times daily. The POES system includes the Advanced Very High Resolution Radiometer (AVHRR) and the Tiros Operational Vertical Sounder (TOVS).[67]

Because they are polar orbiting, these satellites collect global data daily for a variety of land, ocean, and atmospheric applications. Data from the POES system support a broad range of environmental monitoring applications, including weather analysis and forecasting, climate research and prediction, global sea surface temperature measurements, atmospheric soundings of temperature and humidity, ocean dynamics research, volcanic eruption monitoring, forest fire detection, global vegetation analysis, SAR, and many other applications.[68]

The GOES and POES systems are operated to provide critical atmospheric, oceanic, climatic, solar, and space data and images that are used to protect life and property across the United States. NOAA's geostationary satellites, with the next-generation GOES-R series planned for launch beginning in 2014, continuously monitor the same longitudes from two distinct orbits to provide coverage across the eastern United States, most of the Atlantic Ocean, the western United States, Central/South America, and the Pacific Ocean basin. The Polar Acquisition Program consists of NOAA's POES system and the National Polar-orbiting Operational Environmental Satellite System (NPOESS) orbiting from north to south across the poles in three orbit planes to provide global coverage. POES is NOAA's current operational polar system and has one satellite remaining to launch in the current series, while NPOESS is the follow-on polar-orbiting satellite system.[69]

NOAA's satellites provide other services beyond just imaging the Earth. Monitoring conditions in space and solar flares from the sun helps improve the understanding of how conditions in space affect the Earth. Satellites also relay position information from emergency beacons to help save lives when people are in distress on boats, in airplanes, or in remote areas. Scientists also use a data collection system on the satellites to relay data from transmitters on the ground to researchers in the field.

Historical data from NOAA satellites, and other air- and ground-based observation platforms, are archived at NOAA's national data centers for public use.[70]

[67] See http://www.oso.noaa.gov/poes/index.htm.

[68] See http://www.oso.noaa.gov/poes/index.htm.

[69] *Strategic Satellite Plan FY2010–2019*, December 2007, pp. iii–iv.

[70] See http://www.noaa.gov/satellites.html.

1.2.1.6.2.1 Central Function

Satellite systems contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.6.2.2 Federal Assets

Currently, 20 satellites are contributors or near-future contributors to U.S. IOOS. Table 1-12 lists the federal asset inventory by satellite system.

Table 1-12. Satellite Inventory by Federal Managing Entity

Managing entity	Satellite system	Inventory
NOAA	GOES[a]	5
NOAA	POES[b]	6
NASA/JPL	QuikSCAT (expected 2016)[c]	1
NASA	Terra[d]	1
NASA/CNES	Jason 1[e]	1
NASA	Aqua[f]	1
NASA	ICESat II (expected 2016)[g]	1
NASA/NOAA	NPOESS (expected 2015)[h]	2
NASA/NOAA	OCO[i]	1
NASA	Aquarius[j]	1

[a] http://www.oso.noaa.gov/goes/.
[b] http://www.oso.noaa.gov/poes/.
[c] http://www.wunderground.com/blog/JeffMasters/comment.html?entrynum=1388.
[d] http://terra.nasa.gov/.
[e] http://sealevel.jpl.nasa.gov/missions/jason1/.
[f] http://aqua.nasa.gov/.
[g] http://icesat.gsfc.nasa.gov/icesat2/.
[h] http://www.ipo.noaa.gov/.
[i] http://oco.jpl.nasa.gov/.
[j] http://aquarius.nasa.gov/.

1.2.1.6.2.3 Non-Federal Assets

Non-federal participants do not own or operate satellites that contribute to U.S. IOOS. Non federal participants do operate downlinks that create quicker access to the data for users.

1.2.1.6.3 Aircraft

Aircraft are flown in support of NOAA's mission to promote global environmental assessment, prediction, and stewardship of the Earth's environment. NOAA's aircraft operate throughout the United States and around the world; over open oceans, mountains, coastal wetlands, and Arctic pack ice. These versatile aircraft

(Figure 1-7 shows two of them) provide scientists with airborne platforms necessary to collect the environmental and geographic data[71] essential to meeting the mission goals of U.S. IOOS.

Figure 1-7. NOAA Aircraft

Source: http://www.aoc.noaa.gov/.

1.2.1.6.3.1 Central Function

Aircraft contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.6.3.2 Federal Assets

Several federal agencies currently fly aircraft to promote environmental assessment, prediction, and stewardship of the Earth's environment. The Aircraft Operations Center, within the NOAA Marine and Aviation Office, operates the NOAA aircraft fleet. Like the ships of the NOAA fleet, NOAA aircraft are piloted and crewed by NOAA commissioned officers. (See Section 4 on staffing requirements for more information.) Additionally, NOAA has contracted the services of leased aircraft for airborne LIDAR readings of bathymetry in the Bering Sea and in the coastal waters around Alaska. The U.S. Army Corps of Engineers uses this system, with its SHOALS LIDAR topography mapping system to map bottom surfaces of ports and coastal areas from contracted helicopters.[72]

Other federal partner aircraft that contribute to U.S. IOOS include NASA, which operates IceBridge, a 6-year NASA mission to conduct the largest airborne survey of Earth's polar ice. It will yield an unprecedented three-dimensional view of Arctic and Antarctic ice sheets, ice shelves, and sea ice. These flights will provide a

[71] See http://www.aoc.noaa.gov/.
[72] http://www.fugro-pelagos.com/lidar/proj/usace_intl.html

yearly, multi-instrument look at the behavior of the rapidly changing features of the Greenland and Antarctic ice. IceBridge operates from three NASA aircraft.[73] IceBridge was intended to fill the data gap between the time when the ICESat satellite stopped functioning and the deployment of ICESat II in 2016.

The U.S. Coast Guard operates a fleet of HU-25, which are a military derivative of the Dassault Falcon. The HU-25 is a medium-range surveillance fixed-wing aircraft. The HU-25 performs multiple missions for the Coast Guard including search and rescue, marine environmental protection, and disaster data collection, monitoring and surveillance, as during the Deepwater Horizon Gulf oil spill.

The service ceiling is 42,000ft, though current avionics restrict operations to 28,000ft and below. Maximum cruise speed at altitude is 420kts, with a maximum operating speed of .855 Mach. Sea-level maximum airspeed is 350kts. The HU-25 are distinguished its capable mission sensors. Varying by model dash number, the HU-25 are equipped with surface search radar, electro-optical/infrared sensors, multi-mode radar, and tactical workstations.

USCG took delivery of 41 HU-25s from 1982 through 1983 and are decommissioning those aircraft. They will be replaced with the HC-144A Ocean Sentry, starting 2014.

Surveys of polar ice and the impact of oil spills on marine life are among the 26 key variables observed by U.S. IOOS, and the Deepwater Horizon oil spill marine monitoring response was done in partnership with U.S. IOOS, Table 1-13 provides the currently known inventory of federal aircraft contributing or identified to contribute to U.S. IOOS.

Table 1-13. Fleet of Federal Aircraft Assets for U.S. IOOS

Managing entity	Aircraft	Fleet
NOAA	Gulfstream IV-SP (G-IV)	1
	Lockheed WP-3D Orion	2
	Rockwell Aero Commander (AC-500S)	2
	Gulfstream Jet Prop Commander 1000 (695A)	1
	Cessna Citation II	1
	DeHavilland Twin Otter (DHC-6)	2
	Bell 212 helicopter	1
	MD369 (Hughes 500) helicopter	1
	Aerofab Lake amphibian aircraft	2

[73] See http://www.nasa.gov/mission_pages/icebridge/mission/index.html.

Table 1-13. Fleet of Federal Aircraft Assets for U.S. IOOS

Managing entity	Aircraft	Fleet
NASA	DC-8	1
	P-3B	1
	Beechcraft King Air B200	1
USCG	HU-25	41

Sources: http://www.aoc.noaa.gov/history.htm, http://www.nasa.gov/mission_pages/icebridge/science/index.html, and http://www.uscg.mil/hq/cg7/cg711/hu25.asp

Currently no unmanned aerial systems are part of U.S. IOOS.

1.2.1.6.3.3 Non-Federal Assets

Currently no non-federal participants operate aircraft assets that contribute to U.S. IOOS.

1.2.1.7 TRANSITORY OBSERVING ASSETS

Transitory sensing assets include autonomous or remotely controlled underwater vehicles, such as gliders and remotely operated vehicles (ROVs), and ships with their associated sampling devices and transmitters. The following subsections describe these assets:

1.2.1.7.1, Human occupied vehicles (submersible)

1.2.1.7.2 Towed underwater vehicles

1.2.1.7.3 Gliders

1.2.1.7.4 Autonomous underwater vehicles

1.2.1.7.5 Remotely operated vehicles

1.2.1.7.6 Drifters and floats

1.2.1.7.7 Surveys, ship-based

1.2.1.7.8 Sampling

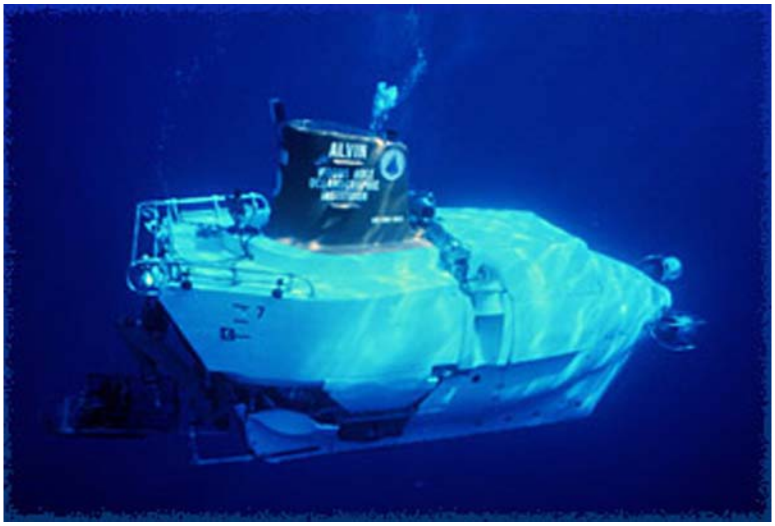
1.2.1.7.9 Ships.

1.2.1.7.1 Human Occupied Vehicles

Human occupied vehicles (HOVs) are submersibles that allow scientists to explore the deep ocean, far deeper than is possible by wet diving, due to the physiological restrictions on the human body.[74] Figure 1-8 shows an HOV.

[74] See http://explore.noaa.gov/human-occupied-vehicle-hov.

Figure 1-8. Human Occupied Vehicle



Source: http://oceanexplorer.noaa.gov/.

1.2.1.7.1.1 Central Function

HOV systems contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.7.1.2 Federal Assets

The federal partners will be asked to self-identify their observing assets. A partial list of the assets that potentially may participate in IOOS are listed here. Appendix B contains details about the data collected, notably key parameters.

Submersibles owned by NOAA include Pisces IV and V, two of only nine submersibles in the world that can dive to depths of more than 6,562 feet. Both carry a pilot and two scientists. The submersibles are custom equipped to accommodate a variety of mission requirements. Standard gear includes external video and still cameras, two hydraulic manipulator arms, a conductivity/temperature/depth profiler, and sonar. Their use has provided unprecedented knowledge of the Pacific's undersea volcanic processes and deep sea coral habitats. Through partnerships, NOAA can also lease other submarines, including the Johnson Sea Link, Delta and Alvin.[75]

Table 1-14 provides the known inventory of federal HOV systems contributing or identified to contribute to U.S. IOOS.

[75] See http://explore.noaa.gov/human-occupied-vehicle-hov.

Table 1-14. Federal Asset Inventory of HOVs

Owning agency	Fleet
NOAA	2

Source: http://oceanexplorer.noaa.gov/technology/subs/subs.html.

1.2.1.7.1.3 Non-Federal Assets

None of the RAs own HOVs. However, a few nonprofit organizations own and operate HOVs that are available for lease by RAs and could potentially participate as U.S. IOOS partners. Table 1-15 provides the identified inventory of non-federal HOVs potentially contributing to U.S. IOOS.

Table 1-15. Non-Federal Asset Inventory of HOVs

Managing agency	Fleet
Harbor Branch Oceanographic Institution, Florida International University	8

Source: http://oceanexplorer.noaa.gov/technology/subs/subs.html

1.2.1.7.2 Towed Underwater Vehicles

Towed underwater vehicles (TUVs) are devices that are dragged behind a ship to gather marine data by, for example, mapping seafloor bathymetry with sonar, taking pictures or video of the seafloor and marine life, and recording gravity and magnetics profiles of the oceanic crust. TUVs can be outfitted with instrumentation to collect the desired marine data.

1.2.1.7.2.1 Central Function

TUVs contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.7.2.2 Federal Assets

A number of arrays are available for towing behind research vessels for information gathering. NOAA's plankton sampling towed recorder has been identified as a potential contributor to U.S. IOOS. NOAA also operates manta nets for ocean plastic surveys. Table 1-16 provides the known inventory of federal TUV systems contributing or identified to contribute to U.S. IOOS.

Table 1-16. TUV Inventory by Federal Managing Entity

Managing entity	Inventory
NOAA Continuous Plankton Recorder	1
NOAA Manta Net	Numerous

Source: http://oceanexplorer.noaa.gov/okeanos/explorations/ex1006/background/cpr/cpr.html.

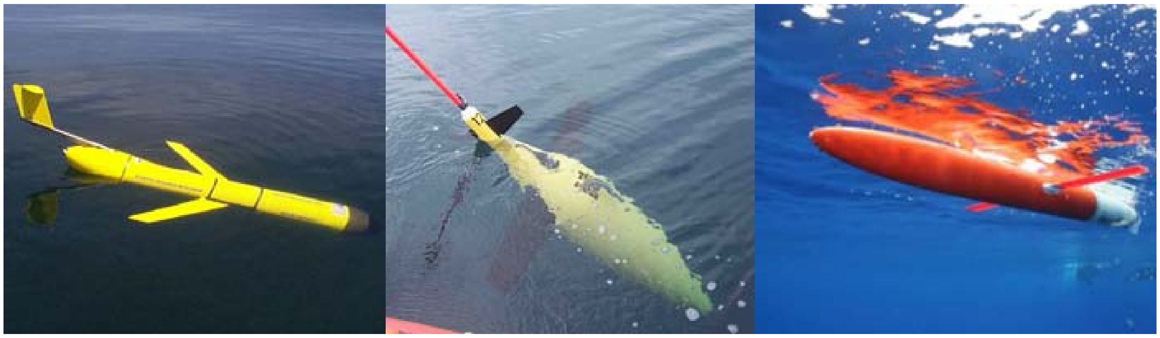
1.2.1.7.2.3 Non-Federal Assets

Although a number of sensors can be affixed to a floating towed object for longitudinal study, few of the RAs have this capability. The single known regionally deployed towed sensor array, a side-scanning radar system, was deployed in Hawaii. The Hawaii Mapping Research Group deployed and operates one MR1 Towed Long Range Sidescan Sensor System.[76]

1.2.1.7.3 Gliders

Gliders are robotic submarines that navigate underwater without a human crew onboard and without cables connecting them to research vessels at the sea surface. Figure 1-9 shows examples of gliders. These gliders carry a variety of sensors and are programmed by researchers to go wherever research is needed. They are used to take vertical profiles of data, giving scientists a clearer understanding of the temperature, salinity, and turbidity of specific areas of the oceans. These measurements are then used to determine and understand ocean circulation and its role and influence on the global climate.[77]

Figure 1-9. Examples of Gliders



Gliders have no external moving parts or motors. Instead, they move on a preprogrammed course vertically and horizontally in the water, typically by pumping mineral oil between two bladders, one internal and the other external to the hull. This action changes the volume of the glider, making it denser or lighter than the

[76] See http://www.soest.hawaii.edu/hioos/components/index.php.

[77] See http://www.whoi.edu/instruments/viewInstrument.do?id=1498.

surrounding water.[78] Researchers guide the glider by giving it waypoints, or target positions. The glider steers to these waypoints by controlling its buoyancy and orientation, using the lift from its wings to move horizontally. The maximum depth is prescribed independently of the waypoints. Maximum depth is chosen to avoid hitting bottom and to cover the range of depth of interest. In the deep ocean, the basic principal is the deeper the glider goes, the further the horizontal distance per dive.[79] Information from the compass and altitude sensors is used to control pitch (fore and aft angle) and roll (rotation around the axis of the glider). This changes the orientation of the wings, similar to the way a pilot guides and operates a hang glider.[80]

At the beginning and the end of each dive, the glider obtains and records its position by exposing a global positioning system (GPS) antenna. Researchers can then obtain data from the glider and send new instructions to it using a satellite phone system built into the glider.[81]

Gliders can provide a look at entire sections of ocean basins, as well as serve as virtual moorings by remaining at a single point. Unlike humans, who need to stop for breaks, gliders can carry out missions as long as 6 months in duration.[82]

1.2.1.7.3.1 Central Function

Glider systems contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.7.3.2 Federal Assets

The U.S. Navy uses submarine-launched gliders to gather seawater temperature, salinity, water clarity, and ocean current speeds at various depths. The glider transmits its data via satphone when it surfaces. The gliders perform multi-day missions to characterize the ocean temperature versus depth and provide sound speeds, the rate at which sound from a source travels through water.[83]

It is not known whether this data is shared with U.S. IOOS.

1.2.1.7.3.3 Non-Federal Assets

Table 1-17 shows the currently identified inventory of gliders that contribute to U.S. IOOS. The number of gliders available will undoubtedly increase, because they are inexpensive to buy and not difficult to make.

[78] See http://www.whoi.edu/instruments/viewInstrument.do?id=1498.
[79] See http://www.whoi.edu/instruments/viewInstrument.do?id=1498.
[80] See http://www.whoi.edu/instruments/viewInstrument.do?id=1498.
[81] See http://www.whoi.edu/instruments/viewInstrument.do?id=1498.
[82] See http://www.whoi.edu/instruments/viewInstrument.do?id=1498.
[83] http://www.navy.mil/navydata/cno/n87/usw/issue_29/glider.html

Table 1-17. Glider Inventory by Non-Federal Managing Entity

Managing entity and reporting RA	Inventory
University of Alaska, Fairbanks, AOOS	2
Rutgers University, NERACOOS	5
APL-UW, NANOOS	1
CMOP, NANOOS	1
Oregon State University, NANOOS	2
PacIOOS (gliders owned by Univ. of Hawaii)	2
Scripps Institution of Oceanography, SCCOOS	3
Mote Marine Laboratory , GCOOS	≥2
University of Southern Mississippi, GCOOS	≥2
Texas A&M University, GCOOS	≥2

Source: Regional Association websites listed in Appendix A.

1.2.1.7.4 Autonomous Underwater Vehicles

Autonomous underwater vehicles (AUVs), also known as unmanned underwater vehicles, can be used for underwater survey missions such as detecting and mapping submerged wrecks, rocks, and obstructions that pose a hazard to navigation for commercial and recreational vessels. The AUV conducts its survey mission without operator intervention. When a mission is complete, the AUV will return to a preprogrammed location and the data collected can be downloaded and processed in the same way as data collected by shipboard systems.[84]

AUVs can be equipped with a wide variety of oceanographic sensors or sonar systems. NOAA's hydrographic survey AUVs are typically equipped with side-scan sonar, Conductivity-Temperature-Depth (CTD) sensors, GPS-aided Inertial Navigation Systems (INSs), and an Acoustic Doppler Current Profiler (ADCP).[85]

NOAA's Coast Survey Development Laboratory is evaluating the use of AUVs for hydrographic surveys in support of NOAA's nautical charting mission. The use of AUVs, in collaboration with NOAA's manned survey fleet, could greatly increase survey efficiency. In addition, because of their small size and flexible deployment options, AUVs could be used for marine incident response and port security surveys.[86]

AUVs can be distinguished from ROVs in that they operate independently of the ship and have no connecting cables.[87] However, this distinction is not widely accepted, and ROVs are often called AUVs even by their operators. Gliders are also sometimes referred to as AUVs.

[84] See http://www.nauticalcharts.noaa.gov/csdl/AUV.html.
[85] See http://www.nauticalcharts.noaa.gov/csdl/AUV.html.
[86] See http://www.nauticalcharts.noaa.gov/csdl/AUV.html.
[87] See http://www.nauticalcharts.noaa.gov/csdl/AUV.html.

1.2.1.7.4.1 Central Function

AUV systems contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.7.4.2 Federal Assets

U.S. IOOS federal partners will be asked to self-identify their observing assets. Currently, no federal agencies are operating AUVs that may contribute to U.S. IOOS. Military applications of AUVs for mine hunting are being researched with trial deployments, but no U.S. civil government efforts are known.

1.2.1.7.4.3 Non-Federal Assets

AUVs are an inexpensive alternative to manned observation. PacIOOS operates one REMUS AUV in the state of Hawaii. The Woods Hole Oceanographic Institute created the design for the AUVs and produces and manufactures several models, including the REMUS.[88]

1.2.1.7.5 Remotely Operated Vehicles

ROVs are unoccupied, highly maneuverable underwater robots operated by a person aboard a surface vessel. They are linked to the ship by cables that carry electrical signals back and forth between the operator and the vehicle. Most are equipped with at least a video camera and lights. Equipment—such as a still camera, a manipulator or cutting arm, water samplers, and instruments that measure water clarity, light penetration, and temperature—is commonly added to expand the vehicle's capabilities. First developed for industrial purposes, such as internal and external inspections of pipelines and the structural testing of offshore platforms, ROVs are now used for many applications, many of them scientific. They have proven extremely valuable in ocean exploration and are also used for educational programs at aquariums and to link to scientific expeditions live via the Internet.[89] They are often confused with AUVs.

ROVs vary greatly in size. Deployment and recovery operations range from simply dropping the ROV over the side of a small boat to complex deck operations involving large winches for lifting and A-frames to swing the ROV back onto the deck. In some instances, ROVs have "garages" that are lowered to the bottom. The cabled ROV then leaves the garage to explore, returning when the mission is completed. In most cases, ROV operations are simpler and safer to conduct than any type of occupied-submersible or diving operation.[90] Figure 1-10 shows an example of an ROV on a ship and in operation.

[88] See http://www.whoi.edu/page.do?pid=8458.

[89] See http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html.

[90] See http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html.

Figure 1-10. Example ROV on Ship and in Operation

Source: http://www.noaanews.noaa.gov/stories2005/s2370.htm.

ROVs are often kept aboard vessels mounting submersible operations for several reasons. The most important reason is safety. If a submersible becomes entangled or otherwise incapacitated, an ROV can be used to investigate the scene, providing information that can help the operators decide how to respond. If appropriate, cutter blades can be attached to the manipulator arm and used to free the sub. If a sub loses power and cannot surface, the ROV's manipulator arm can grab onto the sub. The deck crew can then bring the sub to the surface.[91]

ROVs also support exploration and science objectives. When the submersible cannot be used because of weather or maintenance problems, the ROV often can take its place. It can also be used to investigate questionable dive sites before a sub is deployed, limiting risk to the expensive subs and their pilots.[92]

1.2.1.7.5.1 *Central Function*

ROVs contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

1.2.1.7.5.2 *Federal Assets*

No federal entities have been identified currently using or providing ROVs contributing to U.S. IOOS.

1.2.1.7.5.3 *Non-Federal Assets*

No non-federal entities have been identified currently using or providing ROVs contributing to U.S. IOOS. ROVs are used privately for surveying, inspecting, and repairing underwater oil rigs and for deep sea treasure hunting. It is possible that ROVs could be leased by non-federal RAs to support U.S. IOOS.

[91] See http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html.

[92] See http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html.

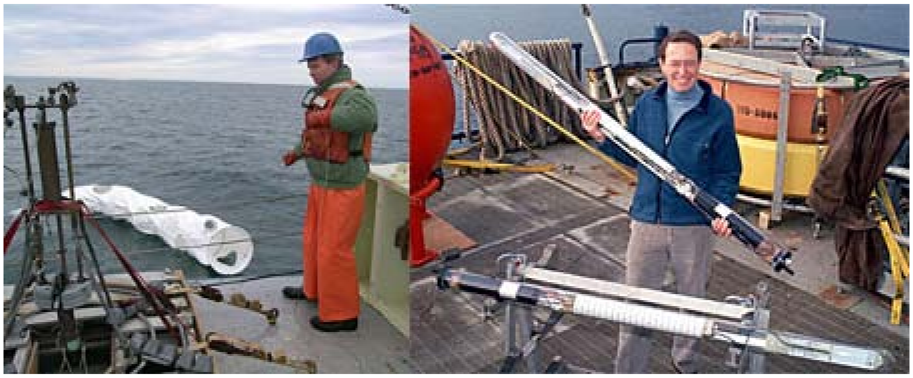
1.2.1.7.6 Drifters and Floats

Drifter systems are devices that when released in the ocean, are left to the ocean currents for locomotion and destination. Devices are usually outfitted with radio or satellite beacons and GPS receivers, and the shapes of drifters can vary from cylinders to hardened, floating kites.[93]

Float systems are similar to drifters, in that they are built in various shapes and sizes, and they move horizontally with ocean currents, traveling long distances without the need of a ship, person, or propeller. But floats are also built to rise and fall vertically through the water. Simple mechanical pumps, bladders, and other devices are used to change the buoyancy of the float relative to the water, allowing it to bob between various depths. Modern floats are usually programmed to rise to the surface periodically in order to send data via satellite antenna to scientists on shore.

Despite the relatively simple mechanics of these observing systems, drifters and floats still have a critical role to play in measuring the fine details of ocean dynamics—from the direction and speed of currents and eddies to the physical characteristics (particularly temperature and salinity) of parcels of water within the wider ocean. Figure 1-11 shows a drifter system and float system before deployment.

Figure 1-11. Example of Drifter System and Float System



Source: http://www.whoi.edu/.

1.2.1.7.6.1 Central Function

Drifter and float systems contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

[93] See http://www.whoi.edu/page.do?pid=10320.

1.2.1.7.6.2 Federal Assets

One example lies in NOAA participation in the GOOS Global Drifter Program (GDP) through AOML and Scripps Institute of Oceanography. Some 1,250 GDPs have been deployed to map worldwide sea surface temperatures. NOAA operates a Drifter Data Assembly Center in Miami, FL. Appendix B contains details about the data collected, notably key parameters.

Environmental Monitors on Lobster Traps, or eMOLT, is a partnership involving NOAA, the Maine, Massachusetts, Downeast and Atlantic Offshore Lobstermen's Associations, the Gulf of Maine Lobster Foundation, and the Marine Science Department at Southern Maine Community College (SMCC) in Portland, Maine. The monitoring devices, which cost about $150 each, internally record temperature every hour around the clock while the pots are in the water. At the end of the season when the pots are hauled out, the instruments are removed and shipped back to Woods Hole Laboratory of the Northeast Fisheries Science Center (NEFSC), part of NOAA's Fisheries Service. The data is processed and loaded to the eMOLT web site. [94]

The data collected from temperature sensors on the lobster pots and from GPS surface drifters deployed as part of the eMOLT program help ocean circulation modelers better understand processes in the Gulf of Maine, such as how lobster larvae and other planktonic animals and plants, including those that cause harmful algal blooms, drift and settle. This information may also help determine how ocean currents disperse, condense and transport pollutants, as well as provide information about invasive species transport and measure plankton abundance.

1.2.1.7.6.3 Non-Federal Assets

Researchers who work for the NOAA GDP also support IOOS RAs. However, NOAA is the primary provider of drifter research.

A nonprofit organization, Earth and Space Research (ESR), deploys, tracks, maintains, and operates drifters and floats. In the future these drifters and floats may provide some of the key IOOS parameters.

Student researchers from local universities participate in drifter design, assembly, and deployment in the GoMOOS region.

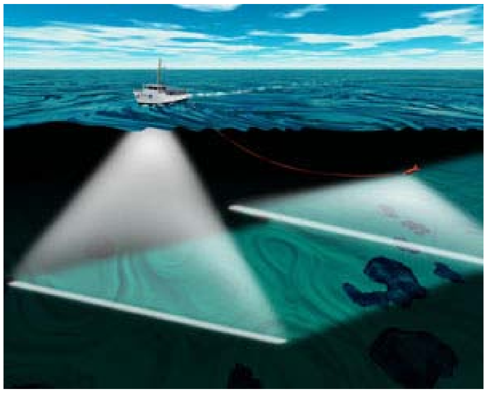
1.2.1.7.7 Surveys

The International Hydrographic Organization defines hydrography as “the branch of applied science which deals with the measurement and description of the physical features of the navigable portion of the earth’s surface [seas] and adjoining

[94] http://www.nefsc.noaa.gov/press_release/2009/SciSpot/SS0902/

coastal areas, with special reference to their use for the purpose of navigation." Hydrographic surveys are used to visualize the sea floor (see Figure 1-12).[95]

Figure 1-12. Visualization of Hydrographic Surveys



Source: http://www.nauticalcharts.noaa.gov/.

Hydrographic surveys support a variety of activities: nautical charting, port and harbor maintenance (dredging), coastal engineering (beach erosion and replenishment studies), coastal zone management, and offshore resource development. Most surveys are primarily concerned with water depth. Of additional concern is the nature of the sea floor material (sand, mud, rock) because of the implications for anchoring, dredging, structure construction, pipeline and cable routing, and fish habitat.[96]

Surveyors pay particular attention to acquiring the precise location of the least (shallowest) depths that pose a danger to navigation and depths significant to surface navigation. They record the precise location of aids to navigation. Tide and water levels are also recorded to provide a vertical reference (Mean Lower Low Water) for water depths.[97]

The data are collected, processed, and stored digitally with specialized computer systems. Chart makers use the data, with shoreline information, to update nautical charts and generate graphical displays in both digital and hard-copy form.[98]

1.2.1.7.7.1 Central Function

Surveys contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

95 See http://www.nauticalcharts.noaa.gov/hsd/learn_survey.html.

96 See http://www.nauticalcharts.noaa.gov/hsd/learn_survey.html.

97 See http://www.nauticalcharts.noaa.gov/hsd/learn_survey.html.

98 See http://www.nauticalcharts.noaa.gov/hsd/learn_survey.html.

1.2.1.7.7.2 Federal Assets

NOAA's Office of Coast Survey (OCS) conducts hydrographic surveys to measure the depth and bottom configuration of water bodies. The data are used to produce the nation's nautical charts and ensure safe navigation in U.S. coastal waters and the EEZ.[99]

OCS conducts hydrographic surveys primarily with side-scan and multibeam sonar. Sonar uses sound waves to find and identify objects in the water and to determine water depth. Most survey vessels are equipped with side-scan and multibeam sonar systems. Some vessels use single-beam echo sounders, diversleast-depth gauges, and lead lines. Some NOAA contractors employ LIDAR, which uses light to determine objects in the water and water depth.[100]

NOAA and its contractors usually complete 70 to 80 hydrographic surveys each year.[101]

1.2.1.7.7.3 Non-Federal Assets

The RAs do not conduct surveys but can provide a portal for reporting the survey data in their region. AOOS hosts the data from airborne and USCG cutter Healy-hosted surveys.

1.2.1.7.8 Sampling

Sampling in the context of U.S. IOOS is defined as the taking of a representative sample of a given experimental population, which could include ocean water, marine species, sediment, and geologic material. Samples are studied for physical measurements, chemical analysis, microbiological examination, and other measurements. The technology used for sampling is varied, and sampling systems are often outfitted on other observing systems such as ROVs. Sampling is done to support fish abundance and species data observation, water quality measuring, water contamination, and other purposes. The sampling efforts that contribute to U.S. IOOS identified thus far are described in this section.

An example of a deployable sampling system is a sediment trap. Sediment traps are containers that scientists place in the water to collect particles falling toward the sea floor. The traps collect tiny sediment or larger accumulations called marine snow, which consists of organic matter, dead sea creatures, tiny shells, dust, and minerals.[102] Analyzing the samples helps scientists understand how fast nutrients and trace elements like carbon, nitrogen, phosphorus, calcium, silicon and uranium move from the ocean surface to the deep ocean. These materials are what almost all deep-sea life uses for food. Other researchers analyze the trace ele-

[99] See http://www.nauticalcharts.noaa.gov/hsd/learn_survey.html.

[100] See http://www.nauticalcharts.noaa.gov/hsd/learn_survey.html.

[101] See http://www.nauticalcharts.noaa.gov/hsd/learn_survey.html.

[102] See http://www.whoi.edu/page.do?pid=10979&tid=282&cid=10286.

ments for clues about ocean circulation thousands of years ago. Sediment trap data also help to understand the other end of the nutrient cycle: how upwelling currents create such productive fishing areas.[103]

The basic sediment trap consists of a broad funnel with a collecting jar at the bottom. The funnel opening covers a standard area (such as 0.25 square meters) and has baffles at the top to keep out very large objects that might clog the funnel. The traps are clamped at a specific depth to a fixed cable attached to an anchor or buoy, where they remain for up to a year before a research vessel returns to collect the samples. Traps are often placed very deep, where they can catch sediment near the ocean bottom. Sediment traps are the only means for scientists to get hard data about the amounts and kinds of material that surface waters transport to the deep ocean. Figure 1-13 depicts a moored sediment trap.

Figure 1-13. Moored Sediment Trap

Source: http://www.whoi.edu/.

When a ship returns to retrieve the trap, the crew activates a remote-controlled device called an acoustic release. The release severs the line between the trap and its anchor, and the trap floats to the surface with its samples.

Scientists studying the upper ocean use smaller traps that are easier to handle and collect multiple samples at the same time. Much more sediment falls through shallow water than water at depth. That means upper-ocean sediment traps can forgo the bulky funnel top. They can be deployed for only a few days at a time and still collect useful samples.

1.2.1.7.8.1 Central Function

Sampling contributes to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint.

[103] See http://www.whoi.edu/page.do?pid=10979&tid=282&cid=10286.

1.2.1.7.8.2 Federal Assets

The U.S. Army Corps of Engineers routinely dredges harbors and waterways to maintain shipping lanes, and it analyzes sediments obtained during those operations. The EPA also samples ocean sediments outside land effluents, particularly near industrial sites, for federal environmental compliance. These federal capabilities are not currently contributing to U.S. IOOS.

1.2.1.7.8.3 Non-Federal Assets

The RAs do not currently operate or maintain sediment traps. The Woods Hole Oceanographic Institute (WHOI) has an extensive sediment trap research, study, and publishing program. Brookhaven Institute also conducts sediment studies in the Atlantic Ocean.

1.2.1.7.9 Ships

NOAA's Office of Marine and Aviation Operations operates a wide assortment of hydrographic survey, oceanographic research, and fisheries research vessels. (Figure 1-14 shows one of them.) Ships located in the Pacific are managed by the Marine Operations Center, Pacific (MOP) in Seattle, WA. Ships located in the Atlantic are managed by the Marine Operations Center, Atlantic (MOA) in Norfolk, VA. Logistic support for the vessels is provided by the appropriate marine operations center or, for vessels in Woods Hole, Charleston, Pascagoula, San Diego, and Honolulu, by port captains located in those ports.[104]

Figure 1-14. NOAA Ship Hi'ialakai

Source: http://www.moc.noaa.gov/.

[104] See http://www.moc.noaa.gov/.

The ships are run by a combination of NOAA commissioned officers and wage marine personnel, including licensed masters, mates, and engineers and unlicensed members of the engine, steward, and deck departments. In addition, survey and electronic technicians operate and maintain the ships' mission, communication, and navigation equipment. The ships' officers and crew provide mission support and assistance to embarked scientists from various NOAA laboratories as well as from the academic community.[105]

The NOAA fleet is supplemented by NGO fleets (charter, university) and volunteer vessels. NOAA solicits the help of volunteer ships through the U.S. Voluntary Observing Ship (VOS) Project, which allows volunteer crew members on nearly 1,000 ships around the world to observe the weather, encode each observation in a standard format, and send the data over satellite or radio to the many national meteorological services responsible for marine weather forecasts. The data are archived for future use by climatologists and other scientists.[106]

Ships participating in the VOS program get data support from a number of sources, including the Carbon Dioxide Information Analysis Center (CDIAC), the primary climate-change data and information analysis center of the U.S. Department of Energy (DOE).[107] CDIAC's ocean carbon data collection includes discrete and underway measurements from a variety of platforms (research ships, commercial ships, buoys). The measurements come from deep and shallow waters from all oceans.[108] CDIAC's data holdings include records of the atmospheric concentrations of carbon dioxide and other radiatively active gases, the role of the terrestrial biosphere and the oceans in the biogeochemical cycles of greenhouse gases, emissions of carbon dioxide from fossil-fuel consumption and land-use changes, long-term climate trends, the effects of elevated carbon dioxide on vegetation, and the vulnerability of coastal areas to rising sea level.[109]

The CDIAC Ocean Carbon Data Management Project started in 1993 when CDIAC became a member of the DOE/NOAA Ocean Carbon Science Team with data management and permanent archive responsibilities for the World Ocean Circulation Experiment (WOCE) CO2 measurements. The resulting WOCE carbon database is available from the CDIAC Ocean website. WOCE was a major component of the World Climate Research Program with the overall goal of better understanding the oceans' role in climate and climatic changes resulting from both natural and anthropogenic causes. The CO2 survey took advantage of the sampling opportunities provided by the cruises between 1990 and 1998. The final data set covers approximately 23,000 stations from 42 WOCE cruises.[110]

[105] See http://www.moc.noaa.gov/.
[106] See http://www.vos.noaa.gov/.
[107] See http://cdiac.ornl.gov/.
[108] See http://cdiac.ornl.gov/oceans/genInfo.html.
[109] See http://cdiac.ornl.gov/.
[110] See http://cdiac.ornl.gov/oceans/genInfo.html.

1.2.1.7.9.1 Central Function

Ships contribute to gathering marine environment data. The central function coordinates integration of data provided by these systems into U.S. IOOS as defined in the Blueprint. In addition, they serve in a key capacity for the deployment, retrieval, and ongoing maintenance of deployed observing systems.

1.2.1.7.9.2 Federal Assets

NOAA owns and operates 19 ships.[111] Table 1-18 lists NOAA and UNOLS ships, their owners, operators, and identifies their missions.

Table 1-18. NOAA Ship Fleet and Mission

Operator	Owner	Ship Name	Mission
NOAA	NOAA OMAO	*Bell M. Shimada*	Fisheries research
NOAA	NOAA OMAO	*David Starr Jordan*	Fisheries research
NOAA	NOAA OMAO	*Delaware II*	Fisheries research
NOAA	NOAA OMAO	*Fairweather*	Nautical charting
NOAA	NOAA OMAO	*Gordon Gunter*	Fisheries research
NOAA	NOAA OMAO	*Henry B. Bigelow*	Fisheries research
NOAA	NOAA OMAO	*Hi'ialakai*	Ocean and coral reef research
NOAA	NOAA OMAO	*Ka'imimoana*	Oceanographic and atmospheric research
NOAA	NOAA OMAO	*McArthur II*	Environmental monitoring/
NOAA	NOAA OMAO	*Miller Freeman*	Fisheries research
NOAA	NOAA OMAO	*Nancy Foster*	Environmental monitoring and fisheries research
NOAA	NOAA OMAO	*Okeanos Explorer*	Ocean exploration
NOAA	NOAA OMAO	*Oregon II*	Fisheries research
NOAA	NOAA OMAO	*Oscar Dyson*	Fisheries research
NOAA	NOAA OMAO	*Oscar Elton Sette*	Fisheries research
NOAA	NOAA OMAO	*Pisces*	Fisheries research
NOAA	NOAA OMAO	*Rainier*	Nautical charting
NOAA	NOAA OMAO	*Ronald H. Brown*	Oceanographic and atmospheric research
NOAA	NOAA OMAO	*Thomas Jefferson*	Nautical charting
Scripps Institution of Oceanography (SIO)	Navy	*Melville*	Research
Woods Hole Oceanographic Institution (WHOI)	Navy	*Knorr*	Research
University of Washington	Navy	*Thomas G. Thompson*	Research

[111] See http://www.moc.noaa.gov/.

Table 1-18. NOAA Ship Fleet and Mission

Operator	Owner	Ship Name	Mission
SIO	Navy	*Roger Revelle*	Research
WHOI	Navy	*Atlantis*	Research
Lamont-Doherty Earth Observatory	NSF	*Marcus Langseth*	Research
University of Hawaii	Navy	*Kilo Moana*	Research
Oregon State University	NSF	*Wecoma*	Research
University of Rhode Island	NSF	*Endeavor*	Research
WHOI	NSF	*Oceanus*	Research
SIO	SIO	*New Horizon*	Research
Bermuda Institute for Ocean Sciences	BBSR	*Atlantic Explorer*	Research
Duke University/UNC	NSF	*Cape Hatteras*	Research
Moss Landing Marine Laboratories	NSF	*Point Sur*	Research
University of Delaware (UD)	UD	*Hugh R. Sharp*	Research
SIO	SIO	*Robert Gordon Sproul*	Research
Louisiana Universities Marine Consortium (LUMCON)	LUMCON	*Pelican*	Research
University of Miami (UM)	UM	*F.G Walton Smith*	Research
University System of Georgia (UG)	UG	*Savannah*	Research
University of Minnesota Duluth (UMD)	UMD	*Blue Heron*	Research
University of Washington	NSF	*Clifford A. Barnes*	Research
USCG	USCG	*Healy*	Research
USCG	USCG	*Polar Star*	Research
USCG	USCG	*Polar Sea*	Research

Source: http://www.moc.noaa.gov/ and http://www.unols.org/info/vessels.htm

NOAA has procured some ships through a transfer from another agency. For example, *Okeanos Explorer*, formerly the USNS *Capable*, was an ocean surveillance ship of the U.S. Navy, transferred to NOAA in 2005.[112]

Other federal agencies, such as EPA, NSF, and USCG operate research and environmental monitoring ships. USCG operates polar icebreaking research ships in concert with NOAA on an ongoing research mission. It is not known how much these assets contribute to U.S. IOOS.

[112] See http://www.noaanews.noaa.gov/stories2005/s2370.htm.

1.2.1.7.9.3 Non-Federal Assets

To meet ship-time requirements, NOAA uses, in addition to its own fleet, chartered ships from the University National Oceanographic Laboratory System (UNOLS) fleet, ships of opportunity, and ships provided by its foreign partners.[113]

RA s use ships and small boats for sampling, for observing asset maintenance, and to deploy and recover observational assets. This includes UNOLS ships, ships owned by various institutions such as oceanographic research institutes, and workboats and fishing boats chartered for operations and maintenance of in-water instrumentation.

Currently, there is no comprehensive inventory of identified non-federal ships that contribute to U.S. IOOS.

1.2.2 Data Management and Communication Subsystem

As described in the U.S. IOOS Blueprint, the DMAC subsystem will

> manage data provider and sponsored model participation and create, manage, and deliver IOOS DMAC-compliant data and utility services. Collective activities form the framework for the integration of both heterogeneous and independent DMAC systems (adapted from the *DMAC Plan for Research and Operational Integrated Ocean Observing Systems*, Ocean.US Publication 6, March 2005).[114]

The nation's various observing systems are not well integrated. They operate largely independent of one another, and most were designed to support a single purpose, with limited data interoperability. Congressional action and directed funding were instrumental to the development of initial regional and federal IOOS components. However, because U.S. IOOS is not "owned" by one agency or entity and must accommodate the needs of multiple data providers and users, it is difficult to engineer a cohesive, operational system solution that ties these various elements together. Technically, integrating massive volumes of data from disparate sources and providing the data in formats and at rates that are useful for a broad array of applications represent a major and fundamental challenge.[115]

Federal and state agencies already support, operate, and maintain many ocean observing systems. Also, many governmental and nongovernmental institutions are capable of developing models, products, and services. But no common system exists to provide a timely and efficient link between all of the players and the vast volumes of data. The lack of such a link is costly—valuable research resources are wasted when each researcher, engineer, modeler, and service provider must individually tap into separate data sources—and precludes the development of

[113] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 4-1.

[114] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capa*bility, p. F-6.

[115] 2008 IOOS Report to Congress, p. 5.

highly sophisticated and data-dependent models, forecasts, and other capabilities.[116]

DMAC is the vital missing link. NOAA has made a commitment that internal investments will be largely dedicated to further development and implementation of this fundamental, data sharing component of IOOS. Efforts were initially focused on a framework integrating a subset of oceanographic data for the initial set of 20 core IOOS variables. Internally NOAA integrated temperature, salinity, water level, currents, and ocean color data first and distributed these data to decision-support models and tools. This Data Integration Framework (DIF) was specifically designed as a limited-scope, risk-reduction project to demonstrate that improved data interoperability can and will improve the performance of operational models, improve efficiency, and ultimately provide measurable national benefits. This effort will provide the foundation for implementing a national DMAC.[117]

Data management and communication are executed through the following functions:

- Registration of data providers
- Management of data providers
- Deregistration of data providers
- Standards management
- Utility services management
- Utility services development
- Data services and component development
- Data services and component management
- Configuration control.

1.2.2.1 REGISTRATION OF DATA PROVIDERS

As described in the U.S. IOOS Blueprint, this function will

> bring data providers, archives, or sponsored models into U.S. IOOS and facilitate proper categorization of their holdings to inform potential data/services customers of data availability, data quality, and metadata available. This activity includes certifying and adding data providers, archives, and sponsored models to the U.S. IOOS registry.[118]

[116] 2008 IOOS Report to Congress, p. ii.
[117] 2008 IOOS Report to Congress, p. ii.
[118] *U.S. Integrated Ocean Observing System: A Blueprint for Full Ca*pability, p. F-6.

1.2.2.1.1 Central Function

Registration of data providers is a requisite central function. Table 1-19 decomposes this function into subactivities.

Table 1-19. Register Data Providers—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Certification	Certify a data provider's DAC, archive, or sponsored model as DMAC compliant and gather the information needed to properly categorize their holdings for publication in the U.S. IOOS registry. Collect assessment information required to certify a new U.S. IOOS data provider, archive, or sponsored model. That information is as follows: • Observations Available—Assess which core variables are available and in which data structures and formats they are offered. • Data quality—Assess and categorize the data quality procedures used by the data provider, archive, or sponsored model. • Metadata—Assess metadata available and the degree to which it conforms to U.S. IOOS minimum standards. • Update Latency—Assess the latency between observations and the time they are available for transmission in U.S. IOOS. • Refresh Frequency—Assess how frequently data are refreshed. • Security—Assess current security measures and identify additional security measures required. • Access Rights—Assess if there any limitations on who should be allowed to access any data. • Archive Requirements—Assess which data are archived, where they are archived, and for how long they will be accessible: o Standards to Be Employed—Identify which IOOS DMAC-compliant data standards will be employed. o Interface Requirements—Assess how data users will access the data and whether the data provider needs to make changes to hardware or software. o Maturity Model Assessment—Assess the "maturity" of the data provider, archive, or sponsored model in terms of the U.S. IOOS maturity model. • Certification Decision—Make determinations to grant or deny certification pending specified actions being completed. • Complete MOA—Create memorandums of agreement or service level agreements (SLAs) that detail the commitments made by the data provider, archive, sponsored model, and U.S. IOOS.

Table 1-19. Register Data Providers—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Registration	Add the data provider's DAC, archive, or sponsored model to the U.S. IOOS registry. Subactivities are as follows: • Institute Usage Reporting—Establish routine reporting of data provider, archive, and sponsored model's data usage on a predetermined schedule. • Add to Registry—Update the U.S. IOOS registry to include new data providers, archives, and sponsored models; core variables served; data structures available; data quality; and metadata available. • Notify Users—Provide broad notification to U.S. IOOS partners, data/services customers, and internal U.S. IOOS offices that new data providers, archives, or sponsored models are available. The notification includes a recap of the registry information. • Installation Support—Provide technical assistance to the data provider, archive, or sponsored model owner in setting up IOOS DMAC-compliant data services. This could include reference implementations, "how to" guides, and help desk support. • Reference Implementations—Maintain a library of reference implementations for use by new data providers, archives, or sponsored models.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-6–F-7.

1.2.2.1.2 Federal Assets

Currently, the design of the federal contribution to DMAC is unknown. A description of the federal contribution to DMAC should be stated here.

1.2.2.1.3 Non-Federal Assets

One of the primary roles of regional data management is to facilitate the sharing an easy access to coastal and Great Lake data. RAs contribute observing data to the DIF. Currently, the design of the non-federal contribution to DMAC is unknown. A description of the non-federal contribution to DMAC should be stated here.

1.2.2.2 MANAGEMENT OF DATA PROVIDERS

As described in the U.S. IOOS Blueprint, this function will

> manage DACs, archives, and sponsored models that are already U.S. IOOS providers.[119]

[119] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-7.

1.2.2.2.1 Central Function

Management of data providers is a requisite central function. Table 1-20 decomposes this function into subactivities.

Table 1-20. Manage Data Providers—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Change request	Change registry, interface, or any other aspect of the relationship between the data provider, archive, or sponsored model owner and U.S. IOOS. • Receive Change Request—Accept, log, and process change requests initiated by a data provider, archive, or sponsored model owner. • Evaluate Request—Evaluate change requests to see if they are reasonable, supportable, and determine any impacts on the system. • Approve Request—Approve change requests. • Publish Notifications—Publish notification of an impending change and effective date to the requesting data provider, archive, or sponsored model owner and to U.S. IOOS internal and data/services customers. • Make Changes—Implement change requests as scheduled.
Cyclic review	Review participating DACs, archives, and sponsored models on a recurring basis. The time between reviews may be different depending on the unique aspects of each data provider's participation: • Identify Required Changes—Change the registry or make other changes identified in the cyclic review and negotiated with a data provider, archive, or sponsored model owner. • Approve Changes—Evaluate changes to determine if they are reasonable and supportable as well as to determine their impacts. • Make Changes—Implement changes that result from cyclic reviews. • Publish Notifications—Publish notification of an impending change and effective date to the requesting data provider, archive, sponsored model owner and to U.S. IOOS internal and data/services customers.
Monitor	Monitor the U.S. IOOS network to ensure functionality and identify problems: • Monitor Usage—Monitor customer interest in data by monitoring registry and catalog requests. • Monitor Availability—Check on the availability of data provider (DACs, archives, and sponsored models) offerings in U.S. IOOS. • Review Reports—Review data provider (DACs, archives, and sponsored models) utilization reports. • Data Provider Help Desk—Provide technical assistance to data providers (DACs, archives, and sponsored models) in isolating and resolving issues.
Update	Periodically update data provider (DACs, archives, sponsored models) certification and registration information: • Update Certification—Update existing certifications and assessments. • Update Registry—Update registry information. • Update MOA—Update existing MOAs/SLAs for reissue. • Update Services—Create change requests for existing IOOS DMAC-compliant data and utility services.

Table 1-20. Manage Data Providers—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Capability assessments	Assess the composite capability of the U.S. IOOS participating data providers' DACs, archives, and sponsored models in light of existing requirements and future plans.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capa*bility, pp. F-7–F-8.

1.2.2.2.2 Federal Assets

Currently, this DMAC function is being updated. NSF has an infrastructure that may contribute to this function.

1.2.2.2.3 Non-Federal Assets

Currently, there is no non-federal contribution to this DMAC function.

1.2.2.3 DEREGISTRATION OF DATA PROVIDERS

As described in the U.S. IOOS Blueprint, this function will

> remove a data provider (DAC, archive, sponsored model) from U.S. IOOS if/when circumstances dictate.[120]

1.2.2.3.1 Central Function

Deregistration of data providers is a requisite central function. Table 1-21 decomposes this function into subactivities.

Table 1-21. Deregistration of Data Providers—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Request to deregister	Allow data providers (DAC, archive, sponsored model owners) to request removal from U.S. IOOS. The request may also be generated as a result of U.S. IOOS monitoring and quality control efforts: • Receive Request—Receive, log, and process requests to deregister a data provider. • Approval—Approve deregistration requests.

[120] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-8.

Table 1-21. Deregistration of Data Providers—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Notice to data provider	Notify the affected data provider (DAC, archive, or sponsored model owner) of the intent to remove their data from U.S. IOOS: • Create Notice—Create the notice to the data provider (DAC, archive, or sponsored model owner) citing the reasons for removal and the effective date. • Transmission—Transmit removal notice to the data provider. • Approval—Adjudicate and approve the decision to remove a data provider (DAC, archive, or sponsored model owner) from U.S. IOOS. • Reconsideration—Allow a data provider (DAC, archive, or sponsored model owner) to request reconsideration of a deregistration action. • Final Approval—Provide final approval or disapproval of removal decisions after review of requests for reconsideration.
Notice to users	Provide notice to data/services customers and internal U.S. IOOS offices of the impending deregistration action: • Create Notice—Create notification materials. • Approval—Approve notices for publication. • Publish—Publish notice of deregistration of a data provider (DAC, archive, or sponsored model) to data/services customers and internal U.S. IOOS offices. • Respond to Inquiries—Respond to inquiries from affected data/services customers based on deregistration of a data provider.
Adjustment to products and services	Make changes to DMAC utility services and sponsored models that are affected by the decision to deregister a data provider DAC, archive, or sponsored model: • Identify Changes—Identify all changes to DMAC utility services and sponsored models that are required by a deregistration action. • Approve Changes—Approve the changes to DMAC utility services and sponsored models that are required by a deregistration action. • Make Changes—Implement the changes to DMAC utility services and sponsored models that are required by a deregistration action. • Testing—Test DMAC utility services and sponsored models to ensure changes required by a deregistration action were properly applied and the services and models are functioning correctly. • Update Configuration Control Documents—Ensure configuration control documentation is updated after a deregistration action.
Deregister	Remove a data provider (DAC, archive, or sponsored model owner) information/data from the U.S. IOOS registry. • Update Registry—Ensure that the U.S. IOOS registry reflects the registration and all other changes made as a result of a deregistration. • Archive Documents—Archive all documentation associated with a deregistration action.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-8–F-9.

1.2.2.3.2 Federal Assets

Currently, this DMAC function is being updated.

1.2.2.3.3 Non-Federal Assets

Currently, this DMAC function is being updated.

1.2.2.4 STANDARDS MANAGEMENT

As described in the U.S. IOOS Blueprint, this function will

> manage U.S. IOOS standards, including IOOS DMAC-compliant data services.[121]

Data standards are an essential component of DMAC. Data standards, management, and quality control procedures are implemented at the individual system level but are not consistently applied from one system to another.[122] The success of a national IOOS depends on the development of a consistent data management infrastructure that will link observations to the data and information needs of multiple users at the global, national, regional, and state levels. Few commonly accepted and applied standards exist for data format and transport, except for some specific applications. Consequently, data are not easily assembled from numerous diverse sources to meet the geographic coverage, vertical and horizontal resolution, accuracy, timeliness, and data processing needs of multiple ocean models, assessments, or other end uses. Effectively linking a societal need for environmental information to observations will require an efficiently managed, two-way flow of data and information among the three U.S. IOOS subsystems[123] that make up the central functions of IOOS: observations, DMAC, and data analysis and modeling. These subsystems refer to necessary functions of IOOS, not organizational entities or physical components.[124]

The U.S. IOOS Program Office tested the interoperability of federal and non-federal systems and determined that disparate formats and a number of other difficulties impede the integration of data from multiple providers, particularly for non-real-time data sources.[125]

1.2.2.4.1 Central Function

Standards management is a requisite central function. Table 1-22 decomposes this function into subactivities.

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[121] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-9.
[122] 2008 IOOS Report to Congress, p. 9.
[123] 2008 IOOS Report to Congress, p. 8.
[124] 2008 IOOS Report to Congress, p. 8.
[125] 2008 IOOS Report to Congress, p. 9.

Table 1-22. Standards Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Standards assessment	Evaluate U.S. IOOS standards and to develop standards requirements: • Assess Efficiency and Effectiveness of Current Standards—Assess efficiency and effectiveness of U.S. IOOS standards. • Monitor Evolution of Standards—Keep track of proposed changes in open standards proposed by standards bodies. • Create Requirements for New or Modified Standards—Define requirements for U.S. IOOS standards. • Standards Release Planning—Determine the optimum time for the release of new or improved U.S. IOOS standards to ensure synchronized application.
Standards development	Adopt, adapt, or develop new U.S. IOOS standards: • Requirements Analysis—Analyze requirements for new U.S. IOOS standards. • Solution Development—Adopt, adapt, or create new U.S. IOOS standards as required. • Testing—Test the proposed new U.S. IOOS standards to ensure that they work as intended and meet U.S. IOOS requirements. • Approval—Approve implementation of new U.S. IOOS standards as part of U.S. IOOS DMAC.
Existing standards maintenance	Maintain DMAC standards in use: • Assess Change Requests—Receive, record, and evaluate requests for changes to published DMAC standards. • Approve Changes—Approve requests to change existing DMAC standards, including timing of releases, to help manage impacts of the changes. • Make Changes—Implement the approved changes to DMAC standards. • Testing—Test changes to ensure that they were properly applied and the results meet expectations. • Publish Change—Publish changes to data providers, archives, and sponsored model owners (IOOS DMAC-compliant data services) and to other interested parties.
Interface management	Manage creation and publishing of solutions to meet specific or unique data/services customers' data interface requirements to allow their interfaces to communicate with IOOS DMAC-compliant data and utility services: • Identify Interface Requirements—Collect interface requirements from data/services customers. • Identify Solutions—Identify and publish solution software, documentation, and procedures to meet data/services customer interface requirements. • Document Solutions—Catalog and retain solution documentation for reference and reuse by other data/services customers.

Table 1-22. Standards Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Dictionaries and catalogs	Control development and maintenance of U.S. IOOS dictionaries and catalogs to facilitate easy discovery of U.S. IOOS data and model outputs and to provide a standard set of references to ensure uniform application of terminology and metrics across U.S. IOOS. • Controlled Vocabularies—Create and maintain controlled vocabularies that provide a uniform meaning for terminology across U.S. IOOS, both in terms of ocean science and in terms of IT supporting documentation that underlies DMAC subsystem functionality. • Data Dictionaries—Create and maintain data dictionaries (technical documentation of data elements) used by U.S. IOOS. • QA/QC Procedures—Create, maintain, and modify quality assurance and quality control procedures that will be employed by U.S. IOOS participants. • Metadata Profiles—Create and maintain metadata profiles that will be used by U.S. IOOS participants. • Catalogs—Create standards for development and maintenance of catalogs.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-9–F-11.

1.2.2.4.2 Federal Assets

Currently, this DMAC function is being updated.

1.2.2.4.3 Non-Federal Assets

Currently, this DMAC function is being updated.

1.2.2.5 Utility Services Management

As described in the U.S. IOOS Blueprint, this function will

> manage and maintain the development and delivery of U.S. IOOS DMAC utility services (services that manipulate data to provide a value-added service as distinct from "data services," which function to enable delivery of DMAC-compliant ocean observing data and model outputs).[126]

1.2.2.5.1 Central Function

Utility services management is a requisite central function. Table 1-23 decomposes this function into subactivities.

[126] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-11.

Table 1-23. Utility Services Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Service registry	Create and maintain the central records that allow data discovery and inform users of the core variables, data structures, metadata, and quality of U.S. IOOS data providers as well as how to access and use them. • Add New—Add new records to the registry. • Delete Old—Delete antiquated records from the registry. • Modify Entries—Modify existing registry entries.
Data catalog service	Create catalogs that are derivative of the registry and other documentation. Catalogs provide simplified and enhanced means for U.S. IOOS data/services customers to find the kinds of data or services that they need. • Establish Services—Create and publish new catalogs. • Maintain Service—Maintain accuracy and availability of catalogs. • Evaluate Service—Evaluate the usefulness of existing catalogs and to determine the need for new catalogs. • Disestablish Service—Remove unneeded catalogs from use.
Data integration service	Develop and maintain data integration services. (Some data will require aggregation from multiple data sources in support of customer needs, or as an intermediate product in support of other U.S. IOOS services.) If required, data translation may be part of this service. • Receive Requests—Receive and record requests from data/utility services customers for data integration service. • Evaluate Requests—Evaluate data integration related requests for current sources or to determine if development is needed. • Approval—Approve or disapprove access to existing data integration services or to approve request to develop new data integration services. • Establish Services—Implement access to existing data integration services. • Maintain Service—Perform routine maintenance of data integration service software and hardware. • Evaluate Service—Evaluate data integration service usage, reliability, cost and performance. • Disestablish Service—Shut down unneeded data integration services.

Table 1-23. Utility Services Management—Core Function Subactivities

<table>
<tr><th>Core function subactivity</th><th>Description and lower-level subactivities</th></tr>
<tr><td>Mapping and visualization service</td><td>Provide data as a visual and/or mapping display that supports data/utility services customer needs. For example, data from multiple data providers may be combined and displayed in the form of a color-coded map to support customer needs:
Receive Requests—Receive and record requests from data/ utility services customers to access mapping and visualization services.
Evaluate Requests—Evaluate requests for mapping and visualization services to determine existing sources or the need to develop new mapping and visualization services.
Approval—Approve or disapprove access to existing mapping and visualization services or to approve request to develop new mapping and visualization services.
Establish Services—Implement the mapping and visualization displays and make appropriate changes to the registry and catalogs, and inform the requesting data/utility services customer.
Maintain Service—Maintain existing mapping and visualization services.
Evaluate Service—Evaluate usage and quality of mapping and visualization services.
Disestablish Service—Delete mapping and visualization display products, including notification to users and changes to the registry and catalogs.</td></tr>
<tr><td>Product generation services</td><td>Support provision of services that provide derived products such as statistical analyses and feature extractions from data:
Receive Requests—Receive product generation requests from data/utility services customers.
Evaluate Requests—Ensure that product generation requests can be accommodated in terms of data availability and that the requested information will properly support the intent of the requestor.
Approval—Approve product generation requests from data/utility services customers.
Establish Services—Deliver product generation services for data/utility services customers.
Maintain Service—Maintain product generation services.
Evaluate Service—Ensure quality control and evaluate usage of product generation services.
Disestablish Service—Remove data/utility services customers from product generation services or to shut down a particular service.</td></tr>
</table>

Table 1-23. Utility Services Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Format conversion service	Support provision of a utility service that allows translation of data from one format to another. Unlike data access services that allow users to access data regardless of the source, this service fundamentally changes the data format into a format more convenient for the data/utility services customer. (Examples of format conversions include XML to NetCDF or GML to KML.) • Receive Requests—Receive requests for format conversion utility services. • Evaluate Requests—Determine if existing format conversion services are adequate or if modified or new services are required. • Approval—Approve requests to access existing format conversion services, or to modify or develop new services. • Establish Services—Set up data/utility services customer access to a format conversion service. • Maintain Service—Maintain format conversion services. • Evaluate Service—Evaluate the quality of format conversion services and evaluate usage. • Disestablish Service—Remove data/utility services customers from access to a format conversion service or to shut down a service.
Coordinate transformation services	Support provision of services that convert between different geographic coordinate systems (e.g., from latitude/longitude to Mercator), between different measurement axes (e.g., from northward and eastward components of wind to wind speed and direction), or between different units of measure (e.g., from Celsius to Fahrenheit): • Establish Services—Set up coordinate transformation services. • Maintain Service—Maintain and modify coordinate transformation services. • Evaluate Service—Monitor quality and usage of coordinate transformation services. • Disestablish Service—Shut down unneeded coordinate transformation services.
Workflow services	Support provision of services that enable customers to chain together multiple processing steps to produce the desired output. For example, get data from the source, convert to another format, compute polygonal boundary of observed phenomenon, then produce an image of the result: • Receive Requests—Receive requests for workflow services. • Evaluate Requests—Determine if existing workflow services are adequate, or if modified or new workflow services are required. • Approval—Approve requests to access existing workflow services, or modify or develop workflow services. • Establish Services—Set up customer access to workflow services. • Maintain Service—Maintain workflow services. • Evaluate Service—Evaluate the quality of workflow services and evaluate usage. • Disestablish Service—Remove customers from access to workflow services or to shut down a workflow service.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-11–F-13.

1.2.2.5.2 Federal Assets

Currently, a number of federal partners are providing data functions to the DMAC, including:

- NOAA OAR
- NOAA NDBC.

1.2.2.5.3 Non-Federal Assets

Non-Federal partners provide data collection and assembly to the DMAC functions.

1.2.2.6 UTILITY SERVICES DEVELOPMENT

As described in the U.S. IOOS Blueprint, this function will

> develop new utility service offerings, or improve existing DMAC utility services.[127]

1.2.2.6.1 Central Function

Utility services development is a requisite central function. Table 1-24 decomposes this function into subactivities.

Table 1-24. Utility Services Development—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Quality monitor existing services	Monitor the quality of the existing set of DMAC utility services to inform improvement decisions: • Sampling—Provide human sampling of existing utility services. • Automated Monitoring—Automatically monitor existing services. • User Surveys—Conduct surveys of utility service customers to identify needed improvements.
Assess service requirements	Assess requirements for new utility services derived from the monitoring efforts: • Priority—Prioritize utility service requirements in terms of importance. • Cost—Determine cost of proposed utility service changes. • Technical Solution—Develop a technical solution to satisfy utility service requirements. • Time—Determine time required to implement utility service changes. • Cost Benefit—Determine cost-benefit of proposed utility service changes.

[127] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-13.

Table 1-24. Utility Services Development—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Approve changes	Approve utility service development efforts and integrate work into existing schedules. • Approve—Approve utility service changes. • Schedule—Integrate work into existing utility service plans.
Execute changes	Make utility service changes to test servers.
Testing	Test new utility services.
Notification	Notify data/utility services customers and internal U.S. IOOS offices of pending release of new utility services.
Deployment	Roll out new utility services for U.S. IOOS DMAC.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-13–F-14.

1.2.2.6.2 Federal Assets

Currently, this DMAC function is being updated.

1.2.2.6.3 Non-Federal Assets

Non-Federal partners provide data collection and assembly to the DMAC functions.

1.2.2.7 Data Services and Component Development

As described in the U.S. IOOS Blueprint, this function will

> adopt, modify, or develop IOOS DMAC-compliant data services and components.[128]

The presence of a DMAC subsystem capable of delivering real-time and non-real-time (delayed-mode) observations to a wide variety of users is central to the success of all the regional, national, and international ocean and coastal observing systems. The DMAC subsystem will provide data streams to modeling centers, model-generated forecasts to users, land and ecosystem planning and management tools to decision makers, and all forms of data to and from secure archive facilities, such as NOAA’s data centers.[129]

NOAA’s development of DACs at the NDBC and the Center for Operational Oceanographic Products and Services (CO-OPS) is a first step toward establishing DMAC capabilities. The NDBC DAC increases availability of many NOAA and regional observations, delivering these data to the World Meteorological Organization (WMO) Global Telecommunication System (GTS). Since the establishment of

[128] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-14.
[129] 2008 IOOS Report to Congress, p. 9.

NDBC's IOOS partnership in 2002, the number of IOOS observations processed grew from 200,000 to 4.4 million in 2008. These observations include data sets that were previously not available, except to local system users. For example, in addition to the regional data, observations from NOAA's NERRS were added in 2007. However, although transmission to the GTS has improved availability for real-time observations, a lack of uniform standards and cataloging procedures hampers access to and use of non-real-time data.[130]

NOAA's DACs, as well as other federal data centers, will play an important role in long-term data archiving and stewardship. In addition to improvements in data delivery and management, data archiving, maintenance, and stewardship are also essential to ensure that the vast IOOS data resources generated each day can be recovered easily to support ecosystem, climate, and other analyses requiring longer-term, historical data records.[131]

The U.S. IOOS Program Office also helps to improve and establish data services through sponsored partnerships. For example, a number of IOOS partners at the state and regional levels, as well as academia, have devoted significant resources to develop HFR capacity within their respective geographical areas; however, these data are provided through many different avenues and not accessible on a national scale. Recognizing the importance of this technology and potential benefits gained through increased access to these data, the U.S. IOOS Program supported a partnership between NOAA's NDBC and Scripps Institution of Oceanography to develop a national HFR server and data management system. The development of national data standards for HFR make it possible for a national data server to provide access to data produced by these various radar sites around the country. The intent is to maximize the benefit of these investments by bringing the data together in an easily accessible and usable format to support decision making.[132]

1.2.2.7.1 Central Function

Data services and component development is a requisite central function. Table 1-25 decomposes this function into subactivities.

[130] 2008 IOOS Report to Congress, p. 9.

[131] 2008 IOOS Report to Congress, p. 10.

[132] See http://www.ioos.gov/program/projects.html.

Table 1-25. Data Services and Component Development—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Quality monitor existing services and components	Monitor the quality of the existing IOOS DMAC-compliant data services and components to inform improvement decisions: • Sampling—Provide human sampling of existing IOOS DMAC-compliant data services and components. • Automated Monitoring—Automatically monitor existing IOOS DMAC-compliant data services and components. • User Surveys—Conduct surveys of IOOS DMAC-compliant data service and component customers to identify needed improvements.
Assess service requirements	Assess requirements for new IOOS DMAC-compliant data services and components derived from the monitoring efforts: • Priority—Prioritize IOOS DMAC-compliant data service and component requirements in terms of importance. • Cost—Determine cost of proposed IOOS DMAC-compliant data service and component changes. • Technical Solution—Develop a technical solution to satisfy IOOS DMAC-compliant data service and component requirements. • Time—Determine time required to implement IOOS DMAC-compliant data service and component changes. • Cost Benefit—Determine cost-benefit of proposed IOOS DMAC-compliant data service and component changes.
Approve changes	Approve IOOS DMAC-compliant data service and component development efforts and integrate work into existing schedules: • Approve—Approve IOOS DMAC-compliant data service and component changes. • Schedule—Integrate work into existing IOOS DMAC-compliant data service and component plans.
Execute changes	Make IOOS DMAC-compliant data service and component changes to test servers.
Testing	Test new IOOS DMAC-compliant data services and components.
Notification	Notify customers and internal U.S. IOOS offices of pending release of new IOOS DMAC-compliant data services and components.
Deployment	Roll out new IOOS DMAC-compliant data services and components for U.S. IOOS DMAC.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-14–F-15.

1.2.2.7.2 Federal Assets

Several federal partners are working to contribute to the DMAC. Several already contribute data in compliant formats. The format of this function is being updated.

1.2.2.7.3 Non-Federal Assets

Operators of ocean observing assets are responsible for transmitting their data to an IOOS DAC (federal, regional, or other DMAC-capable site). The RAs are key providers of observing assets and data transmission services.

1.2.2.8 DATA SERVICES AND COMPONENT MANAGEMENT

As described in the U.S. IOOS Blueprint, this function will

> manage and maintain existing IOOS DMAC-compliant data services and perform component management.[133]

1.2.2.8.1 Central Function

Data services and component management is a requisite central function. Table 1-26 decomposes this function into subactivities.

Table 1-26. Data Services and Component Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Data access services	Manage services that allow customers to “pull” data on request from data assembly centers. Different data types may require different services, and a variety of services may be offered to satisfy different customers, but all data access services are expected to enable the customer to (1) make an explicit request at the moment of need and (2) specify the desired subset of the data based on the location of interest, the time of interest, and possibly other subset criteria.
Data subscriptions and alerts services	Manage services that inform customers of various types about changes in U.S. IOOS, model outputs, data provider offerings, quality or metadata, etc. The customers are grouped into lists that receive notifications when news of interest to that category of customer occurs. The notifications may be administrative, such as changes in a data provider’s data offerings, or data-related, such as the temperature in a specific location has peaked above a specified level. This utility service will have two functions: (1) a subscription service that allows a user to access information on a particular topic area, and (2) an alert service that allows users to define data of interest and thresholds. When the data or combined data exceed these threshold, the users will receive notification automatically.

[133] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-15.

Table 1-26. Data Services and Component Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
System viewer component	Support provision of the component that provides a web-based user interface to the data catalog and the service registry. It allows humans to issue searches for data using map-based or form-based query interface, it displays results of searches in either map or tabular form, and it provides links to the actual data and metadata corresponding to the search results.
System monitor component	Support management of the component that enables monitoring of the status of DMAC services. Monitoring allows U.S. IOOS to identify problems and take action to resolve issues. Monitoring *may* also include gathering of usage statistics if data searches and request are made via an U.S. IOOS catalog or viewer. However, because data requests may go directly to the data providers, this monitoring service will not provide a complete view of system usage.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-15.

1.2.2.8.2 Federal Assets

Currently, the federal contribution to this DMAC function has not been completely defined.

1.2.2.8.3 Non-Federal Assets

The non-federal partners will receive assistance and guidance from the Central Function to implement these sub-activities.

1.2.2.9 Configuration Control

As described in the U.S. IOOS Blueprint, this function will

> ensure that all aspects of U.S. IOOS software development and IT lifecycle management have proper configuration control and documentation.[134]

1.2.2.9.1 Central Function

Configuration control is a requisite central function. Table 1-27 decomposes this function into subactivities.

[134] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-15.

Table 1-27. Configuration Control—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Review documentation	Review U.S. IOOS IT configuration control documentation to ensure that it is current.
Update documentation	Update IT configuration control documentation when changes are required.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-16.

1.2.2.9.2 Federal Assets

No federal assets are associated with this function.

1.2.2.9.3 Non-Federal Assets

No non-federal assets are associated with this function.

1.2.3 Modeling and Analysis Subsystem

As described in the U.S. IOOS Blueprint, the modeling and analysis subsystem will

> include all data/services customers of U.S. IOOS to include Federal, regional, national, international, NGO, corporate, institutional, and private citizen users. All users of U.S. IOOS receive their data/utility services through the processes defined in the Modeling and Analysis subsystem and use these processes to make their requirements known. The Customer Needs process defined in this subsystem combined with the User Councils (Governance and Management) and U.S. IOOS monitoring and assessments processes (all subsystems) are the three methods by which U.S. IOOS defines its requirements and establishes its goals.[135]

Models are the primary tools used to analyze large amounts of data to evaluate the current state of the ocean and coastal environments and to detect, explain and predict changes to support informed decision making. The IOOS modeling and analysis subsystem will improve, develop, test, and validate operational models; produce skilled estimates of current states of marine systems; and develop data assimilating techniques to initialize and update models for more accurate forecasts. Global and coastal models differ in spatial and temporal scale resolutions, but the observational and developmental challenges associated with each are fundamentally similar. The global and coastal components must not be addressed independently, and the U.S. IOOS Program Office is working to ensure collaboration not only between these two components but also with interagency

[135] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-16.

partners through participation in the Interagency Working Group on Ocean Observations (IWGOO).[136]

Modeling and analysis are executed through the following functions:

- Customer needs
- Sponsored models
- MOU management
- Publication of standards.

1.2.3.1 CUSTOMER NEEDS

As described in the U.S. IOOS Blueprint, this function will

> capture customer needs, translate those needs into requirements, and assess the requirements to determine possible sources to resolve customer data needs. Includes processes to record and manage unmet requirements, seek possible solutions, and advocate with user council members to implement solutions.[137]

As information on user needs continues to accumulate, U.S. IOOS modeling, analysis, and decision-support tool requirements will evolve. U.S. IOOS focuses on outcome-based, user-defined needs to drive observation and data management development. This focus helps ensure that operational models will provide outputs in the time frame and format necessary for decision makers and other user groups and will better support the incorporation of uncertainty into models for more useful, probabilistic predictions to support risk- and ecosystem-based management approaches.[138]

1.2.3.1.1 Central Function

Addressing customer needs is a requisite central function. Table 1-28 decomposes this function into subactivities.

[136] 2008 IOOS Report to Congress, p. 10.

[137] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-16.

[138] 2008 IOOS Report to Congress, p. 10.

Table 1-28. Customer Needs—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Customer input	Receive customer input and determine requirements for DMAC services or feedback on U.S. IOOS procedures and policies: • Survey—Obtain customer input through periodic surveys of data/services customers. • Comments—Receive and adjudicate data/services customer comments received through an IOOS DMAC-compliant data/utility service or help desk calls. • Requests—Receive and adjudicate specific data/services customer requests.
Data needs assessment	Assess whether data/services customer needs can be met with existing data sources: • Determine Needs—Interpret data/services customer requirements in terms of data/services required. • Determine Sources—Align data requirements with existing U.S. IOOS and non-U.S. IOOS data/services sources. • Negotiate Participation—Negotiate with non-U.S. IOOS data/services providers to participate in U.S. IOOS and make available the required data/service.
Model output needs assessment	Assess whether data/services customer needs can be met with existing model outputs. • Determine Needs—Interpret data/services customer requirements in terms of model output products. • Determine Sources—Align requirements with existing U.S. IOOS and non-U.S. IOOS model output sources. • Negotiate Participation—Negotiate with non-U.S. IOOS model output sources to participate in U.S. IOOS and make available the required data.
Service needs assessment	Assess whether data/services customer needs can be met with existing, new, or modified DMAC services: • Determine Needs—Interpret data/services customer requirements in terms of DMAC services. • Determine Service—Align data/services customer requirements with existing DMAC services or to recommend new or modified services for development.
Unfulfilled requirements management	Manage data/services customer requirements that could not be satisfied by existing data providers (U.S. IOOS or non-U.S. IOOS), existing model outputs (U.S. IOOS and non-U.S. IOOS) or DMAC services (existing, modified, or planned): • Master List Maintenance—Maintain a prioritized record of all unsatisfied data/services customer requirements. • Solution Scenario Generation—Craft solution sets that meet multiple unfulfilled requirements with an emphasis on cost effectiveness, asset optimization, and efficiency. • Advocacy—Shop solution scenarios to potential providers in and out of the user groups to garner consensus to make the investments necessary to implement solutions.

Table 1-28. Customer Needs—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Customer help desk	Provide customers with help resolving questions and issues: • Help Desk—Provide electronic and phone-based help to assist data/services customers in meeting their U.S. IOOS needs. • Frequency Analysis—Track help requests to inform future U.S. IOOS design and funding decisions.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-16–F-17.

1.2.3.1.2 Federal Assets

The degree to which the federal assets participate in this function should be described here.

1.2.3.1.3 Non-Federal Assets

RAs are actively gathering user needs on an annual or continuing basis, and this user input is shaping their modeling and analysis research. Examples of this involvement are described here:

- PacIOOS is involved, through regular stakeholder engagement, in the assessment of customer needs for data collection, model, and product development. These annual needs assessments and reviews are used to refine proposals for future activities and annual drawdowns in proposed operations.
- AOOS conducts user and customer surveys, stakeholder workshops and direct stakeholder meetings to determine user needs.
- NANOOS works with its users to understand needs and provide outreach and engagement.
- SECOORA partners with stakeholders at workshops, at annual meetings and through the engagement of the south Atlantic Alliance. SECOORA has also conducted stakeholder assessments, and reviewed other assessments for applicability in establishing priorities.

1.2.3.2 SPONSORED MODELS

As described in the U.S. IOOS Blueprint, this function will

> assess models and make their outputs available through U.S. IOOS. Once the decision is made to provide a models output through U.S. IOOS, the processes used are identical to those used to bring a new data providers into U.S. IOOS.[139]

1.2.3.2.1 Central Function

Sponsored models constitute a requisite central function. Table 1-29 decomposes this function into subactivities.

Table 1-29. Sponsored Models—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Register a data provider	Bring data providers, archives, or sponsored models into U.S. IOOS and facilitate proper categorization of their holdings to inform potential data/services customers of data availability, data quality, and metadata available. This activity includes certification and adding data providers, archives, and sponsored models to the U.S. IOOS registry.
Manage data providers	Manage DACs, archives, and sponsored models that are already U.S. IOOS providers.
Deregister a data provider	Remove a data provider (DAC/archive/sponsored model) from U.S. IOOS if/when circumstances dictate.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-17.

1.2.3.2.2 Federal Assets

The degree to which the federal assets participate in this function should be described here.

1.2.3.2.3 Non-Federal Assets

Regional partners have an obvious role in providing oceanographic and meteorological observations in support of many programs that aim to meet the societal benefit objectives of U.S. IOOS, including, for example, coastal inundation forecasting. In addition, the RCOOSs include a number of academic institutions capable of providing modeling and analytical expertise to complement NOAA's activities associated with coastal inundation. U.S. IOOS regional partners provide considerable capacity to conduct targeted R&D needed to produce high-resolution, locally specific models and value-added products for decision makers. These efforts, when coupled with the applied research and modeling efforts ongoing within federal offices and laboratories, will contribute useful information and

[139] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-17.

lessons learned to support, for example, federal operational responsibility to issue storm surge and other inundation forecasts.[140]

1.2.3.3 MOU Management

As described in the U.S. IOOS Blueprint, this function will

> govern the management of memorandums of understanding between U.S. IOOS and potential data providers/sponsored models owners. These MOUs articulate the required steps to become certified and registered as a U.S. IOOS provider, expected functionality consistent with U.S. IOOS participatory role, and define the expected schedule for those actions.[141]

1.2.3.3.1 Central Function

MOU management is a requisite central function. Table 1-30 decomposes this function into subactivities.

Table 1-30. MOU Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Create MOU	Create MOUs.
Gain concurrence	Approve MOUs.
Coordinate for certification	Transition a potential data/service provider DAC/sponsored model output from MOU status to certification as a U.S. IOOS data provider.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability,* p. F-17.

1.2.3.3.2 Federal Assets

The degree to which the federal assets participate in this function should be described here.

1.2.3.3.3 Non-Federal Assets

No non-federal assets are associated with this function.

1.2.3.4 Publication of Standards

As described in the U.S. IOOS Blueprint, this function will

> make U.S. IOOS standards accessible to data/services customers.[142]

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[140] 2008 IOOS Report to Congress, p. 33.

[141] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-17.

[142] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-17.

1.2.3.4.1 Central Function

Publication of standards is a requisite central function. Table 1-31 decomposes this function into subactivities.

Table 1-31. Publication of Standards—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Standards to use	Disseminate existing standards information.
"How to"	Make available simple "how to" instructions for using U.S. IOOS data and services.
Reference implementations	Develop, maintain, and make available reference implementations for typical customer needs.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-17–F-18.

1.2.3.4.2 Federal Assets

Federal participants are assisting in the promulgation of U.S. IOOS standards, in concert with the U.S. IOOS Program Office.

1.2.3.4.3 Non-Federal Assets

RAs are assisting in the promulgation of U.S. IOOS standards, in collaboration with the U.S. IOOS Program Office and federal partners.

1.2.4 Governance and Management Subsystem

As described in the U.S. IOOS Blueprint, the governance and management subsystem will

> support U.S. IOOS in terms of guidance, resources, process, tools, and infrastructure.[143]

Governance and management are executed through the following functions:

- User councils
- Financial management
- Policy
- Plans and operations
- Human resources
- Acquisition and grants

[143] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-1.

- Marketing, outreach, and engagement
- IT support.

1.2.4.1 USER COUNCILS

As described in the U.S. IOOS Blueprint, this function will

> provide input/feedback on plans for and execution of U.S. IOOS, and provide a forum for discussion of U.S. IOOS user needs keyed to specific areas of interest and to influence future U.S. IOOS plans. Also provide a forum through which collaboration and agreements for future development can be made. They are a primary means for U.S. IOOS to stay engaged with myriad System stakeholders. They are advisory in nature, but also provide the forum in which agreements between partners can be initiated and IOOS plans can be vetted.[144]

1.2.4.1.1 Central Function

User councils constitute a requisite central function. Table 1-32 decomposes this function into subactivities.

Table 1-32. User Councils—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Standards bodies	Represent the interests of the various standards organizations that govern nationally and international recognized standards used by U.S. IOOS (OGC, ISO, etc.).
Data providers	Represent data providers who are current or anticipated U.S. IOOS compliant data providers. These data providers include DAC owners, owners of U.S. IOOS sponsored models, and archives.
Data/service customers	Represent the various U.S. IOOS customer communities. These include customers that access data directly from the source (DACs, archives, or sponsored models) and those that use U.S. IOOS-compliant data or utility services. There may be subgroups within this user council to represent the various types of customers such as high-volume institutional users or low-volume users such as citizens. Third-party service providers are included in this user group.
Federal partners	Represent the interests of federal agencies that have a role or interest in ocean observing data.
RAs	Represent the interests of the RAs participating in, or anticipated to participate in, U.S. IOOS.
NGOs	Represent the interests of nongovernmental entities not represented in other user councils (i.e., they are not federal entities and they are not part of the U.S. IOOS regional structure). The Consortium on Ocean Leadership is an example of an NGO.

[144] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-1.

Table 1-32. User Councils—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
International	Represent the interests of integrating U.S. IOOS with international ocean observations. This includes GEOSS and GOOS: • GEOSS—Represent the interests of integrating U.S. IOOS into GEOSS. • GOOS—Represent the interests of integrating U.S. IOOS into GOOS.
IEOS	Represent the interests of integrating U.S. IOOS into IEOS.
Combined forums by geographic area	Represent all U.S. IOOS users with a role or interest in a stated large geographic area (e.g., the Atlantic Ocean). Council members may include data collectors that collect ocean observing data in that area, data providers that assemble observations and make them available in DMAC-compliant form for that area, Federal agencies, RAs, international members, data/services customers, and others.
Combined forums by functional area	Represent all U.S. IOOS users with a role or interest in a stated functional area of interest (e.g., ocean acidification). Council members may include data collectors that collect relevant ocean observing data, data providers that compile relevant observations, federal agencies, RAs, international members, data/services customers, and others.
R&D asset owners	Represent the interests of U.S. IOOS participating organizations that conduct R&D. This forum allows for an exchange of ideas about approaches to solving ocean observation problems, coordination across R&D programs, transition from R&D to operations, and joint R&D ventures and budgeting.

Source: U.S. Integrated Ocean Observing System: A Blueprint for Full Capability, pp. F-1, F-2.

1.2.4.1.2 Federal Assets

Federal agencies also have user councils. For instance, NMFS has regional fishery councils.

1.2.4.1.3 Non-Federal Assets

RAs provide a conduit for U.S. IOOS to and from end user communities of varying interests. Each RA can be thought of as the core of a regionally focused user council. NFRA itself is also a user council.

1.2.4.2 FINANCIAL MANAGEMENT

As described in the U.S. IOOS Blueprint, this function will

> manage planning, programming, budgeting, and execution of funds. This includes management of internal U.S. IOOS Program funds, funding for U.S. IOOS projects, and coordination of financial plans and budgets with other U.S. IOOS participating organizations.[145]

1.2.4.2.1 Central Function

Financial management is a requisite central function. Table 1-33 decomposes this function into subactivities.

Table 1-33. Financial Management—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Financial plans	Create U.S. IOOS financial plans, including prescribed planning, programming, and budget documents.
Budget	Create U.S. IOOS-required planning, programming, and budget documentation and to develop final budget plans.
Execution	Manage execution of the annual budget.
Analysis	Conduct program/budget analysis, economic analysis, and cost-benefit studies.
Interagency coordination	Create financial plans and monitor execution of funds in cooperation with other federal and non-federal U.S. IOOS organizations.

Source: U.S. Integrated Ocean Observing System: A Blueprint for Full Capability, p. F-2.

1.2.4.2.2 Federal Assets

Federal partners perform this level of management for the assets under their purview.

1.2.4.2.3 Non-Federal Assets

RAs perform this level of management for the assets under their purview.

1.2.4.3 POLICY

As described in the U.S. IOOS Blueprint, this function will

> create and manage policy both internal to the U.S. IOOS Program and external. Policies may be administrative, such as the steps required to become a data provider, or technical, such as data quality standards that must be in place. Congressional liaison activities fall within this area.[146]

[145] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-2.
[146] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability,* p. F-2.

1.2.4.3.1 Central Function

Policy is a requisite central function. Table 1-34 decomposes this function into subactivities.

Table 1-34. Policy—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Intramural	Create and manage policy within the U.S. IOOS Office.
Extramural	Create and manage policies that affect external partners. These include technical and administrative: • Technical—Create and manage technical policy. • Administrative—Create and manage administrative policy.
Congressional liaison	Provide information requested by congressional members and analyze congressional language to assess policy ramifications.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-2.

1.2.4.3.2 Federal Assets

No federal assets are associated with this function.

1.2.4.3.3 Non-Federal Assets

No non-federal assets are associated with this function.

1.2.4.4 Plans and Operations

As described in the U.S. IOOS Blueprint, this function will

> manage plans and operations supporting the full range of U.S. IOOS activities. These include coordination of IOOS subsystem development efforts, plans and operations relating to modeling and analysis, DMAC observing subsystem, R&D, training and education, and change management. In addition to routine functions of planning and controlling U.S. IOOS functions, plans and operations can include activities agreed upon by user council, national, or international plans agreed to by U.S. IOOS.[147]

1.2.4.4.1 Central Function

Plans and operations constitute a requisite central function. Table 1-35 decomposes this function into subactivities.

[147] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-3.

Table 1-35. Plans and Operations—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Plans	*National:* Create and manage plans that coordinate activities at a national level that may include members of some or all user councils or other entities with interest. (Examples are the National Waves Plan and the National Surface Current Mapping Plan.)
	IOOS internal: Create and manage plans that do not include participation by non-U.S. IOOS partners. Requires the following lower-level subactivities: • Observations—Create and manage plans, including regional U.S. IOOS plans, relating to development, management, and improvement of ocean observing capability. • Data Providers—Create and manage plans relating to management of U.S. IOOS data providers, include federal and non-federal data assembly centers, sponsored models, and archives. • DMAC Services—Create and manage plans that affect DMAC services development, management, evolution, and delivery. • Models—Create and manage plans that affect data delivery to models and efforts to assimilate and manage U.S. IOOS-sponsored models. • Archives—Create and manage plans that affect U.S. IOOS-compliant archives, including data storage, retrieval, and backup. • Education—Create and manage plans related to assessing U.S. IOOS-related training and education requirements, content development, and delivery. • R & D—Create and manage plans related to R&D efforts in support of U.S. • IOOS or user council member needs.
	International: Create and manage plans that coordinate activities at an international level that may include members of some or all user councils or other entities with an interest (e.g., U.S. participation in an international ocean observing plan).

Table 1-35. Plans and Operations—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Operations	Control, monitor, and report on operations covering the full range of U.S. IOOS activities. These include operations relating to modeling and analysis, DMAC, observing subsystem, R&D, and training and education. Operations can include activities agreed upon by user councils and national or international plans agreed to by U.S. IOOS. Operations are conducted at the interagency, national, international, regional assessment, regional project, and program office levels.
	Interagency: Control, monitor, and report on operations conducted with or by interagency partners. • Program Management Teams—Manage interagency programs and projects where U.S. IOOS is the lead.
	National: Control, monitor, and report on operations conducted with or by domestic partners.
	International: Control, monitor, and report on operations conducted with or by international partners. • Program Management Teams—Manage international programs and projects where U.S. IOOS represents the United States as the lead country.
	Regional assessment: Conduct capability maturity assessments of the U.S. IOOS regions.
	Regional project management: Manage regional projects funded by U.S. IOOS.
	Program office internal: Control, monitor, and report on U.S. IOOS Program Office internal operations.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-3–F-4.

1.2.4.4.2 Federal Assets

No federal assets are associated with this function.

1.2.4.4.3 Non-Federal Assets

Non-federal partners and RAs provide these management sub-activities within their own associations.

1.2.4.5 Human Resources

As described in the U.S. IOOS Blueprint, this function will

> manage/coordinate U.S. IOOS Program Office human resources, including job descriptions, hiring, employee benefits, personnel actions, and other routine personnel administration tasks.[148]

1.2.4.5.1 Central Function

Human resources constitute a requisite central function. Table 1-36 decomposes this function into subactivities.

Table 1-36. Human Resources—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Staffing	Manage people to positions.
Recruiting	Recruit new employees.
Awards	Receive recommendations and approve awards.
Personnel actions	Perform personnel actions.
Training	Manage training for employees.
Benefits	Manage employee benefit programs.
Personnel records	Maintain and update employee personnel files.
Personnel policy	Develop and implement personnel policies.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-4.

1.2.4.5.2 Federal Assets

Federal partners perform this level of management for the assets under their purview.

1.2.4.5.3 Non-Federal Assets

Non-federal partners and RAs provide these management sub-activities within their own associations.

[148] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-4.

1.2.4.6 Acquisition and Grants

As described in the U.S. IOOS Blueprint, this function will

> acquire required items and services, award grants and cooperative agreements, and do independent cost estimates.[149]

1.2.4.6.1 Central Function

Acquisition and grants constitute a requisite central function. Table 1-37 decomposes this function into subactivities.

Table 1-37. Acquisition and Grants—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Purchasing	Make purchases (including government credit card).
Contracting	Manage contracts from identification of requirements through closeout.
Grants and cooperative agreements	Create FFO, conduct competitions, award grants and cooperative agreements, and manage postaward administration: • Services—Create and manage services grants and cooperative agreements. • R&D—Create and manage R&D grants and cooperative agreements.
Independent cost estimates	Conduct independent cost estimates in anticipation of a contracting action.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capa*bility, p. F-4.

1.2.4.6.2 Federal Assets

Federal partners perform this level of management for the assets under their purview.

1.2.4.6.3 Non-Federal Assets

RAs are the recipients of grant actions, and also create cooperative agreements and manage purchases and contracts.

[149] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-4.

1.2.4.7 Marketing, Outreach, and Engagement

As described in the U.S. IOOS Blueprint, this function will

> convince data providers, data/services customers, and model owners to participate in U.S. IOOS. This function includes "communications," outreach, and other aspects of managing the public face of U.S. IOOS, but has a strong central focus on causing the target audience to join and actively participate in the U.S. IOOS effort. Although some activities are similar to traditional "outreach," the purpose of outreach is to inform, while this effort is unsuccessful if only information is transmitted. This is targeted information designed to engender action. It is also fundamentally different from "training and education," where the intent is to give the target audience a skill or knowledge.[150]

1.2.4.7.1 Central Function

Marketing, outreach, and engagement constitute a requisite central function. Table 1-38 decomposes this function into subactivities.

Table 1-38. Marketing, Outreach, and Engagement—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Manage communication strategy	Create and manage the communication strategy, including identification of target audiences, desired outcomes, communications messages, channels, vehicles, schedules, and results assessments.
Create products	Manage creation of marketing, outreach, and engagement products, including brochures, web pages, articles, position papers, briefings, and congressional correspondence support documents.
Speaker program	Manage providing U.S. IOOS knowledgeable speakers at influential conferences and other venues according to the communications strategy.
Conference participation	Ensure knowledgeable and proactive participation at U.S. IOOS related conferences.
Membership in forums	Ensure that U.S. IOOS is properly represented in councils and forums of importance to U.S. IOOS.
News releases	Manage media engagement and information releases to press/media outlets and third-party communications managers and publishers.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-4–F-5.

1.2.4.7.2 Federal Assets

Some federal assets participate in these sub-activities; the degree to which they contribute to IOOS needs to be defined.

[150] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-5.

1.2.4.7.3 Non-Federal Assets

RAs contribute to these sub-activities through direct participation. RAs are actively engaged in the outreach of their efforts and engage other data providers to include their information in the IOOS system. RAs engage user communities by hosting conferences, presentations by staff members, publishing newsletters, websites, conducting meetings, and meeting one on one with members of the community.

1.2.4.8 IT SUPPORT

As described in the U.S. IOOS Blueprint, this function will

> manage information technology related to delivery of DMAC services and all realms of services for internal U.S. IOOS Program Office users.[151]

1.2.4.8.1 Central Function

IT support is a requisite central function. Table 1-39 decomposes this function into subactivities.

Table 1-39. IT Support—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Desktop management	Manage office IT services, including hardware, software, and help desk support. These services include desktop computers, printers, laptops, backups, COOP, hand-held devices, and other computer resources that interface with individuals.
Network management	Manage the U.S. IOOS-owned network, including cabling, servers, routers, bridges, gateways, etc. Due to the nature of computer networks, there is no differentiation between the network to support internal U.S. IOOS office needs and the network that provides DMAC services. The network will likely be a composite of owned, leased, and partner-provided assets.
Architecture management	Manage the IT architecture, including internal, network, and DMAC, to ensure effectiveness, efficiency, and compliance with federal and other standards. • DMAC—Manage IT services, including hardware, software, and help desk support related to the delivery of IOOS DMAC-compliant data and utility services. • IOOS Program Internal—Manage IT services, including hardware, software, and help desk support related to U.S. IOOS Program Office user needs.
Website management	Manage the U.S. IOOS website, including technical management and content management.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-4.

[151] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-5.

1.2.4.8.2 Federal Assets

Currently the federal assets do not contribute to this function.

1.2.4.8.3 Non-Federal Assets

RAs perform these sub-activities for their data assembly centers.

1.2.5 Research and Development Subsystem

As described in the U.S. IOOS Blueprint, this function will

> coordinate R&D efforts across U.S. IOOS participating entities. Also processes to manage R&D pilot projects, conduct technical assessments, field technology enhancements, and transition technology solutions from the laboratory to the field.[152]

Oceanographic and ecosystem research provides the foundation for the design and full implementation of U.S. IOOS. Research is providing the technologies and understanding required to build and improve a scientifically sound, operational observing system. Research projects selected for funding via the National Oceanographic Partnership Program process, as well as by individual federal agencies, support national research priorities established to provide the scientific foundation to improve society's stewardship and use of, and interaction with, the ocean.[153]

New technology and scientific knowledge is required to meet U.S. IOOS user requirements, improve products and their interpretation, develop new applications to serve existing requirements, and provide new products for user requirements not currently anticipated. For example, continued research is needed to develop data assimilation techniques to extract useful information from raw data streams and transform it into a data product that can be incorporated into models and end products. NOAA has already funded the Alliance for Coastal Technologies to conduct new sensor verification and validation tests and to support technology transfer efforts. Research communities from academia, industry, NGOs, and government agencies are needed to address these issues and, in addition, are important users of the data and information provided by U.S. IOOS. Therefore, it is critical to engage researchers and research agencies in the system's evolution. [154]

R&D is executed through the following functions:

- R&D requirements determination
- Coordination of R&D programs

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[152] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-18.

[153] Joint Subcommittee on Ocean Science and Technology, National Science and Technology Council, *Charting the Course for Ocean Science for the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy*, January 26, 2007.

[154] 2008 IOOS Report to Congress, p. 11.

- R&D pilot projects
- Technical assessments
- Technology enhancements
- Technology transition.

1.2.5.1 R&D Requirements Determination

As described in the U.S. IOOS Blueprint, this function will

> gather R&D requirements, analyze and prioritize those requirements, and publish the requirements to inform R&D efforts.[155]

1.2.5.1.1 Central Function

R&D requirements determination is a requisite central function. Table 1-40 decomposes this function into subactivities.

Table 1-40. R&D Requirements Determination—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Requirements gathering	Gather and record R&D requirements from all U.S. IOOS participating entities.
Requirements analysis	Analyze raw requirements and restate them in terms meaningful to the R&D community.
Requirements prioritization	Prioritize refined R&D requirements based on criticality and size of population that is experiencing the need.
Requirements publication	Publish the prioritized R&D requirements to all R&D performing entities in order to spark interest and coordinate efforts.

Source: U.S. Integrated Ocean Observing System: A Blueprint for Full Capability, p. F-18.

1.2.5.1.2 Federal Assets

The gathering, evaluation, prioritization, and publication and coordination of stakeholder requirements for R&D are a central functions of the federal agencies.

1.2.5.1.3 Non-Federal Assets

The gathering, evaluation, prioritization, and publication and coordination of stakeholder requirements for R&D are key functions of the RAs and RAs expending efforts performing these functions.

RA principal investigators are an engine of pilot R&D projects and strive to turn pilots into sustained successful operations where appropriate.

[155] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-18.

1.2.5.2 COORDINATION OF R&D PROGRAMS

As described in the U.S. IOOS Blueprint, this function will

> coordinate research and development activities among participating U.S. IOOS R&D organizations.[156]

1.2.5.2.1 Central Function

Coordination of R&D programs is a requisite central function. Table 1-41 decomposes this function into subactivities.

Table 1-41. Coordination of R&D Programs—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Sponsor forums	Sponsor forums where R&D-capable organizations can meet to discuss approaches to solving R&D requirements.
R&D progress monitoring	Monitor and report progress in addressing R&D requirements based on R&D activities in participating organizations.
R&D grants technical management	Assess and manage R&D efforts that accrue from R&D grants made by or through U.S. IOOS.
R&D agreements management	Create and manage cross-organizational R&D agreements to pursue solutions to prioritized R&D requirements.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-18.

1.2.5.2.2 Federal Assets

U.S. IOOS Program office and other federal partners are involved in R&D coordination for systems and are under their area of expertise.

1.2.5.2.3 Non-Federal Assets

RAs are actively involved in coordinating local research and development functions. RAs provide discussion venues for their principal investigators to share and compare research efforts. RAs include research efforts in their annual budget to carry on, promote, and sustain R&D efforts.

[156] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-18.

1.2.5.3 R&D PILOT PROJECTS

As described in the U.S. IOOS Blueprint, this function will

> create and manage R&D pilot projects that demonstrate R&D solutions to assess effectiveness and limit risk.[157]

1.2.5.3.1 Central Function

R&D pilot projects constitute a requisite central function. Table 1-42 decomposes this function into subactivities.

Table 1-42. R&D Pilot Projects—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Concept development	Control development of R&D pilot project concepts, including concept approval.
Project team agreements	Create multi-organizational R&D project teams to implement R&D pilot projects.
Project management	Manage the R&D pilot project execution.
Budgeting	Plan, budget, and execute financial aspects of the R&D pilot projects.
Reporting	Assess technical merits of the R&D pilot project and report results.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-18.

1.2.5.3.2 Federal Assets

U.S. IOOS Program office and other federal partners are involved in R&D pilot projects for systems and are under their area of expertise. For example, U.S. IOOS, ONR, and other federal partners were active promoters of national fielding of HFR. The initial fielding of HFR has increased recreational boating safety by reducing search and rescue times. This pilot project was successful and now an expansion of the program is sought to increase safety over an expanded domain.

1.2.5.3.3 Non-Federal Assets

RA PIs get involved in R&D pilot projects when opportunities present, and seek to turn successful pilots into sustained operation. For example, MACOORA expended R&D investments to increase the operational function of HFR; and those investments benefitted all RAs as HFR was fielded nationally. Much of the ocean observing in the Alaska region is experimental in nature as researchers strive to operate HFRs, buoys and other sensors function consistently in remote locations with extreme weather and seasonal ice. The Alaska research lends to better observations in the AOOS region and other areas affected by ice and extreme weather.

[157] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-18.

1.2.5.4 TECHNICAL ASSESSMENTS

As described in the U.S. IOOS Blueprint, this function will

> conduct assessments of existing technology that is either in use or available for implementations from a government or commercial source. These assessments will generally be to assess the fidelity of observations and or durability and reliability of the sensor or platform.[158]

1.2.5.4.1 Central Function

Technical assessments constitute a requisite central function. Table 1-43 decomposes this function into subactivities.

Table 1-43. Technical Assessments—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Candidate technology management	Keep visibility of technology that is available and aspects of that technology that require assessment.
Technology assessment design	Design technology assessments that are scientifically sound and that can be practically conducted within budget.
Budget	Manage the financial planning and execution of technology assessments.
Plans	Plan and coordinate the technology assessments.
Operations	Conduct technology assessments.
Report generation	Assess the findings of the technology assessment and create comprehensive reports on findings.
Findings publication	Publish the findings of technology assessments to concerned parties and to make the findings generally available to all concerned U.S. IOOS participants.
Archives	Keep permanent archives of assessment to ensure their availability for future use.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, pp. F-18–F-19.

1.2.5.4.2 Federal Assets

The U.S. IOOS Program Office promotes technology assessments, particularly though funding the ACT.

1.2.5.4.3 Non-Federal Assets

RA researchers frequently evaluate new technologies through observational trials. In addition, ACT provides independent verification and validation of sensors, buoys, cables, and observing components. Some ocean observing equipment is manufactured by small technology companies and start-ups, and this validation

[158] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-18.

assures buyers that the observing equipment functions as designed so that the market for observing equipment can function efficiently. The ACT also provides beta testing on the manufactured products back to the manufacturers.

1.2.5.5 Technology Enhancements

As described in the U.S. IOOS Blueprint, this function will

> manage implementation of technology enhancements or upgrades to existing technology to include sensors and platforms.[159]

1.2.5.5.1 Central Function

Technology enhancements constitute a requisite central function. Table 1-44 decomposes this function into subactivities.

Table 1-44. Technology Enhancements—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Project definition	Define succinct projects that field specific upgrade packages to specific sets of hardware or software on a specific timeline.
Project management	Manage the execution of planned technology enhancements.
Agreements management	Create and manage cross-agency/organization agreements to allow execution of the planned technology enhancements.
Budgeting	Manage the planning and execution of funds associated with fielding technology enhancements.
COTR	Manage contractors, if needed, that execute fielding of technology enhancements.
Test and evaluation	Test and evaluate that the enhancements are properly applied and the resulting improved technology performs to expected standards.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-19.

1.2.5.5.2 Federal Assets

The U.S. IOOS Program Office promotes technology assessments, particularly though funding the ACT.

1.2.5.5.3 Non-Federal Assets

RA researchers frequently evaluate new technologies through observational trials. ACT assists in technology enhancements by testing technologies and providing advisories to manufacturers.

[159] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-19.

1.2.5.6 Technology Transition

As described in the U.S. IOOS Blueprint, this function will

> assist with transitioning new R&D products from the labs to use in the field. In some cases, the R&D product will be an enhancement to an existing technology that will be executed using the processes defined for "technology enhancements." The processes described here in "Technology Transition" will normally apply to fielding new technology solutions that may include new hardware, software, procedures, maintenance procedures, etc.[160]

1.2.5.6.1 Central Function

Technology transition is a requisite central function. Table 1-45 decomposes this function into subactivities.

Table 1-45. Technology Transition—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Project definition	Establish comprehensive projects to field new technology to specific customers on a specific timeline to include training.
Project management	Manage the execution of planned technology transitions.
Agreements management	Create and manage cross agency/organization agreements to allow execution of the planned technology transition.
Budgeting	Manage the planning and execution of funds associated with technology transition.
Test and evaluation	Test and evaluate that the technology transition are properly implemented and the resulting technology performs to expected standards.

Source: U.S. Integrated Ocean Observing System: A Blueprint for Full Capability, p. F-19.

1.2.5.6.2 Federal Assets

The degree to which the federal assets participate in this function should be described here.

1.2.5.6.3 Non-Federal Assets

No non-federal assets associated with this function.

[160] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-19.

1.2.6 Training and Education Subsystem

As described in the U.S. IOOS Blueprint, the training and education subsystem will

> manage development of U.S. IOOS specific training and educational materials to support the needs of training and education providers. These processes include development of training and education strategy, plans, and curriculum. Other processes include development and execution of training and education pilot projects, assessments and professional certifications.[161]

U.S. IOOS provides a capability to change the public perception of our oceans and motivate people to become stewards of the environment. The U.S. IOOS Program office will work with federal, regional, and other partners to develop a science- and technology-literate society and workforce to create the breakthroughs needed to tackle the challenges involving our oceans and coasts. [162] The interdependencies among the national, regional, and state IOOS components require building on existing efforts in training and education to achieve the goals and objectives of IOOS. [163]

Although the U.S. IOOS Program Office will not own classrooms or schools, it will be a key provider of training and education materials. These materials can be geared to teaching specific skills (training) or can support development of knowledge about the marine environment (education). The U.S. IOOS Program Office will work with training and education providers to understand their requirements and to develop products and services to meet those needs. As identified in the IWGOO strategic plan, the U.S. IOOS Program Office will engage professional societies to assist with training and the development of professional certifications.[164]

Training and education are executed through the following functions:

- Training and education strategy and plans development
- Training and curriculum development
- Training and education pilot projects
- Training and education assessments
- Collaboration with education delivery managers
- Professional certifications.

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[161] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-19.
[162] 2008 IOOS Report to Congress, p. 11.
[163] 2008 IOOS Report to Congress, p. 10.
[164] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. 2-7.

1.2.6.1 Training and Education Strategy and Plans Development

As described in the U.S. IOOS Blueprint, this function will

> develop U.S. IOOS training and education strategies and plans to achieve training and education strategic goals.[165]

By 2014, the IOOS education component will focus primarily on training and outreach to ensure that resource and emergency managers, national and local decision makers, and other key user communities are able to understand and apply the improved observation products and services for maximum benefit and return on investment. A similar effort will be made to reach out to IOOS data providers and other partners to communicate and ensure proper implementation of the standardized data management and quality control procedures to address inconsistencies and incompatibilities. These education efforts will enable development of a truly integrated system.[166]

Ultimately, the U.S. IOOS Program Office will partner with the broader ocean education communities to develop a comprehensive education component that uses the outputs of these enhanced products and services to increase understanding of our ocean environment and its importance for society. The U.S. IOOS Program Office will capitalize on the significant expertise within NOAA, regional, and interagency education communities to design and deliver the training modules and materials needed to support full application of IOOS data products and tools.[167]

1.2.6.1.1 Central Function

Training and education strategy and plans development is a requisite central function. Table 1-46 decomposes this function into subactivities.

Table 1-46. Training and Education Strategy and Plans Development—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Strategy development	Manage development of U.S. IOOS training and education strategy.
Plans development	Manage development of U.S. IOOS training and education plans.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

[165] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.
[166] 2008 IOOS Report to Congress, p. 11.
[167] 2008 IOOS Report to Congress, p. 11.

1.2.6.1.2 Federal Assets

The U.S. IOOS Program Office promotes development of training and education through its regional and federal partners.

1.2.6.1.3 Non-Federal Assets

RAs, including AOOS, provide lead PIs for COSEE regional offices. COSEE is a NSF funded program for ocean education, and uses the observing system as a component of teacher workshops and other education programs. Additionally RAs coordinate training and education in their regions to the extent that their resources allow. SECORRA has an Education and Outreach committee that defines and coordinates its projects for the RA.

1.2.6.2 Training and Curriculum Development

As described in the U.S. IOOS Blueprint, this function will

> manage development of U.S. IOOS training programs and curriculum.[168]

1.2.6.2.1 Central Function

Training and curriculum development is a requisite central function. Table 1-47 decomposes this function into subactivities.

Table 1-47. Training and Curriculum Development—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Training development	Develop training programs to meet the needs of U.S. IOOS members (organizations and individuals).
Curriculum development	Develop curriculum to meet the educational needs of U.S. IOOS members (organizations and individuals).

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

1.2.6.2.2 Federal Assets

No federal assets are associated with this function.

1.2.6.2.3 Non-Federal Assets

The Centers for Ocean Sciences Education Excellence (COSEE) Network has established to 12 thematic and regional Centers located around the U.S. The overall mission is "to spark and nurture collaborations among research scientists and educators to advance ocean discovery and make known the vital role of the ocean in our lives." COSEE goals include integrating ocean research into high-quality

[168] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

educational materials; enabling ocean researchers to better understand educational organizations and pedagogy; and enhancing high-quality educational programs in the ocean sciences. AOOS and other RAs work with COSEE curriculum development to incorporate ocean observing. Many RAs PIS develop training and education. For example, PacIOOS is involved, directly, in both curriculum development and training. Our personnel, through PacIOOS support, have taught professional and introductory level GIS classes in Hawaii and the Marshall Islands. These classes are taught annually in one or more PacIOOS sub-reigons. Also, PacIOOS has been directly involved in the development of ocean science curriculum in Hawaii through the Navigating Change Curriculum Program. The Navigating Change Curriculum Program combines scientific, cultural, and stewardship principles into a hands-on curriculum that aims at encouraging students to be proactive about caring for the land and sea in their neighborhoods (aka "navigating change in their communities"). The program coordinator felt that an important addition to the curriculum was a unit addressing climate change. PacIOOS created a climate change unit that addresses two topics: 1) sea level rise, and 2) ocean temperature and coral health. All materials are available on a teacher resource CD which includes two in-class lessons and accompanying hands-on activities, hand outs, instructional video, and informational video on global ocean observing.

SECOORA will partner with the Monterey Bay Research Institute to offer a 2012 Education and Research, Testing Hypotheses (EARTH) workshop. EARTH has a strong history of delivering inquiry lessons based on ocean observing systems and real-time data. The workshop will deliver lesson plans based on data from SECOORA assets, aligned with national science standards, and posted on both the EARTH and SECOORA websites. SECOORA also supports the development of additional teacher materials.

1.2.6.3 Training and Education Pilot Projects

As described in the U.S. IOOS Blueprint, this function will

> develop and execute U.S. IOOS specific training and education pilot projects.[169]

1.2.6.3.1 Central Function

Training and education pilot projects constitute a requisite central function. Table 1-48 decomposes this function into subactivities.

[169] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

Table 1-48. Training and Education Pilot Projects—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Concept development	Manage the development of training and education pilot project concepts.
Project team agreements	Secure agreements with participating organizations to conduct the training and education pilot project.
Project management	Manage the conduct of training and education pilot projects.
Budgeting	Manage the financial planning and execution of training and education pilot projects.
Reporting	Manage reporting results from training and education pilot projects.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

1.2.6.3.2 Federal Assets

No federal assets are associated with this function.

1.2.6.3.3 Non-Federal Assets

RAs support and participate in training and education pilot projects as budgets an opportunity allow. For example, SECOORA has been working with COSEE-SE and NOAA IOOS on the Basic Observation Buoy (BOB) project. BOB is a low cost student-constructible floating platform with capacity to carry a suite of environmental sensors.

1.2.6.4 Training and Education Assessments

As described in the U.S. IOOS Blueprint, this function will

> create, execute, and assess the results of U.S. IOOS training and education programs. These assessments may take the form of standard tests that accompany training packages and curriculum, or they may be assessments of effectiveness of training programs and curriculum. Assessments include the creation, executing, and evaluation of certification testing for U.S. IOOS professional certifications.[170]

1.2.6.4.1 Central Function

Training and education assessments constitute a requisite central function. Table 1-49 decomposes this function into subactivities.

[170] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

Table 1-49. Training and Education Assessments—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Work force needs assessments	Create, execute and assess the training and education needs of U.S. IOOS workforce. This includes U.S. IOOS Program Office personnel as well as data providers, archives, sponsored model owners, and data/services customers.
Assessment development	Develop assessments tools to support training programs and curriculum products to include professional certifications.
Assessment results and evaluation	Evaluate the results of administered assessments and determine effectiveness of training and education efforts and to provide feedback to improve future training and education products.

Source: U.S. Integrated Ocean Observing System: A Blueprint for Full Capability, p. F-20.

1.2.6.4.2 Federal Assets

No federal assets are associated with this function.

1.2.6.4.3 Non-Federal Assets

No non-federal assets are associated with this function.

1.2.6.5 Collaboration with Education Delivery Managers

As described in the U.S. IOOS Blueprint, this function will

> manage relationships with entities that deliver educational services and deliver U.S. IOOS-related training or education. U.S. IOOS will not own classrooms or instructors, but will provide training programs and curriculum for others to use. This requires robust collaboration to ensure that training and education requirements are well understood and to ensure that training and education products are properly used.[171]

1.2.6.5.1 Central Function

This requisite central function has not been decomposed into subactivities.

1.2.6.5.2 Federal Assets

The degree to which the federal assets participate in this function should be described here, specifically the plans and actions supporting the provision of education products.

[171] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

1.2.6.5.3 Non-Federal Assets

Many primary investigators that participate in the RAs are university professors, who provide training and education. RAs are also engaged in research and education collaboration through local partners such as COSEE. As a partner of COSEE AK, AOOS works closely with rural school districts and their curriculum developers. SECOORA coordinates with educators in the BOB project and EARTH Workshops. COSEE-SE and COSEE-FL are members of SECOORA. Numerous other partnerships exist.

1.2.6.6 Professional Certifications

As described in the U.S. IOOS Blueprint, this function will

> create and manage U.S. IOOS professional certifications, as required. These certifications may be related to any of the U.S. IOOS subsystems. Examples may include IT certifications at the data provider/archive level related to proper integration of U.S. IOOS data services or certifications to manage U.S. IOOS test and evaluation projects.[172]

1.2.6.6.1 Central Function

Professional certifications constitute a requisite central function. Table 1-50 decomposes this function into subactivities.

Table 1-50. Professional Certifications—Core Function Subactivities

Core function subactivity	Description and lower-level subactivities
Standards development	Develop the standards for certifications.
Publications	Publish and maintain the certification standards.
Assessment administration	Perform assessments of an individual's ability to meet certification standards.
Application processing	Receive and adjudicate request for certification packets.
Certification and notifications	Award certification and make notifications.
Records maintenance	Maintain records of certifications so that concerned parties can easily access them.

Source: *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-21.

1.2.6.6.2 Federal Assets

No federal assets are associated with this function.

1.2.6.6.3 Non-Federal Assets

No non-federal assets are associated with this function.

[172] *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, p. F-20.

1.3 WORK BREAKDOWN STRUCTURE

A work breakdown structure (WBS) is used in cost analysis to facilitate and improve the cost estimate. The WBS provides a logical framework for costable elements that constitute the entire structure. It helps ensure that all elements of a project or program are included in the cost estimate. In the case of an independent cost estimate, the WBS provides a common framework, making side-by-side comparison of two estimates of the same program easier, enabling eventual reconciliation. Appendix C contains a WBS designed to be used in costing the U.S. IOOS program.

1.4 SYSTEM QUALITY FACTORS

This section describes the attributes—reliability, maintainability, availability, usability, and other quality factors—that U.S. IOOS must have if it is to provide acceptable levels of functionality.

1.4.1 Reliability

Reliability is the ability of a system or component to perform its required functions under stated conditions for a specified period of time. To system engineers, reliability is a probability distribution. For most people, the practical use of the term “reliability” is mean time between failures, or the length of time a piece of equipment can be expected to perform its job before stopping and needing repair or replacement.

For some systems, such as computer equipment, computing a mean lifetime is relatively easy because the variance around the average lifetime is fairly tight. Most of the equipment fails at about the same time, exhibiting a marked central tendency. For other systems, such as U.S. IOOS observing assets like buoys fitted with sensors and transmitters, lifetimes are highly variable. In a group of 50 buoys deployed at the same time, some will cease functioning in days, some will last years, and some will continue sending data several lifetimes beyond their expected duration. A proper average or mean life cannot be accurately computed for a population when not all the members have reached a measurement age. Excluding those that are still functioning from the age computation underestimates the true capabilities. For this reason, they are commonly measured with a half life. Computing the half life simply requires reporting the lifetime of the median-lived asset when arranged from youngest to oldest.[173]

Lifetimes and expected reliability vary greatly depending on the asset and its deployment setting. NOAA’s experiences with in situ ocean observing systems have

[173] Rick Lumpkin and Mayra Pazos, *Lifetime Statistics of Most Recent Drifter Deployments (2000-2003, Global Drifter Program/ Drifter Data Assembly Center, NOAA/AOML, Miami, Florida)*, DBCP-20, Chennai, India, October 18–22, 2004.

been uneven. Two experiences highlight the reliability of an observing system as a key quality factor:

- The initial deployment of DART buoys was completed successfully; subsequently, the DART array grew from 6 to 39 moorings. The DART buoys have experienced O&M problems (at one time, 13 of 39 moorings were out of service), and its cost of operation has increased as the number of moorings has grown and as the location of these moorings has increased travel time.[174]
- TAO buoys are still being deployed. The NOAA Inspector General's report indicates that the TAO array has experienced O&M problems and had problems with moorings periodically going off-line.[175]

Reliability both for observing assets and for data management services is perhaps best considered in the context of availability, which considers not only the inherent lifetime, but also duplication of assets, which ensures availability of an asset even if reliability is uncertain.

1.4.2 Maintainability

Most of the assets that make up the U.S. IOOS observing systems have high maintenance costs, because of the relatively harsh environment in which they operate. Buoys in areas of high recreational boating activity often suffer vandalism or breakage from tie ups, theft, or pure curiosity. Although a channel marking buoy can operate for up to 20 years, it needs annual maintenance to prevent it from being moved during high-sea conditions or blocked in by ice. The sensors that observe from buoys operate in moist and salty sea air, which is highly corrosive to electronics. Batteries powering the transmission of data from the sensors to a satellite relay system must be fairly powerful; they require regular replacement to continue providing their function. Some buoy maintenance requires buoys to be picked up and put down again. Maintaining most observing assets requires boats, which themselves require maintenance.

The data management centers also require standard routine maintenance.

1.4.3 Availability

The systems engineering definition of availability is the proportion of time a system is in a functioning condition. This is often described as a mission-capable rate. Mathematically, this is expressed as 1 minus unavailability, or as the ratio of uptime to total time. When the ratio of uptime to total time is expressed as a decimal, high availability requirements are expressed as a series of nines, e.g., 99.99 percent uptime. There is always a cost to increasing uptime; in fact, for

[174] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, p. 5-4.

[175] *The National Data Buoy Center Should Improve Data Availability and Contracting Practices*, Final Inspection Report No. IPE-18585, May 2008, p. 6.

most systems, the marginal increments of availability cost increasingly more. This is because minimizing downtime requires excess parts and repair personnel to be on hand all of the time. Maintaining a large inventory of spare parts and a staff of maintenance technicians available round the clock is much more costly than providing the same repair rate on a 2-hour delay. Because unnecessary levels of availability carry a high cost in resources, the desired level of availability must be chosen with care.

The DAC desired availability is 24 hours a day, 7 days a week. With redundant data servers, 99.9% availability should be achievable.

1.4.3.1 BACKUP AND ARCHIVES

Data from observing assets are currently archived at the data center that hosts the data. At full operational capability, archives will be fully redundant, possibly through mirroring and a regular archiving schedule, with backups kept for years.

1.4.3.2 REDUNDANT SYSTEMS

1.4.3.2.1 Observing Assets

At the current state of the art, most autonomous observing stations do not deliver prognostics, so there is no warning when they will fail. Every failure is a corrective maintenance event. Redundancy is pursued in observing assets when possible, both in redundant numbers and in redundant systems. Thus availabilities of 75 percent of single assets do not have disastrous consequences for analysis and data collection. Further, most analysis capabilities have evolved methods for smoothing or interpolating over missing data values.

1.4.3.2.2 Data Management

The data management systems maintained by the non-federal observing associations currently collect, sort, archive, and provide data for the observing assets that belong to their association. This includes assets owned by the RA, assets owned by a cooperative association and maintained by the RA, and assets owned and maintained by a cooperative association.[176] The data management services have availabilities consistent with university or nonprofit data centers, that is, sufficient to support research and analysis, but not in the realm of high availabilities associated with, for instance, emergency support services or flight-critical systems.

[176] Some regional observing associations are made up of multiple cooperating associations. For instance, the Gulf of Mexico Coastal Ocean Observing System receives data from systems such as the Dauphin Island Sea Laboratory, Texas Coastal Ocean Observation Network, Mote Marine Laboratory, Coastal Ocean Monitoring and Prediction System, Central Gulf Ocean Observing System, Louisiana Universities Marine Consortium, Wave-Current-Surge Information System, and Texas Automated Buoy System.

1.4.3.3 Redundant Access

Currently, the RAs' data management centers have limited inter-redundancy. For instance, NERACOOS lists some data that are also supported by MACOORA. Most RAs also list assets that belong to NBDC. Some data are hosted in redundant servers, ensuring higher availability. In full operational capability, all data assets will be served by redundant servers or will be mirrored among the RAs, for full availability despite any local issues.

The models and analysis products also have availability consistent with study or university products.

1.4.4 Usability

The RAs' data centers offer data according to these protocols:

- OPeNDAP (Open-source Project for a Network Data Access Protocol), a set of protocols that allows web access to scientific data and imagery across servers. MATLAB and Java application search and retrieval are enabled on OPeNDAP data servers.
- THREDDS (Thematic Realtime Environmental Distributed Data Services), a federally supported web service protocol that supports metadata, searching, and publishing.

Data and imagery are accessible to other observing associations, researchers, universities, and the general public worldwide, via all the tools in a web browser and with several analytical and scientific applications as well. Metadata allows convenient searching and access of the stored information.

1.4.4.1 Accuracy

No national standards have been established in U.S. IOOS for raw observing asset data. Models and applications follow individual standards for identifying and discounting outlying values due to error, often caused by sensor failure.

The RAs are involved in monitoring the quality of data produced by observing assets. The DMAC functions are involved in assuring quality of the resulting data products. These quality control and quality assurance functions may seem to overlap but both are essential.

1.4.4.2 Responsiveness

Responsiveness is the specific ability of a functional unit to complete assigned tasks within a given time. It is one of the criteria under the principle of robustness. Responsiveness in a data and imagery context refers to upload and download speed and to model and application speed.

Responsiveness from a provider perspective is often managed through thorough metadata, bulk download options, and provision of download time estimates, which prevent users from mistakenly downloading large datasets, which can slow server speeds and is one of the demands that leads to denial of service. Thus the data provider should ensure accurate characterizations of the data provided, provide subsample data sets for trial downloads, offer compressed download options, and properly size the server supply for the download demand. Mirroring is a cost-effective way to manage spikes in demand caused by the posting of popular new applications or datasets.

At full operational capability, U.S. IOOS data centers should offer utilities as well as downloads. Federal data sites such as the Department of Transportation Statistics and the Bureau of Labor Statistics provide staff members to assist any and all users with download services.

1.4.5 Additional Quality Factors

This section discusses quality factors of U.S. IOOS services that may be second-order cost drivers.

1.4.5.1 Technology Obsolescence

Each in situ observational systems, whether wholly or partially owned, was implemented to respond to specific data collection requirements and support specific program goals. Over time, the continued development of single-solution systems has created a portfolio management problem, because with each system comes an enduring O&M requirement. The rapid pace of technological evolution and the small size of the marine instrumentation market[177] have exacerbated this problem by increasing the rate of capability development and, at the same time, the rate of obsolescence.[178] This reduces the ability of researchers, engineers, and technicians to standardize their designs on a fixed set of components, and it increases the numbers and types of equipment in use. As a result, NOAA now owns a diverse, distributed set of observing assets that it must maintain in order to sustain the flow of observational data.[179]

To ensure that existing systems can continue providing ocean data well into the future, NOAA is developing or has developed recapitalization plans for the major observing systems. The plans are intended to provide a strategy to support investments in ocean observing systems to ensure the sustained collection and delivery of ocean data.[180]

[177] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 1-1.
[178] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-1.
[179] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-1.
[180] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 1-1.

Federal partners also provide satellite information to U.S. IOOS. Satellite life cycles are typically 5 years. To continue providing services, the satellites must be refreshed. A period of overlap between old and new satellite services is desired to allow for time series calibration.

Data management and analysis centers will also need to refresh their equipment. In fact, they should establish a regular upgrade cycle to accommodate growing datasets, growing user communities, and increased products, including models. A regular hardware and software refresh cycle should be assumed for the existing and growing data centers.

1.4.5.2 Potential New Technology Developments

The core observation variables listed in Section 1.1.2 of this document are not all collected within U.S. IOOS. To support collection of these variables, existing observing assets will have to be retrofitted or new observing assets acquired.

As U.S. IOOS models additional phenomena and takes on new questions, more variables will be added to the list. New observing assets will have to be developed and deployed to meet this challenge in the years after U.S. IOOS has reached full operational capability.

1.4.5.3 Environmental Factors

The costs of retrieving and disposing of used observing assets and maintenance platforms such as boats should be included in the total U.S. IOOS cost estimate. The costs of any reparations of identifiable environmental damage as a result of observation also must be estimated.

1.5 Embedded Security

Normal firewall, antivirus, and archival services for the U.S. IOOS data centers must be pursued. As global terrorists move into the realm of cyberterrorism to create economic disruption, it must be assumed that U.S. IOOS could be a potential target, because it can be perceived as a government computer service. Current cybersecurity costs can be assumed to grow in magnitude over the development of U.S. IOOS to full operational capability and in the period beyond. These costs will be borne by the hosting authorities. In particular, access to IOOS data servers may have to be restricted to administrators, and data archives may have to be secured, perhaps with offline archival capability.

U.S. IOOS will have to meet compliance data security requirements, which are defined as the process of establishing and maintaining a framework and supporting management structure and processes to provide assurance that information security strategies are aligned with and support business objectives, are consistent with applicable laws and regulations through adherence to policies and internal controls, and provide assignment of responsibility, all in an effort to manage risk.[181]

Encrypted data services with the federal air and marine fleet that supports services such as undersea imagery will be needed as well.

[181] *Strategic Satellite Plan FY2010–2019*, December 2007, p. 12.

Section 2.
System Operational Concept

2.1 ORGANIZATIONAL STRUCTURE

Achieving an effective U.S. IOOS requires organizational integration as well as data and product integration. To achieve the full potential of U.S. IOOS, the NOAA IOOS Program will lead program decision-making, support the development of regional capabilities, and ensure that the U.S. IOOS observing subsystem has sufficient observation capabilities.[1]

The U.S. IOOS Blueprint identified functions to be managed centrally by the U.S. IOOS Program Office. Those functions may be carried out by the internal workforce, other federal partners, RAs, contracted personnel, or other entities operating under grants and cooperative agreements. IOOC will fulfill its role in the central functions as defined in the ICOOS Act.

Federal partners and non-federal partners such as the RAs are the principal deliverers of observing assets and data. In general, the entity that carries an asset on its property books is considered responsible for its operation and maintenance in the fulfillment of the central functions. There are some exceptions, however. Appendix A contains a table listing the observing assets and, for each, identifying the owner and the entity responsible for maintenance.

2.2 OPERATIONS AND SUPPORT CONCEPT

The overarching assumption of support responsibility lies with the organization keeping a particular asset on its books. For instance, an HFR may have been purchased under an award by the Office of Naval Research and transferred to an RA, which now has maintenance and operational responsibility for the asset. Such support may be funded through competitive grants from NOAA, but the support responsibility lies with the office or agency carrying the asset on its books.

The support concept varies by asset. Each asset type requires its own form of support. Support for sea-based observing platforms is provided by observing organization members (see Appendix A for details). Operators of ocean observing assets are responsible for transmitting their data to a U.S. IOOS DAC (federal, regional, or other DMAC-capable site).

[1] 2008 IOOS Report to Congress, p. 39.

2.2.1 Hardware

Sea-based observing assets contain equipment for reporting observing information. The observations are collected by the RA that owns the asset and is a part of its workload. Currently, most observing assets' prognostics are limited or unknown; the data center knows that a sensor needs maintenance when it ceases reporting or reports consistently outlying variables. As the science of sensor buoys is developed, however, more informative reports may be developed by the sensor manufacturers.

Support for observing data centers is provided by the operators.

2.2.2 Software

Software for data services, models, and applications require continuous maintenance, because the products are being continuously improved, even after reaching full operational capability. Software licenses fees apply.

Many operational models will be maintained and operated by nongovernmental associations such as ESRI, GLERL, Scripps, and Woods Hole. Other models are operated and maintained by agencies of the federal government (EPA, NOAA) and by certain state government agencies, such as Coastal Ocean Currents Monitoring Program, even though the models are hosted, mirrored, or linked from RA websites. Models of the physical attributes of the ocean include atmospheric forcing (e.g., wind, heat content, precipitation), buoyancy flux forcing (e.g., from river discharge), tidal forcing, state-of-the-art ocean physics and numerical modeling, and possibly particle tracking. Ecosystem models may be coupled with the physical models and may include nutrients, dissolved oxygen, suspended sediments, phytoplankton, zooplankton, sea grasses, fish, marine mammals, sea turtles, and other parameters.

Operational models should be maintained and operated round the clock.

2.3 MAINTENANCE

2.3.1 Observing Assets

Sea-based observing assets require regular maintenance, generally provided by boat. Appendix D contains the life cycles of buoy-mounted sensors and batteries. Maintenance to replace batteries and sensors is required on regular intervals. Some assets, like floaters and drifters, require pickup at the end of their useful life. Table 2-1 lists maintenance intervals for observing assets.

Table 2-1. Maintenance Intervals for Observing Assets

Observing asset type	Maintenance requirements	Availability requirements
Water-level gauge, hurricane proof	1–4 service visits/year	24/7 availability; service restored within 3 days of failure
Stream gauges	1–4 service visits/year	24/7 availability; service restored within 3 days of failure
Gliders and AUVs	1–2 service intervals/year	Variable availability
Buoys	12 service visits/year for repair, defouling	24/7 availability; service restored within 3 days of failure
HAB stations	12 service visits/year	24/7 availability; service restored within 3 days of failure
HFR stations	12 service visits/year	24/7 availability; service restored within 3 days of failure
Autonomous meteorological stations	2–4 service visits/year	24/7 availability
HOVs	Service after each mission and mid-life overhaul	Variable availability

Labor can be provided by researchers and scientists. Boats used to provide maintenance may be owned or leased.

2.3.2 DMAC

Server and computer equipment should be refreshed every 5 years.

2.3.3 Models

Models may require either continual or periodic (monthly, annual) maintenance and updates. Newer models still undergoing improvements will consume 50 percent of a model developer's time over a year. Mature models require only incidental backups, updates, and minor changes. Every 3 to 5 years, models will need to be rehosted and will require recoding or virtual machineware (VMWARE) to ensure continual operation.

2.3.4 Maintenance Assets

Researchers and scientists currently maintain seagoing observing assets. The USCG and the NOAA marine fleet maintain major seagoing buoys; buoy maintenance requires specialized boats, cranes, and capture hooks.

In situ observing systems have significant maintenance requirements, which need ship time to support. With the growth in NOAA's system inventory, the need for ship time grows as well. According to the Office of Marine and Aviation Operations (OMAO) NOAA Ship Recapitalization Plan, the number of operating ships will decrease from 10 in 2010 to 6 in 2017; operating days are expected to decline over the same period from 1,858 to 1,255.[2] Currently, to meet ship-time requirements, NOAA utilizes its own fleet resources, chartered ships from the University National Oceanographic Laboratory System (UNOLS) fleet, ships of opportunity, and ships provided by its foreign partners.[3]

NOAA ship scheduling is managed by the NOAA Fleet Allocation Council, as part of the NOAA Planning, Programming, Budgeting, and Execution System (PPBES) process[4] Requests that could not be filled in part or at all had to be met using program funds, partner agreements, ships of opportunity, or some other alternative arrangement. The determination of how many ship-days would be allocated came late in the PPBE year, limiting a program's ability to garner additional funding to acquire additional ship-days.

A number of factors enter into the ship request and subsequent ship scheduling process. Among the most important are the capabilities of alternative ships such as charters, UNOLS fleet, and partner vessels to meet a program's specific needs; and the priority of program needs. Given this complex set of variables, and the fact that the total demand far exceeds the available supply represented by NOAA ships, scheduling has become increasingly critical to the research and operations organizations.[5]

Because the current process does not sufficiently support the needs of system owners, NOAA is refining its ship-day allocation process. The new process establishes a more formal prioritization method, based on the following criteria:[6]

- NOAA mission goals supported
- Field of science
- Berths required (NOAA and non-NOAA)
- Ship capabilities required
- NOAA vessel preferences
- Piggyback possibilities with other projects
- Days At Sea and time frame
- Time sensitivity for project completion
- Risks from not completing the project

[2] *NOAA Ship Recapitalization Plan (2008)*, p. 141.

[3] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 4-1.

[4] See http://www.omao.noaa.gov/fleettimereq.html.

[5] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 4-2.

[6] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 4-2–4-3.

- Availability of program funds to pay for non-NOAA ship alternatives
- Legislative mandates, executive orders, and international treaties
- Impact on society
- NOAA vessel capability
- Long-term data series
- Promotion of One NOAA projects.

2.4 SUPPLY

Commercial off-the-shelf parts are often used, except for satellite operations.

2.5 TRAINING

Training for the maintenance of observing assets is a part of researcher time that could otherwise be spent on data analysis. At full operational capability, third-party maintenance may be assumed for the observing assets.

Section 3.
Requirements and Services

3.1 PROGRAM REQUIREMENTS

U.S. IOOS Program requirements are documented in *IOOS High Level Functional Requirements, Version 1.5*, published in January 2009. That document describes the seven parameters collected in the DIF in Sections 2 and 3, but Section 4 contains the most complete accounting of requirements for the DMAC subsystem. In addition, the Blueprint identifies the central functions and subsystems requirements for the U.S. IOOS Program Office.

Requirements for U.S. IOOS come from the ultimate users. Defining the requirements is accomplished through three constructs:

- Fulfilling the seven societal benefit areas[1]
  - weather and climate
  - marine operations
  - natural hazards
  - national and homeland security
  - public health
  - healthy ecosystems
  - sustained resources;
- Answering user needs at the local level, and
- Federal requirements.

The RAs express their derived requirements through their budget requests and budget justifications, and through the *Regional Build Out Plans*. RA requirements contain requirements derived from all three requirement sources listed above. The U.S. IOOS Program Office helps guide the implementation of Federal requirements through its annual budget request review, by specifying requirements in RA submissions. For instance, national fielding of HFR was a requirement for RA budget requests; all RA budgets had to include a component of HFR for the budget request to be accepted. Not all Federal requirements need to be

[1] U.S. IOOS Office, *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, Version 1.0, November 2010, p3-12.

expressed this way; federal partners can work directly with RAs and PIs, and other needs could be expressed in legislation, such as the ICOOS Act of 2009.

Requirements for the temporal and spatial frequency and terrestrial use of in situ observation assets are derived based on user needs and regional patterns, in the regional build-out plans, issued annually. Thus spatial and temporal frequency of observational assets may change in the future, as the science of observation changes and new policy issues drive public interest.

A global set of observational requirements are found in *Integrated Global Observing Strategy: Coastal Theme Report for the Monitoring of Our Environment from Space and from Earth, Report of the Coastal Theme Team* (January 2006), also known as the IGOS Coastal Theme Report. These needs are a globally recommended level for observations. Table 3-4 of the IGOS Coastal Theme Report gives global data measurement requirements for key parameters in terms of horizontal resolution, observation cycle time, availability, and accuracy, as well as the minimal useful standards for each. The IGOS Coastal Theme Report includes parameters beyond the 26 for which U.S. IOOS is collecting data. Table 3-1 lists the parameters that appear in the IGOS Coastal Theme Report and are also part of the U.S. IOOS 26 parameters.

Table 3-1. Reporting Requirements for Key Parameters

Parameter	Horizontal resolution	Observation cycle	Availability	Accuracy
Bathymetry	30 m	2 d	4 h	0.1m (depth)
Colored dissolved organic matter	100 m	1 h	1 h	30%
Dissolved nutrients	10 km	1 d	1 d	10%
Ice cover/distribution	50 m	6 h	1 h	100 m
Phytoplankton pigments	100 m	1 h	1 h	20%
Optical properties	100 m	1 h	1 h	10%
pCO2	10 km	1 d	1 d	10%
Salinity	1 km	1 d	1 h	0.1 psu
Sea level/sea surface height	1 km	1 d	1 h	4 cm
Stream flow/river discharge	10 m	1 h	1 h	10%
(Surface) currents	300 m	1 h	1 h	3 cm/s
Surface wave height and direction	1 km	3 h	1 h	0.2 m and 5°
Temperature/sea surface temperature	100 m	3 h	1 h	0.2° C
Total suspended matter	100 m	1 h	1 h	30%
Wind speed and direction	300 m	1 h	1 h	1 m/s and 10°

The accuracy requirements and observation cycles described in Table 3-1 may be considered an end goal for U.S. IOOS. Government-Furnished Equipment, Property, and Services

Numerous federal agencies do and will participate in U.S. IOOS. Section 1 identifies federal assets that are contributing to or are expected to participate in U.S. IOOS, and Section 8 identifies federal assets to be developed. Appendix B describes candidate assets. The total U.S. IOOS Program accounting must include the federal agency-provided equipment contributing to U.S. IOOS.

3.2 Non-Federal Equipment, Property, and Services

RAs provide many of the U.S. IOOS observing assets, either by providing data from federal assets or through procurement and maintenance of their own assets. Section 1 identifies assets reported by RAs, and Appendix A contains a table listing the assets and, for each, identifying the owner, maintainer, number, and parameters reported.

Section 4.
System Staffing Requirements

4.1 CENTRAL FUNCTION

Central functions are activities that exist to design, implement, or support U.S. IOOS. These activities include providing for the networking of observing and data assets to obtain measurements for 26 key parameters and the sharing of those measurements with users. Table 4-1 shows the number of staff members needed to accomplish the central function.

Table 4-1. Current and Future Central Function Staffing Needs, by Subsystem

Subsystem	Year										
	Current	1	2	3	4	5	6	7	8	9	10
Observing	1	4	6	8	8	8	8	8	8	8	8
DMAC	3	9	10	16	16	18	19	20	20	21	21
Modeling and analysis	1	5	6	7	7	8	8	9	9	9	9
Governance and management	21	19	20	27	28	34	35	35	35	35	35
Research and development		2	2	6	6	6	6	6	6	6	6
Training and education		2	4	7	8	9	9	9	9	9	9
Total	26	41	48	71	73	83	85	87	87	88	88

Table 4-2 shows the distribution of junior, mid-level, and senior staff members.

Table 4-2. Staff Levels in the Current Central Program, by Subsystem

Subsystem	Junior	Mid-level	Senior
Observing	—	1	—
DMAC	—	3	—
Modeling and analysis	—	1	—
Governance and management	2	13	6
Research and development	—	—	—
Training and education	—	—	—
Total	2	18	6

In addition, the IOOC, which guides U.S. IOOS, consists of two full-time directors and a number of part-time personnel, as described in Table 4-3.

Table 4-3. IOOC Current Staffing Levels

Full-time staff	Part-time staff
2 senior officers	1 graphic artist 1 meeting coordinator 1 IT support person 1 IT/web support person 2 support personnel

Section 9 describes U.S. IOOS facility needs, such as office, conference, and storage space.

4.2 FEDERAL ASSETS

Not all of the federal assets and personnel that contribute to U.S. IOOS have been identified. Federal employees who spend a percentage of their time on the sharing of observing and data assets have costs that are borne by other federal departments and agencies. However, for full cost accounting, the number of federal employees and contractors contributing to U.S. IOOS should be identified and the percentage of time used estimated.

As an example, the NOAA Commissioned Officer Corps, one of the seven uniformed services of the United States, consists of approximately 321 commissioned officers.[1] Officers can be found operating one of NOAA's 19 ships or 12 aircraft in support of NOAA's missions. Examples of their duties and areas of operations include launching a weather balloon at the South Pole, conducting hydrographic or fishery surveys in Alaska, maintaining buoys in the tropical Pacific, and flying into hurricanes.[2] The number of officers and percentage of time they spend specifically supporting the U.S. IOOS mission should be estimated for this section.

Additional time contributions are expected from other offices of NOAA, NASA, EPA, USGS, and the Army Corps of Engineers, among others. The exact level of commitment has not been determined.

4.3 NON-FEDERAL ASSETS

Non-federal assets contributing to U.S. IOOS consist of ACT and the regional observing associations, each of which has a primary and alternate point of contact to interface with the central function, as well as graphic web designers, web

[1] See http://www.noaacorps.noaa.gov/about/about.html.

[2] See http://www.noaacorps.noaa.gov/.

technicians, observation asset maintainers, researchers, analysts, and modelers, as well as executive boards, often staffed with volunteers. Table 4-4 shows the staffing, including volunteer staffing, for ACT and the RAs. Staff members are located at each RA headquarters unless a different location is noted parenthetically after the staff description. Those locations are described in Section 9, as are the requirements for office, conference, storage, docking, and other facilities. The staffing required to support a full complement of observing assets, DMAC, models, and other U.S. IOOS activities has not been defined. The growth in staff levels should be commensurate with the growth in observing assets. As this is skilled research, it will be difficult for staffing to grow in excess of 20% per year, and so deployment of assets will be constrained by that limit.

Table 4-4. Current Staffing of ACT and the Regional Associations

Component	Full-time personnel	Part-time personnel	Volunteers
ACT	Technical coordinators • 1, ACT HQ • 1, USF • 1, UH • 1, UM	Executive director (ACT HQ) Chief scientist (ACT HQ) IT/multimedia specialist (ACT HQ) Database specialist (ACT HQ) Support technician (ACT-HQ) Outreach coordinator (ACT-HQ) Independent QA/QC specialist (ACT HQ) Administrative assistant (ACT HQ) Primary investigators: • 1, ACT HQ • 1, USF • 1, UH • 2, UM • 1, UAF • 1, MLML Technical coordinators • 2, UAF • 1, MLML • 1 graduate student at MLML	1 summer intern at ACT HQ
AOOS	1 executive director 2 program managers 4 data analysts, modelers, and technicians All at ANC	1 science advisor (25%–50%) Contractor support for web support and print publications	16 executive board members

Table 4-4. Current Staffing of ACT and the Regional Associations

Component	Full-time personnel	Part-time personnel	Volunteers
CaRA	Director Administrative assistant Modeling coordinator Programmer/model developer Electronics technician Laboratory technician Field technician	Associate director Education and outreach coordinator Coastal hazards coordinator Ocean weather coordinator Ocean waves and currents coordinator Event coordinator 2 programmers 2 field technicians Legal counsel 3 education consultants 1 laboratory technician 2 graduate students	
CeNCOOS	Program coordinator	Executive director (50%) Information manager (80%) Programmer (50%) 2 paid student interns (16.7% each) 5 primary investigators to operate HFR systems, part of Coastal Ocean Currents Monitoring Program (COCMP)	None.
GCOOS	1 regional coordinator 1 data coordinator 1 education and outreach coordinator 1 GIS management scientist 1 executive assistant	OSD adviser (15%) Data portal programmer (50%) Data standardization programmer (50%) Education and outreach adviser (5%) 2 graduate students (50%)	14 executive board members 11 to 22 data providers who maintain and operate observing systems 6 committee chairs (100 hours/year each)
GLOS	1 program coordinator 1 technical coordinator 1 technician at GLWIUW	Executive director (50%) Business manager (25%) DMAC coordinator (50%) Programmer (25%–33%) 3 support personnel Primary investigators • 2, UM (16.7% each) • 2, UMD (20% and 10%) • 1, GLWIUW (16.7%) • 1, GLRC-SUNY (16.7%) • 1, GLERL (16.7%) 2 technical coordinators at UM (16.7% each) Technicians • 1, UM (16.7%) • 2, UMD (16.7%) • 1, GLERL (50%) 3 staff members at the Cooperative Institute for Limnology and Ecosystem Research	None

Table 4-4. Current Staffing of ACT and the Regional Associations

Component	Full-time personnel	Part-time personnel	Volunteers
MACOORA	1 executive director 1 weather director 3 HF radar technicians 3 ocean modelers	1 part time administrative assistant Technical data administrator for satellites equivalent to 50% of time 1 HF Radar coordinator, 25% time 3 glider operators/researchers at 50% 3 data management administrators at 50% 4 education and outreach staff at 25%	None
NANOOS		1 executive director (50%) 1 board chair (20%) 1 primary investigator (20%) 4 fiscal and administrative assistants (10%) 2 education and outreach specialists (50%–80%) Primary investigators (10%–25%) • 3, APL-UW • 6, OSU • 1, OHSU • 1, OR-DOSL • 1, DOGAMI • 2, WADOE Technicians (10%–75%) ▪ 5, APL-UW • 16, OSU • 3, OHSU • 3, OR-DOSL • 2, DOGAMI • 4, WADOE Modeling analysts primary investigators • 2, APL-UW • 1, OSU • 1, OHSU Modeling and analysis technicians • 2, APL-UW • 1, OSU • 2, OHSU DMAC practitioners and committee members, primary investigators • 1, APL-UW • 1, OSU DMAC practitioners and committee members, technicians • 2, APL-UW • 1, OSU • 2, OHSU • 1, DOGAMI (Some PIs/technicians may be individuals who do two or more functions within NANOOS. NANOOS entails contributions from 20 PIs, about 45 technicians, and 60 volunteers. The total level of effort is approximately 4 people at PI level and 10 at the technician level.)	15 executive committee members 45 governing council volunteers 10 education and outreach volunteers 4 user products committee volunteers

Table 4-4. Current Staffing of ACT and the Regional Associations

Component	Full-time personnel	Part-time personnel	Volunteers
NERACOOS	1 executive director with PhD 1 administrative assistant both at Rye, NH	1 communication and outreach specialist with M.S.	none
PacIOOS	1 director 6 research faculty at UH-M 5 data specialists 10 technicians 6 graduate students	10 research faculty members at UH-M 1 outreach coordinator 6 regional liaisons 4 graduate students	
SCCOOS	1 program coordinator 1 programmer	1 executive director: 25% 1 administrative analyst: 40% 1 information manager: 30% 1 technical director: 10% 1 programmer: 20% 14 principal investigators	Joint strategic advisory committee, board of governors, board executive committee, executive steering committee
SECOORA	1 executive director 1 program manager 1 RCOOS manager	1 program manager 1 outreach specialist, Several university PIs	Board of directors

Section 5.
System Activity Rates

System activity rates describe the number of users, amount of data, number of models, frequency of data downloads and uploads, and desired sampling frequency for U.S. IOOS. They can also describe the frequency of maintenance on assets and the number of people supporting U.S. IOOS.

5.1 Central Function

The U.S. IOOS Program Office serves as the Integrated Ocean Observing Program Office called for in the ICOOS Act, with responsibility for overseeing the daily operations and coordination of the IOOS system. It provides the national role in planning and coordinating the networking of observing and data assets to measure 26 key parameters and share the results with users. Section 4 describes the staffing levels leading up to and at full operational capability.

5.2 Federal Assets

The participation of federal agencies consists primarily of maintaining and operating assets, as well as providing data. The primary metric of federal function will be levels of full-time employees (see Section 4). Section 9 describes the facilities—offices, conference rooms, computers, networks, printers, and so on—required to support those personnel. Cost estimates should include the cost of travel. In particular, federal employees supporting the integration of U.S. IOOS will likely need to travel twice a year to support single-day business meetings.

5.3 Non-Federal Assets

When U.S. IOOS reaches full operational capability, non-federal entities will be providing services to researchers, students, decision makers, and the general public. The level of service can be expected to increase as training and education functions encourage participation and informed use of the data provided by U.S. IOOS. Section 4 describes the current level of non-federal personnel contributing to U.S. IOOS. Costs estimates should include the cost for the executive directors of each RA to travel to Washington, DC, twice a year to support integrative IOOS meetings. In addition, two people from each RA will need to travel twice a year to support scientific research meetings.

The Alliance for Coastal Technologies provides independent verification and validation of sensors, buoys, cables, and observing components. Some ocean observing equipment is manufactured by small technology companies and start-ups, and this validation assures buyers that the observing equipment functions as designed so that the market for observing equipment can function efficiently. The ACT also provides beta testing on the manufactured products back to the manufacturers. As an independent validation and verification facility, the ACT does not travel, and conducts its business from its Maryland facility with existing staff and testing equipment. Their testing equipment also includes operational observating assets in the water, but those assets do not contribute data to IOOS.

Observing system data are uploaded to RA servers at a low rate of data flow, a few KB per report; reports are generally hourly. The data flow is provided by line-of-sight RF or satellite relay.

Each RA operates a DAC; the number of servers at the DACs ranges from 2 to 30. When U.S. IOOS reaches full operational capability, each regional DAC can expect 10,000 users per month to view and download data and to run models; usage will vary by region. Users' frequency of use will range from hourly to monthly, depending on the type of service being demanded. Fish species reports may be downloaded daily and may be 1 MB or less. Observation datasets may be downloaded in bulk format to support university and other researchers. Table 5-1 describes current DAC configurations and usage levels.

Table 5-1. Current DAC Hardware and Usage Levels

RA	Hardware description	Users per month	Visit duration or demand
AOOS	10 servers providing high performance computing and visualization; 5 servers for database and file storage. 140 processor cores and 40 TBs of storage	4200 unique users	12 minutes per visit
CenCOOS	1 central data server area	100 (estimated)	Not reported
GCOOS	1 primary and 1 separate backup data and web server system	10,000	Not reported
GLOS	1 web server, 1 primary and 1 backup data servers with storage array, and 1 system backup server	1300	Not reported
NANOOS	DACs at University of Washington, Oregon State University, and Oregon Health Sciences University	2000	Not reported
NERACOOS	1 major data center at Gulf of Maine Research Institute and additional data centers at University of Maine and at University of Connecticut	30,000	Not reported
SCCOOS	1 web server, 2 data ingestion servers, 14 data processing servers (one per PI)	5,000	Not reported
SECOORA	1 primary data Integration and Dissemination hub at University of South Carolina, Columbia. 3 back up hubs at 3 different university locations. Additional data infrastructure from independent observing systems that participate in SECOORA	750 unique visitors measured by Google analytics	Not reported

Section 6.
System Milestone Schedule

6.1 Central Function

The U.S. IOOS Program Office has planned the following near-term milestones:

- Develop independent cost estimate and federal estimate in FY11
- Finalize the implementation plan in February 2012
- Hold capstone meeting September 2012.

In addition, the U.S. IOOS Program Office plans a 10-year build-out to full capability of observing assets, core functions, and data assembly, following the finalization and approval of the implementation plan.

The DMAC development schedule has the following milestones:

- Develop DMAC data standards to encompass 2 new variables per year, until reaching the total of 26. The "focus area approach"[1] will be used to prioritize development of DMAC data standards.
- Integrate data provider DACs into the system at a rate of 2 per year until reaching the total of 20.
- Release DMAC data standards versions annually and include improvements to already published standards.
- Add DMAC utility services at a rate of one every 1.5 years for a total of eight.

When the milestones of the 10-year build-out are known, they will be referenced here.

6.2 Federal Assets

Milestones for incorporating federal assets and partners into the U.S. IOOS capability will be identified in the IOOS central function program schedule, to be referenced in Section 6.1, above.

[1] U.S. IOOS Office, *U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*, Version 1.0, November 2010, p3-14.

6.3 NON-FEDERAL ASSETS

RAs have developed a five-year plan ("Regional Build Out Plan") to continue to grow their current capability, on the road to full capability. Technological innovation is a key consideration in the planning horizon for RAs, because observation technology is continually being improved. The pace of computing power and user connectivity also grows rapidly. Between these two rates of change, it is difficult to describe the exact observing systems and technologies that will be available in five years. Current technology may well be obsolete and replaced with observational assets that are cheaper, more reliable, and have longer lifecycles. Therefore the development plans for beyond the current five years are often stated only in terms of general goals.

Section 7.
Acquisition Plan and Strategy

Full operational capability for U.S. IOOS will be achieved when observing assets meet the spatial and temporal reporting requirements specified in the January 2006 *Integrated Global Observing Strategy: Coastal Theme Report for the Monitoring of Our Environment from Space and from Earth, Report of the Coastal Theme Team.* Meeting those requirements will require the acquisition of additional assets. Many of the assets required are described in Section 1. Appendices A and B contain an inventory of current regional and federal observing assets and some of the parameters for which they collect data. Specific assets and data required can be determined through a gap analysis.

The total operational cost at full capability covers the assets that support the 26 key parameters identified in the U.S. IOOS Blueprint. Over the 10 years leading up to full capability, existing federal and non-federal assets will be enlisted to participate in the U.S. IOOS data observing structure. In addition, assets already contributing to U.S. IOOS may be modified to remediate or fill information gaps. For example, modifying a series of NDBC buoys with an additional sensor may provide needed oceanographic variables and may be less costly than acquiring and maintaining a new series of buoys. The cost of modifying the asset should be estimated.

A gap may also be filled by acquiring and fielding a new observing asset, but this option is usually the most expensive and should be considered the last resort for meeting the requirements for observing assets. If a particular observing asset does not exist, the IOOS Program Office may ask the RAs to propose solutions.

7.1 NEW ACQUISITION

7.1.1 Central Function

The U.S. IOOS Program Office will participate with federal and non federal partners in identifying the needed observing and data assets and determining if other extant assets can be shared or modified to meet U.S. IOOS needs.

At full operational capability, the DMAC subsystem will have 20 contributing DACs: 11 regional, 3 from other NOAA offices or agencies, and 6 from other federal agencies. Data providers will locate and provide the funding sources the implementation, operations, and maintenance of DMAC data standards on their systems.

The U.S. IOOS Program Office will fund the following:

- Development of data services
- Development of utility services
- Implementation, operation, and maintenance of utility services.

RAs will principally use grants and cooperative agreements to fund implementation and O&M of DMAC data services.

New observing assets needed to achieve capabilities not already met by RAs or by existing or planned federal assets will be acquired through the RFP, proposal, and grant structure in use between the U.S. IOOS Program Office and the RAs.

7.1.2 Federal Assets

New and existing federal assets will be identified and may be integrated to fill gaps in U.S. IOOS observations and central functions. For example, the U.S. IOOS Program Office has enlisted NASA earth observing satellites, scheduled to be acquired and launched during the 10-year development of full IOOS capability. Those federal assets previously identified are described in Section 1 and Appendix B. Through partnerships with federal partners, upcoming new assets may be prioritized for development or be altered in design or function, to help meet U.S. IOOS goals and requirements.

7.1.3 Non-Federal Assets

Non-federal assets that will need to be acquired are not currently known; they will be identified through the implementation plan. To help achieve U.S. IOOS full operational capability, RAs will acquire assets through block grants, through federal agency procurement and surplus/supply, or through non-IOOS grants and partnerships, such as from charitable foundations, in partnership with business, or from other governmental and non-governmental organizations such as Earth Science Research Laboratories, Scripps, or NDBC.

7.2 REACQUISITION

Assets that wear out within the U.S. IOOS life cycle may need to be replaced through reacquisition. The reacquisition method may or may not be identical to the method used for the original acquisition. Appendix D describes life-cycle lengths.

7.2.1 Central Function

The U.S. IOOS Program Office will not directly procure or reacquire observation assets.

7.2.2 Federal Assets

Assets that need to be re-procured under federal authority will be identified here. Many earth observing satellites in particular have reached end of life and re-placements are planned. The UNOLS ship fleet is reaching end of life and needs to be recapitalized. USCG observing aircraft (HU-25) have reached end of life and are being replaced. The type and function of the asset must be identified, along with the procuring agency, the purchase cost, and the cost or level of effort to operate and maintain the asset.

7.2.3 Non-Federal Assets

RAs will need to re-procure assets as they reach the end of their life. As with the original acquisitions, reacquisitions will occur through a variety of methods and sources.

Section 8.
System Development Plan

Full operational capability for U.S. IOOS will be achieved when the system as a whole achieves needed observation products in fulfillment of societal and user goals, with those solutions tailored to the needs of each observing region. The societal needs pose different challenges in each region. For instance, wind and waves and local weather are significant variables for efficient shipping under the marine observation goal for west coast regions, but less of a problem on the east coast. Ice observation is a significant observation in the AOOS (Alaskan) region but not in GCOOS, which serves the Gulf of Mexico. Full capability is less than a full complement of all services in all regions. It is partly defined by the Regional Build Out plans.

Full Capability targets the spatial and temporal reporting requirements specified in the January 2006 *Integrated Global Observing Strategy: Coastal Theme Report for the Monitoring of Our Environment from Space and from Earth*, *Report of the Coastal Theme Team*. Table 3-4 of the IGOS Coastal Theme Report gives global data measurement requirements for key parameters in terms of horizontal resolution, observation cycle time, availability, and accuracy, as well as the minimal useful standards for each. Table 3-5 of that report identifies the satellite assets that meet or partially meet the requirements. Analysis of this table against the parameters reported by existing observation assets will form the basis for deriving the development plan for the observation assets.

Additional assets will be required to fill the temporal and spatial reporting requirements. The assets required are described in Section 1, and Appendices A and B contain an inventory of current observing assets and the parameters for which they collect data.

Over the 10 years leading up to full U.S. IOOS capability, existing federal and non-federal assets will be enlisted to participate in the U.S. IOOS data observing structure. If a particular observing asset does not exist, the U.S. IOOS Program Office may ask the RAs to propose solutions for acquiring those assets.

The development plan must identify the parameters for which data are lacking, analyze the types of assets that could provide the missing data, and identify possible assets to fill the capability. The development plan should specify how information about potential observing assets will be obtained, how asset owners will be enlisted, and how cooperative certifications may be put in place, including the length of time needed to negotiate such memorandums of understanding, and who in the U.S. IOOS Program Office will perform that outreach. The development plan should specify a timeline for identifying assets and for enlisting or acquiring those assets. The development plan should include a period of analysis to consider the implications of operating and maintaining the additional assets.

8.1 CENTRAL FUNCTION

The U.S. IOOS Program Office will serve as the integrated ocean observing program office required in the ICOOS Act and will oversee daily operations and coordination of the IOOS systems, including providing for the sharing and networking of observing and data assets to obtain observations for 26 key parameters. The DMAC development schedule will include the following milestones:

- Develop DMAC data standards to encompass 2 new variables per year, until reaching the total of 26. The "focus area approach" will be used to prioritize development of DMAC data standards.
- Integrate data provider DACs into the system at a rate of 2 per year until reaching the total of 20.
- Release DMAC data standards versions annually and include improvements to already published standards.
- Add DMAC utility services at a rate of one every 1.5 years for a total of eight.

Development of the DMAC subsystem will take 10 years. At full capability, DMAC will have 20 contributing DACs: 11 regional, 3 from other NOAA offices or agencies, and 6 from other federal agencies.

Data providers will fund the implementation, operations, and maintenance of DMAC data standards on their systems. The U.S. IOOS Program Office will fund the following:

- Development of data services
- Development of utility services
- Implementation, operations, and maintenance of utility services.

RAs will fund implementation and O&M of DMAC data services principally through grants and cooperative agreements.

8.2 FEDERAL ASSETS

New and existing federal assets will be integrated to fill gaps in U.S. IOOS observations and central functions. For example, the U.S. IOOS Program Office has enlisted NASA earth observing satellites, scheduled to be acquired and launched during the 10-year development of full IOOS capability. Those federal assets previously identified are described in Section 1 and Appendix B. Through partnerships with federal partners, upcoming new assets may be prioritized for development or be altered in design or function, to help meet U.S. IOOS goals and requirements.

8.3 NON-FEDERAL ASSETS

RAs will fill the remaining gaps in observing assets through the RFP, proposal, and grant structure in use between the U.S. IOOS Program Office and the RAs. The ability to find and integrate skilled people to deploy, maintain, and manage observing assets and data will constrain the growth of the RAs.

Section 9.
Facility Requirements

9.1 IOOS Federal Central Functions

Table 9-1 describes the IOOS Program Office's current facilities. The facilities, although not fully occupied, will require expansion to accommodate the planned tripling of the staff to achieve and maintain the fully capable state of U.S. IOOS, as identified in Section 4. Office space includes common space such as reception, waiting lounges, hallways, copier and kitchen rooms, and conference capability.

Table 9-1. IOOS Program Office Facilities

Office	Facilities
IOOS Program Office	10,500 sq. ft. office space in Silver Spring, MD.

The IOOC guides the IOOS Program office. Table 9-2 describes the current office facilities. Whether the IOOC will require expansion or additional facilities is yet to be determined.

Table 9-2. IOOC Office Facilities

Office	Facilities
IOOC	220 sq. ft. office space in Washington, D.C. 660 sq. ft. on-demand (rental, 12/year) ancillary staff office in Washington, D.C. 2068 sq. ft. conference rooms in Washington, D.C.

9.2 Non Federal Facilities

Table 9-3 describes the type, location, and size of current RA facilities. Many RAs have multiple offices, and some are composed of multiple observing associations. Their facilities often consist of the university offices of primary investigators, along with laboratory, storage, and work space.

Table 9-3. Current Regional Association Facilities

Participating component	Description of physical facilities
Alliance for Coast Technologies (ACT)	3,500 sq. ft. headquarters office and laboratory space at Chesapeake Biological Laboratory Center for Environmental Science, University of Maryland, Solomons Island, MD. (ACT HQ) 5 locations with 1500 to 2500 sq. ft. of office and laboratory space each, at • University of South Florida, (USF) • University of Hawaii (UH) • University of Michigan (UM) • University of Alaska Fairbanks (UAF) • Moss Landing Marine Labs, Moss Landing, CA (MLML)
Alaska Ocean Observing System (AOOS)	1770 sq. ft. office space, plus 400 sq. ft. copy/supply/kitchen space, 2 conference rooms of 800 sq. ft., Anchorage, AK (ANC). 1400 sq. ft. of office space for data management and development, at Axiom in Anchorage, AK.
Caribbean Regional Association for Ocean Observing (CaRA)	2272 sq. ft. office, computer lab and laboratory space at the Magueyes Island field facility of the University of Puerto Rico-Magueyes
Central and Northern Coastal Ocean Observing System (CeNCOOS)	432 sq. ft. dedicated office space, plus shared use of additional 432 sq. ft. kitchen and conference facilities at Monterey Bay Aquarium Research Institute (MBARI) in Moss Landing, CA.
Gulf of Mexico Coastal Ocean Observing System (GCOOS)	1000 sq. ft. of office space at Texas A&M University, College Station, TX 1 office and server space at University of Miami, Miami, Florida 1 office at Institute of Marine Mammal Studies, Biloxi, MS 2 offices at University of South Florida, St. Petersburg, FL 11 office supporting data collection and posting, in various coastal towns in Texas, Louisiana, Mississippi, Alabama, and Florida
Great Lakes Observing System (GLOS)	900 sq. ft. commercial space in Ann Arbor, Michigan; 5 locations with approximately 200 sq. ft. office and laboratory space each, at the following locations: • Great Lakes Environmental Research Laboratory (GLERL) • University of Michigan (UM) • University of Minnesota, Duluth (UMD) • Great Lakes Water Institute at University of Wisconsin (GLIUW) • Great Lakes Research Consortium at State University of New York (GLRC-SUNY) DMAC services provided by Great Lakes Commission, with a total sq. ft. of 5000, only part of which is shared or used for DMAC hosting and services. Space for approximately 3 staff at the Cooperative Institute for Limnology and Ecosystem Research, assumed 600 sq. ft.
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	20 separate facilities at universities comprised of • 16 university and office suites providing lab and office space; assume 200 sq. ft. each • Environmental data center at Applied Science Associates, assume 1200 sq. ft.

Table 9-3. Current Regional Association Facilities

Participating component	Description of physical facilities
	• 3 satellite ground data processing facilities, 2 at Rutgers and 1 at Univ. of Delaware. Rutgers facility “COOL-room,” is housed in a 1 to 3 story building with a one-block footprint, at Rutgers, N.J., with a large satellite receiving antenna on the roof; performs data aggregation, processing and distribution center, including satellite data acquisition center, HF radar national node, glider command and control, with meeting rooms, situation room with monitors & computers. Assume Rutgers facility is similar.
Northwest Association of Networked Ocean Observing Systems (NANOOS)	7 locations all consisting of offices, storage, staging facilities, laboratories, and workrooms, totaling 1500 office sq. ft. and 3000 sq. ft. supporting areas, at the following sites: • University of Washington, Seattle, WA (UW) • Oregon State University, Corvallis, OR (OSU) • Oregon Health and Sciences University, Beaverton, OR, (OSHU) • The Boeing Company, Seattle, WA • Washington State Department of Ecology, Olympia, WA (WADOE) • Oregon Department of State Lands, Coos Bay, OR (OR-DOSL) • Oregon Department of Geology and Mineral Industries, Portland, OR (ORGAMI) Shared server rooms at four of the above universities; each site having about 6 dedicated servers.
Northeastern Regional Association of Coastal Ocean Observing (NERACOOS)	400 sq. ft. office space and meeting space, Seacoast Science Center, Rye, NH
Pacific Islands Ocean Observing System (PacIOOS)	14 office suites totaling approximately 7,500 sq.ft. of office, laboratory, and storage space, in the following locations: 4 offices in 4 buildings at University of Hawaii at Manoa (UH-M), and offices for 1 individual each in: • University of Guam • College of the Marshall Islands • American Samoa Community College • Palau International Coral Reef Center • Pacific Marine Resources Institute (Saipan, CNMI) • Hawaii Institute for Marine Biology • University of Hawaii at Hilo • Pohnpei (home-based office) • Federated States of Micronesia (home-based office) • Honolulu, Hawaii (home-based office)
Southern California Coastal Ocean Observing System (SCCOOS)	240 sq.ft. headquarters office for full time staff and 480 sq. ft. office space for parttime staff ad Scripps Institution of Oceanography, University of California, San Diego, CA. 2 additional offices off-site in San Diego 1,200 sq.ft. of shared lab space
Southeast Coastal Ocean Observing Regional Association (SECOORA)	Approximately 120 sq.ft. office space at University of south Carolina, approximately 120 sq.ft. of office space at a state governmental office building, and approximately 120 sq. ft. home

Table 9-3. Current Regional Association Facilities

Participating component	Description of physical facilities
	office in South Carolina. Additional business space belonging to maintenance contractors and other contractors

No infrastructure supporting the observing assets themselves has been identified.

Growth of the RAs and their office facilities to support an expansion of the observing asset infrastructure has yet to be determined.

9.3 DMAC Facilities

The DMAC at present consists of DACs at the IOOS Program office, at each RA; in the case of NANOOS, four DACs. Those facilities are included in the tables at the beginning of this chapter.

Additionally, DACs have been identified in the following federal and non-governmental observing offices:

- Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory
- Global Drifter Center, NOAA
- National Data Buoy Center, NOAA
- National Marine Fisheries Service, NOAA
- National Environmental Satellite Data and Information Service, NOAA

At FC, U.S. IOOS will have 20 DACs, including 11 Regional, 3 based at 3 NOAA, and 6 other federal locations.

9.4 Modeling and Analysis Facilities

The current data management, modeling, and analysis facilities are co-located with associations, research offices, and universities that are participating members of regional associations. Those facilities are included in the facilities listed above in Table 9-3.

Any additional modeling and analysis capabilities required for the FC state of IOOS are specified in the development plan in Chapter 8.

9.5 RESEARCH AND DEVELOPMENT FACILITIES

The current state of IOOS contains research and development facilities shared or operated by contributing members of IOOS. The research conducted by RAs is only partly funded by US IOOS federal dollars. Much of the research and development is funded by grants from other federal agencies or non-governmental organizations and some businesses.

9.6 TRAINING AND EDUCATION FACILITIES

The current state of IOOS does not contain training and education facilities except those operated by contributing members of IOOS. The number and percentage of IOOS training events currently operated is unknown. Such training events should be enumerated and a description of the training venues provided, such as type of location, number of persons trained in the facility, length of training session, and frequency. The description of the training venue is most important and can be seaside, on a moving platform, in a university classroom, or in an office meeting room.

9.7 FACILITIES COMMONALITY

The shared use of facilities for one or more functions should be noted to prevent estimation of unnecessary facilities. The regional associations hold training events and meetings in the facilities they already occupy as offices. Many primary investigators are also university professors and conduct education and outreach from their university offices. Federal partners also conduct data assembly, modeling, outreach, and training. New facilities should not be planned by the cost estimation team, to accommodate the filling out of desired functions, unless specifically identified as a shortfall or growth area in this CARD.

Section 10.
Risk

10.1 INTRODUCTION

10.1.1 Purpose and Scope

All programs experience unexpected events. Frequently, those events cause more resources to be expended than planned. Time is lost in recognizing the risk, identifying the problem, determining whether to take corrective action, identifying the proper action, and taking the action. During that decision process, program personnel are temporarily halted, so they continue to accrue operational cost while not producing the product planned for that period. Hence, the realization of risk leads to cost overruns. The U.S. IOOS Program has a risk management plan. However, cost-relevant risks have not yet been identified.

The purpose of the U.S. IOOS risk management plan is to provide the U.S. IOOS Program Office a consistent method to assess and manage risk. It assigns responsibilities for management activities, and it prescribes documentation, monitoring, and reporting processes. Implementation of this plan will result in

- timely identification and evaluation of risks,
- information that allows management to focus on high-magnitude risks,
- appropriate measures taken to manage risk, and
- a means to record risks, actions, and results.

The risk management plan applies to risks associated with the U.S. IOOS Program Office's roles and responsibilities, including the following:

- Efforts to integrate internal NOAA ocean observations
- Sustainment of the DIF
- Management of the development and implementation of a national DMAC capability
- Participation in inter-governmental working groups and steering committees
- Coordination of regional efforts across NOAA

- Management and administrative oversight of federal investment in regional IOOS components.

Key definitions are as follows:

- *Risk*. Risk is the possibility of an event occurring that can negatively affect the cost, schedule, or performance of a project. The level of risk is assessed based on two factors:
  - Probability of the risk occurring
  - Impact on the program if the risk occurs.
- *Risk rating*. A risk rating is the value given to a risk event based on the probability of occurrence and impact. For the NOAA IOOS Program, a risk rating is described in terms of magnitude: high, medium, or low.
- *Risk trigger*. A risk trigger is an event that confirms or denies the likelihood that an identified risk will come to fruition.
- *Risk management technique.* A risk management technique is an action taken to address a risk:
  - Avoidance—action taken to nullify the possibility of a risk occurring.
  - Mitigation—action taken to minimize the possibility of a risk occurring or the impact of a risk should it occur.
  - Acceptance—decision to take no action to avoid or mitigate a risk.
  - Transfer—action to make the risk the responsibility of another organization. Typically this is achieved by transferring work and associated risk to another entity by agreement or contract.
- *Alternative action.* An alternative action is an optional plan used once a risk becomes likely (based on risk triggers) or once a risk comes to fruition. The alternative action eliminates or mitigates the effects of a risk. Alternative actions are different from avoidance actions. Avoidance actions are taken after a risk is identified; alternative actions are triggered by another trigger event that occurs after the risk has been identified. Alternative actions may add to the cost or schedule, or may be otherwise undesirable as part of the primary plan. Therefore, alternative actions are implemented only after it is clear that they are necessary.

10.1.2 Objective

The mitigation for risk is to plan for risk. A risk management plan identifies a wide ranging set of occurrences that could have a negative effect on the program, estimates the possible costs of those occurrences, and rates those occurrences in ranges of probability. A program plan must incorporate contingency funding for risks that occur, whether they were predicted or not.

10.2 OVERVIEW

10.2.1 Program Description

The U.S. Commission on Ocean Policy (USCOP) called for the implementation of an integrated ocean observing system (IOOS) to increase our knowledge of the ocean.[1] In response to the commission, the U.S. Ocean Action Plan (OAP) called for the integration of U.S. ocean observations into a Global Earth Observation System of Systems (GEOSS).[2] The first U.S. IOOS development plan—approved by the Interagency Committee on Ocean Science and Resource Management Integration—addresses many of the recommendations of the USCOP, as supported by the OAP. Key recommendations are to establish a national IOOS with an emphasis on regional development, to develop the capacity for ecosystem-based management, and to link IOOS data and information to applications.[3]

The U.S. IOOS will gather information on physical, geological, chemical, and biological characteristics of our oceans and coasts, conditions that affect, and are affected by, humans and their activities. This coordinated network of people and technology will generate and disseminate continuous data, information, models, products, and services on our coastal waters, Greats Lakes, and oceans.

U.S. IOOS will employ available assets, knowledge, and advances in technology to develop a unified, comprehensive, and cost-effective approach for providing the data and information that will serve the needs of multiple user groups and will lead to

- improved understanding of climate change and its socioeconomic consequences,
- improved safety and efficiency of marine operations,
- more effective mitigation of the effects of natural hazards such as tropical storms,
- reduced public health risks, and

[1] U.S. Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century*, Final Report, 2004.

[2] Council on Environmental Quality, *U.S. Ocean Action Plan: The Bush Administration's Response to the U.S. Commission on Ocean Policy*, December 17, 2007.

[3] Ocean.US, *The U.S. Integrated Ocean Observing System (IOOS) Development Plan*, January 2005, pp. 20–24 (http://www.ocean.us/documents/docs/IOOSDevPlan_low-res.pdf).

- more effective protection and restoration of healthy marine ecosystems and improved ecosystem-based management of natural resources.[4]

The U.S. IOOS will have six subsystems:

- *Observing subsystem.* This subsystem obtains ocean observations from remote sensors (e.g., satellite- and land-based sensors) and from in situ sensors and observations (e.g., ships, sensors and direct observations that are systematically collected at DACs.
- *DMAC subsystem.* This subsystem is the primary mechanism to efficiently link the observing systems to modeling and analysis efforts using data and utility services.
- *Modeling and analysis subsystem.* This subsystem consists of data and services customers and their analytic tools, including models and decision support tools.
- *Governance and management subsystem.* This subsystem includes the administrative functions required to manage U.S. IOOS, including plans, operations, human resources, contracting, and grants.
- *R&D subsystem.* This subsystem includes coordinated R&D programs that address technical requirements from the three observing, DMAC, and modeling and analysis subsystems.
- *Training and education subsystem.* This subsystem includes the development of training and educational materials and products to assist with training and education programs.

NOAA is the lead federal agency developing the U.S. IOOS. NOAA's goal is to "provide continuous data on NOAA's open oceans, coastal waters, and Great Lakes in the formats, rates, and scales required by scientists, managers, businesses, governments, and the public to support research and inform decision-making."[5]

The U.S. IOOS Program Office will lead the effort to build a national-level DMAC subsystem to link observation data to modeling and analysis tools. This effort will include establishing standards for data and data transport to enable stakeholders to receive, integrate, store, and make available ocean observation data.

[4] *U.S. Ocean Action Plan*, p. 13.
[5] NOAA IOOS website, http://ioos.noaa.gov/about/.

10.2.2 Program Risk Challenges and Mitigation Measures

Program risk challenges for U.S. IOOS identified by Program Office personnel and RAs include requirements creep, lack of collaboration, unclear objectives, cost overruns due to policy cross purposes, lack of funding, and schedule overruns.

Risks peculiar to an ocean observing program include risks from bad weather, inundation, storm surge, rogue waves, tsunamis, hurricanes, and other natural phenomena that could damage or destroy observing assets, data assets, and maintenance assets.

Additional risks to program success include theft of ocean-based instruments, and human interference and damage to observing assets.

10.2.3 Program Risk Strategy

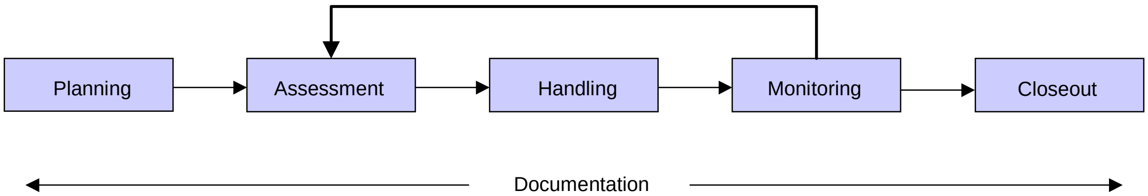
Five principles guide the risk management process:

1. Avoid revisiting decisions once they are made (unless new facts become available).
2. Assign a single owner to take responsibility for a risk, even if several people work to manage it.
3. Manage the highest risks first.
4. Set realistic due dates and work to meet those dates.
5. Document the planned actions and the results.

10.2.4 Program Risk Management Policies

The risk management process identifies risks and describes the actions necessary to manage them before they have a negative effect on cost, schedule, or performance. This process is an integral part of the program management plan. The risk management team (RMT) must routinely assess activities and processes to identify and manage risks. The risk management coordinator will track risks using a risk register. The RMT will use a structured process consisting of five elements: planning, assessment, handling, monitoring, and closeout, as shown in Figure 10-1.

Figure 10-1. Risk Management Process



Risk management planning is essential for the execution of a successful risk management program. The RMT will conduct risk management planning as an integral part of managing the U.S. IOOS Program.

The risk management planning process for the NOAA IOOS program will include planning and direction to

- monitor risks based on program status and U.S. IOOS life-cycle phase,
- maintain the risk management organization and ensure that team members carry out their assigned roles and responsibilities,
- report and document risk management activities, and
- periodically assess and update the risk management process.

The RMT is responsible for all risk assessment activities and for nominating risk owners to manage risks. The program director approves the strategy and assignment of the risk owners.

The risk management coordinator (RMC) maintains the strategy and all other risk management documents.

The RMT and program director will review the risk management plan annually.

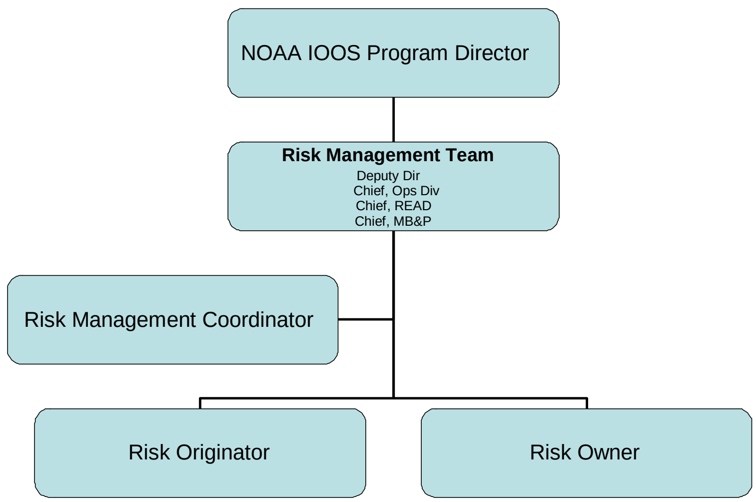
For more information, see the NOAA IOOS Program Risk Management Plan, issued in December 2010.

10.3 ORGANIZATION

10.3.1 Current Risk Management Organization for IOOS

Figure 10-2 depicts the NOAA IOOS risk management organization.

Figure 10-2. Risk Management Organization



10.3.2 Risk Management Roles and Responsibilities

The following subsections explain the roles and responsibilities of the entities identified in Figure 10-2.

10.3.2.1 PROGRAM DIRECTOR

The program director will

- approve the risk management plan;
- approve the addition of new risks to the plan;
- approve risk ratings, risk indicators, and strategies;
- approve the removal of risks from the risk management plan;
- integrate risk management activities within overall program management;
- assign risk owners to each identified risk; and
- review risk status quarterly.

10.3.2.2 Risk Management Coordinator

The RMC will

- maintain the risk management plan,
- collect reports on risk management activities for review by the RMT,
- schedule periodic RMT meetings,
- schedule quarterly risk management reviews for the program director,
- recommend methods and techniques for assessing and handling risks,
- maintain and monitor data in the risk register,[6]
- generate risk reports using the risk register, and
- plan and manage risk management training.

10.3.2.3 Risk Originator

The risk originator is any person who identifies a potential risk to the program. The risk originator is responsible for reporting potential risks to the RMT and for assisting with describing the risk and its precursors, severity, and likelihood of occurring. The preferred method of reporting potential risks is by email to the IOOS Program's deputy director and RMC.

10.3.2.4 Risk Management Team

The risk management team will

- assess potential risks to determine if they should be included in the risk management plan;
- assess the severity and likelihood of occurrence for risks added to the risk management plan;
- advise the program director of newly identified risks and their associated risk ratings, and recommend a risk owner;
- monthly, evaluate risk assessments, risk triggers, and risk strategies, and recommend actions to the program director.

[6] See Appendix A of the NOAA IOOS Risk Management Plan, issued in December 2010).

10.3.2.5 Risk Owner

The risk owner is the person designated the responsibility for handling the risk. The risk owner can be either a government employee or a contractor. The risk owner will

- assess the risk, identify risk triggers, and recommend risk management strategies;
- execute the approved risk management strategy;
- as required, prepare and supervise execution of individual risk plans;
- provide updated risk information to the RMC for entry into the risk register; and
- recommend closeout of risks.

10.4 Program Risk Items

As of December 2010, the U.S. IOOS Program Office has not identified any risk elements, as described in the NOAA IOOS Risk Management Plan (December 2010). Potential areas of risk to be considered include the following:

- Provision of information assurance;
- Projected software productivity;
- Technology maturity;
- Unstable performance requirements, such as vague, ambiguous, and variable performance requirements;
- Candidate technology risk;
- Widespread natural disaster or human interference caused damage to assets
- Coordination with system participants;
- Human factors and training, for example in DMAC implementation;
- Future requirements;
- Protocol/standards longevity, in the face of changes in operating systems, communication protocols, data formats, and data rates.

Appendix A
U.S. IOOS Partner Regional Association Assets and Fact Sheets

Table A-1 lists and describes RA assets available to support U.S. IOOS. The sections following the table contain fact sheets about each RA, excerpted from *FY2010: Regional Integrated Ocean Observing System Development* (pp. 1–25).

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
AOOS	Model	Multisensor Analyzed Sea Ice Exten - Northern Hemisphere (MASIE-NH)	1	National Snow and Ice Data Center (NSIDC)	TBD	
AOOS	Model	National Digital Forecast Database (NDFD) Aggregate Model	1	NOAA		
AOOS	Model	NOAA WAVEWATCH III - NE Pacific	1	NOAA-NCEP		Dominant wave period, wave height, wave mean direction, wind direction, wind speed
AOOS	Model	Regional Ocean Modeling System (ROMS)	1	NASA Jet Propulsion Laboratory		
AOOS	Model	Weather Research and Forecasting Model (WRF)	1			
AOOS	Observing	Buoy	18	National Marine Mammal Laboratory/NOAA		
AOOS	Observing	Buoy	12	NOAA		
AOOS	Observing	Buoy	3	Pacific Marine Environmental Laboratory/NOAA		
AOOS	Observing	Buoy	3	U.S. Army Corps of Engineers		
AOOS	Observing	Buoy	4	U.S. Geological Survey		
AOOS	Observing	Buoy	3	Conoco Phillips		
AOOS	Observing	Buoy	8	Conoco Phillips/Shell		
AOOS	Observing	Buoy	23	Conoco Phillips/Shell/Stat Oil		
AOOS	Observing	Buoy	7	Conoco Phillips/Stat Oil		
AOOS	Observing	Buoy	4	Fisheries and Ocean Canada, Institute of Ocean Sciences		
AOOS	Observing	Buoy	2	Hokkaiko University		
AOOS	Observing	Buoy	4	JAMSTEC		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
AOOS	Observing	Buoy	8	RUSALCA		
AOOS	Observing	Buoy	45	Shell		
AOOS	Observing	Buoy	3	SIO-MPL		
AOOS	Observing	Buoy	7	Stat Oil		
AOOS	Observing	Buoy	7	University of Alaska, Fairbanks		
AOOS	Observing	Buoy	8	University of Alaska, Fairbanks		
AOOS	Observing	Buoy	6	University of Washington, Applied Physics Lab		
AOOS	Observing	Buoy	2	WHOI		
AOOS	Observing	Fixed Station	93	U.S. Geological Survey		
AOOS	Observing	Glider	2	University of Alaska, Fairbanks		
AOOS	Observing	High-Frequency Radar	2	University of Alaska, Fairbanks		
AOOS	Observing	Ice Radar	2	University of Alaska, Fairbanks		
CariCOOS	Model	Experimental WRF Model	1			
CariCOOS	Model	Navy Aerosol Analysis and Prediction System (NAAPS)	1	Naval Research Laboratory		
CariCOOS	Model	Near Real-Time Wave Height	1			
CariCOOS	Model	NOAA WAVEWATCH III - NE Pacific	1	NOAA-NCEP		Dominant wave period, wave height, wave mean direction, wind direction, wind speed
CariCOOS	Model	Peak Periods and Direction	1			
CariCOOS	Model	Significant Wave Height and Direction	1			
CariCOOS	Model	WindStreams	1			
CariCOOS	Observing	Buoy	2	National Data Buoy Center (DART)		
CariCOOS	Observing	Buoy	2	University of Maine		
CariCOOS	Observing	Buoy	2	CDIP-Scripps		
CariCOOS	Observing	Fixed Station	1	NOAA-AOML		Wind direction, wind speed, air temp
CariCOOS	Observing	Fixed Station	13	WeatherFlow, Inc.		Wind direction, wind speed, air temp
CariCOOS	Observing	High-Frequency Radar	1			
CariCOOS	Observing	Tidal Current Stations	5			
CariCOOS	Observing	Virtual Wave Stations	11			
CeNCOOS	Model	Eelgrass distribution maps	1	Humboldt State University		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
CeNCOOS	Model	Humboldt Bay 2 Foot Sea Level Rise from Current High Tide Prediction Model	1	Humboldt State University		
CeNCOOS	Model	Humboldt Bay 3 Foot Sea Level Rise Prediction Model	1	Humboldt State University		
CeNCOOS	Model	North Bay Digital Elevation Model	1	Humboldt State University		
CeNCOOS	Observing	Buoy	5	National Ocean Service CO-OPS		
CeNCOOS	Observing	Buoy	9	National Data Buoy Center		
CeNCOOS	Observing	Buoy	1	California Polytechnic State University		
CeNCOOS	Observing	Buoy	11	CDIP-Scripps		
CeNCOOS	Observing	Buoy	4	Land/Ocean Biogeo-chemical Observatory in Elkhorn Slough (LOBO)		
CeNCOOS	Observing	Buoy	3	Monterey Bay Aquarium Research Institute (MBARI)		
CeNCOOS	Observing	Land Station	3	National Data Buoy Center		
CeNCOOS	Observing	Land Station	1	National Estuarine Research Reserve System		
CeNCOOS	Observing	Land Station	1	National Park Service		
CeNCOOS	Observing	Land Station	1	National Weather Service		
CeNCOOS	Observing	Land Station	1	MBA		
CeNCOOS	Observing	Land Station	1	San Francisco State University		
CeNCOOS	Observing	Land Station	1	University of California, Santa Cruz		
CeNCOOS	Observing	Pier Station	15	National Ocean Service CO-OPS		
CeNCOOS	Observing	Pier Station	4	National Estuarine Research Reserve System		
CeNCOOS	Observing	Pier Station	2	Bodega Marine Laboratory		
CeNCOOS	Observing	Pier Station	1	San Francisco State University		
CeNCOOS	Observing	Pier Station	1	SFSU RTC		
GCOOS	Model	Center for Ocean-Atmospheric Prediction Studies	1			
GCOOS	Model	Galveston Bay Operational Forecast System (NOAA/ CO-OPS/PORTS)	1			
GCOOS	Model	GOES Imagery, Gulf of Mexico Region, NOAA/NESDIS	1			

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
GCOOS	Model	High-Resolution Numerical Modeling of the Gulf of Mexico (COAPS)	1			
GCOOS	Model	Houston Ship Channel Model (HSCM) (NOAA/NOS)	1			
GCOOS	Model	Intra-American Seas Forecast Model at NRL	1			
GCOOS	Model	Lower Mississippi River Forecast information	1			
GCOOS	Model	National Centers for Coastal Ocean Science Gulf of Mexico Hypoxia Assessment	1			
GCOOS	Model	Naval Research Laboratory Gulf of Mexico products	1			
GCOOS	Model	Naval Research Laboratory models	1			
GCOOS	Model	NOAA Coastal Services Center HAB Mapping System	1			
GCOOS	Model	NOAA Water Level Station Monitoring for the Gulf of Mexico Region	1			
GCOOS	Model	Physical Oceanographic Real-Time System (PORTS) - Houston/Galveston	1			
GCOOS	Model	Physical Oceanographic Real-Time System (PORTS) - Tampa Bay	1			
GCOOS	Model	Princeton Ocean Model (8-Apr)	1			
GCOOS	Model	Superior's Surf Forecast Center - Links to a variety of products useful to surfers	1			
GCOOS	Model	Texas Water Development Board Bays and Estuaries Information	1			
GCOOS	Model	TGLO/TAMU surface current forecast for the Northwestern Gulf of Mexico	1			
GCOOS	Model	TxBLEND (2D and 3D)	1			
GCOOS	Model	USGS Geological Research Activities with the U.S. Minerals Management Service	1			
GCOOS	Model	WAVCIS	1	LSU		Wave height
GCOOS	Model	West Florida Shelf Circulation Coastal Monitoring and Prediction System (COMPS) from University of South Florida	1			

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
GCOOS	Observing	Buoy	11	Texas Automated Buoy System (TABS)		Wind, currents, air temp, pressure, humidity (specific to different buoys)
GCOOS	Observing	Buoy	3	Texas Coastal Ocean Observation Network (TCOON)		
GCOOS	Observing	Fixed Station	52	Texas Coastal Ocean Observation Network (TCOON)		
GLOS	Model	2-Dimensional Vertically Averaged Hydrodynamic Model (SMS 8.0)	1			
GLOS	Model	2-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model (v.3.1)	1			
GLOS	Model	Across Trophic Level System Simulation (v.1)	1			
GLOS	Model	Simulation Model for Aquatic Ecosystems (v.3.0, 2009)	1			
GLOS	Model	Advanced Aquatic Ecosystem Model	1			
GLOS	Model	Annualized Agricultural Non-Point Source Pollutant Loading Model (v.5, 2009)	1			
GLOS	Model	Aquatic Landscape Inventory System	1			
GLOS	Model	Better Assessment Science Integrating Point and Nonpoint Sources(v.4, 2007)	1			
GLOS	Model	Biogeochemical Reaction Network Simulator (2009)	1			
GLOS	Model	Cladophora Growth Model (v. 3.1, 2006)	1			
GLOS	Model	Coupled Hydrosphere-Atmosphere Research Model	1			
GLOS	Model	Curvilinear Hydrodynamics in Three-Dimensions	1			
GLOS	Model	Digital Watershed & L-THIA (August 2009)	1			
GLOS	Model	Digital Watershed (v.8, August 2009)	1			
GLOS	Model	Dynamic Linear Forecasting Models (LM and LH, 2007, and Lk Sup, 2008)	1			
GLOS	Model	Dynamics of River Ice	1			
GLOS	Model	Ecological Fate and Transport	1			

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
GLOS	Model	ELCOM and Computational Aquatic Ecosystem Dynamics Model (Unknown)	1			
GLOS	Model	Environmental Fluid Dynamics Computer Code (v.1, 2002)	1			
GLOS	Model	Everglades Landscape Model (v.2.5, 2006)	1			
GLOS	Model	Exposure Analysis Modeling System (v.2.98.04.06, 2005)	1			
GLOS	Model	Food and Gill Exchange of Toxic Substances (v.3.0.18, 1994)	1			
GLOS	Model	Generalized Modeling Package 2-D-Hydrodynamics	1			
GLOS	Model	Great Lakes Coastal Forecasting System (2009)	1			
GLOS	Model	Great Lakes Multi-Media Screening Model	1			
GLOS	Model	Green Bay Toxics Model	1			
GLOS	Model	Groundwater Modeling System (v.7.0, 2009)	1			
GLOS	Model	High Impact Targeting(v. 2, August 2009)	1			
GLOS	Model	Huron-Erie Connecting Waterways Forecasting System (2009)	1			
GLOS	Model	Hydrologic Engineering Centers River Analysis System (v.4, 2008)	1			
GLOS	Model	Hydrological Simulation Program – FORTRAN (v. 12, 2003)	1			
GLOS	Model	Integrated Catchments Model for Carbon	1			
GLOS	Model	Integrated Ecological Response Model	1			
GLOS	Model	Integrated-Compartment Eutrophication Model (v.3)	1			
GLOS	Model	Lake Ontario Comparative Offshore Food Web Mass Balance	1			
GLOS	Model	Lake Ontario Toxics Model 2	1			
GLOS	Model	Lake Superior Anthropogenic Stressor Model	1			
GLOS	Model	Large Basin Runoff Model	1			
GLOS	Model	Modular Three-Dimensional Ground-Water Flow Model (v1.6.02, 2009)	1			
GLOS	Model	Numeric River Ice Model	1			

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
GLOS	Model	NWRI 9-Box Water Quality Model for Lake Erie (2008)	1			
GLOS	Model	One-dimensional, dynamic flow and water quality model for streams (v.2, 1995)	1			
GLOS	Model	Ontario Flow Assessment Techniques (v1.0, 2003)	1			
GLOS	Model	Population Viability Analysis (v4.0, 2002)	1			
GLOS	Model	Princeton Ocean Model	1			
GLOS	Model	Rate Constant Model for Chemical Dynamics (v1.1)	1			
GLOS	Model	Resource Management Associates 2 Model (SMS 8.0)	1			
GLOS	Model	River and Stream Water Quality Model (v2.11b8, 2009)	1			
GLOS	Model	Saginaw Bay Ecosystem Model	1			
GLOS	Model	Salmonid Population Model (v3.8)	1			
GLOS	Model	Sanitary Sewer Overflow Analysis and Planning Toolbox	1			
GLOS	Model	Simplified Method Program - Variable-Complexity Stream Toxics Model	1			
GLOS	Model	Soil and Water Assessment Tool (ArcSWAT, 2009)	1			
GLOS	Model	Spatially Referenced Regression Watershed Attributes (v2.9)	1			
GLOS	Model	Stream Network/Stream Segment Temperature Models	1			
GLOS	Model	Enhanced Stream Water Quality Model (v.3, 1987)	1			
GLOS	Model	Time Varying Fish Consumption Model	1			
GLOS	Model	Water Quality Analysis Simulation Program (v7.3.1, 2008)	1			
GLOS	Model	Watershed Analysis Risk Management Framework (v6.3, 2005)	1			
GLOS	Model	Watershed and Lake Modeling Procedure	1			
GLOS	Model	Watershed Assessment Model	1			
GLOS	Model	Wetland Plant Community Predictive Model (GIS based)	1			
GLOS	Model	Wetland Response to Lake Level Declines	1			

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
GLOS	Observing	Buoy	9	National Data Buoy Center		
GLOS	Observing	Buoy	6	University of Michigan		
GLOS	Observing	Fixed Station	45	NDBC/C-MAN		
GLOS	Observing	Fixed Station	8	National Weather Service		
GLOS	Observing	Fixed Station	27	National Ocean Service CO-OPS		
GLOS	Observing	Fixed Station	1	National Estuarine Research Reserve System		
GLOS	Observing	Fixed Station	68	National Weather Service ASOS		
MACOORA	Model	HYbrid Coordinate Ocean Model (HYCOM)	1	National Ocean Partnership Program		
MACOORA	Model	HOPS Real-Time Forecast	1	University of Massachusetts, Dartmouth		
MACOORA	Model	Mid-Atlantic Surface Currents (STPS)	1			
MACOORA	Model	New York Harbor Observing and Prediction System (NYHOPS)	1	Stevens Institute of Technology		
MACOORA	Model	NOAA WAVEWATCH III - Mid-Atlantic	1	NOAA-NCEP		Dominant wave period, wave height, wave mean direction, wind direction, wind speed
MACOORA	Model	North American Mesoscale Model (NAM)	1	National Centers for Environmental Predictions		
MACOORA	Model	Regional Ocean Modeling System (ROMS)	1	Rutgers University		
MACOORA	Model	U.S. Navy Operational Global Ocean Model (NCOM) SST	1	Naval Oceanographic Office		
MACOORA	Model	U.S. Navy Operational Global Ocean Model (NCOM)	1	Naval Oceanographic Office		
MACOORA	Model	Weather Research and Fore-casting	1	Rutgers		Atmospheric and wind mod-elused for wave height, sea level, and forc-ing
MACOORA	Observing	Buoy	15	National Data Buoy Center		
MACOORA	Observing	Fixed Station	27	WeatherFlow, Inc.		
MACOORA	Observing	Glider	21	Rutgers (5) and other universities	University-maintained	
MACOORA	Observing	High-Frequency Radar	30	Various universities and private companies		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
MACOORA	Observing	Satellite Ground Station	3	2 at Rutgers, 1 at University of Delwre		
MACOORA	Observing	Stream Gauge	425	U.S. Geological Survey		
NANOOS	Model	CMOP/SATURN Daily Forecasts	1	CMOP		Salinity, water temperature
NANOOS	Model	NOAA North American Mesoscale (NAM) Model	1	NOAA-NCEP		Air temperature, barometric pressure, relative humidity, wind direction, wind gust, wind speed
NANOOS	Model	NOAA NOS/CO-OPS Tide Forecast	1	National Ocean Service CO-OPS		Water level
NANOOS	Model	NOAA WAVEWATCH III - NE Pacific	1	NOAA-NCEP		Dominant wave period, wave height, wave mean direction, wind direction, wind speed
NANOOS	Model	OSU Regional Ocean Modeling System (ROMS) Surface Fields	1	Oregon State University		Water temperature
NANOOS	Observing	Buoy	11	National Data Buoy Center		
NANOOS	Observing	Buoy	1	PMEL		
NANOOS	Observing	Buoy	3	APL-UW		
NANOOS	Observing	Buoy	6	CDIP-Scripps		
NANOOS	Observing	Buoy	1	CMOP		
NANOOS	Observing	Buoy	4	ORCA-UW		
NANOOS	Observing	Buoy	1	Oregon State University		
NANOOS	Observing	Buoy	2	King County		
NANOOS	Observing	Buoy	5	Env. Canada		
NANOOS	Observing	Buoy	4	ICM-Mobilisa		
NANOOS	Observing	Buoy	1	LOBO		
NANOOS	Observing	Cruise	1	PRISM-UW		
NANOOS	Observing	Cruise	1	HCDOP		
NANOOS	Observing	Fixed Shore Platform	6	NERRS		
NANOOS	Observing	Fixed Shore Platform	24	National Ocean Service CO-OPS		
NANOOS	Observing	Fixed Shore Platform	15	CMOP		
NANOOS	Observing	Fixed Shore Platform	3	King County		
NANOOS	Observing	Fixed Shore Platform	1	PSI		
NANOOS	Observing	Fixed Shore Platform	4	WADOE		
NANOOS	Observing	Glider	1	APL-UW		
NANOOS	Observing	Glider	1	CMOP		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
NANOOS	Observing	Glider	2	Oregon State University		
NANOOS	Observing	High-Frequency Radar	1	Oregon State University		
NANOOS	Observing	Land Station	6	NDBC/C-MAN		
NANOOS	Observing	Land Station	2	National Estuarine Research Reserve System		
NANOOS	Observing	River Gage	29	U.S. Geological Survey		
NANOOS	Observing	River Gage	1	CMOP		
NANOOS	Observing	Satellite (Composite)	2	NOAA CoastWatch		
NANOOS	Observing	Seabed Cabled Platform	4	VENUS		
NANOOS	Observing	X-Band Radar	1	Oregon State University		
NERACOOS	Model	Coastal Flooding and Erosion Forecast	1	GoMOOS		
NERACOOS	Model	NOAA WAVEWATCH III - NE Pacific	1	NOAA-NCEP Bedford Institute of Oceanography		Dominant wave period, wave height, wave mean direction, wind direction, wind speed
NERACOOS	Model	Northeast Coastal Ocean Forecast System (NECOFS)	1	UMASS Dartmouth		
NERACOOS	Model	Search and Rescue Optimal Planning System (SAROPS)	1			
NERACOOS	Model	Water Level Model (FVCOM)	1			
NERACOOS	Observing	Buoy	8	NOAA NDBC		
NERACOOS	Observing	Buoy	1	National Weather Service		
NERACOOS	Observing	Buoy	9	University of Maine		
NERACOOS	Observing	Buoy	1	CDIP-Scripps		
NERACOOS	Observing	Buoy	1	Bowdoin University		
NERACOOS	Observing	Buoy	3	Environment Canada		
NERACOOS	Observing	Buoy	4	University of Connecticut (LISICOS)		
NERACOOS	Observing	Buoy	1	Woods Hole Oceano-graphic Institute		
NERACOOS	Observing	Buoy	1	University of New Hampshire		
NERACOOS	Observing	Fixed Station	21	National Ocean Service		
NERACOOS	Observing	Fixed Station	4	National Estuarine Research Reserve System		
NERACOOS	Observing	Fixed Station	4	NDBC/C-MAN		
NERACOOS	Observing	High-Frequency Radar	24			
NERACOOS	webserver	OPENDAP, THREDDS				

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
PacIOOS	Model	NOAA WAVEWATCH III - NE Pacific	1	PacIOOS		Dominant wave period, wave height, wave mean direction, wind direction, wind speed
PacIOOS	Model	Surface Tidal Currents	1	University of Hawaii		
PacIOOS	Model	WWW Tide and Current Predictor	1	University of Hawaii		
PacIOOS	Model	Simulating Waves Near shore (SWAN) for each island group	1	PacIOOS		
PacIOOS	Observing	Buoy	7	National Data Buoy Center		
PacIOOS	Observing	Buoy	1	National Data Buoy Center (DART)		
PacIOOS	Observing	Waverider Buoys	6	PacIOOS, NSF and USACE	CDIP manages data processing	
PacIOOS	Observing	PMEL/CO2 Buoy	4	PMEL, PacIOOS and Univ. of Hawaii		
PacIOOS	Observing	Buoy	42	Fish Aggregation Device (FAD)		
PacIOOS	Observing	Buoy	12	Fish Aggregation Device (FAD) w/Receiver		
PacIOOS	Observing	Cruise Survey Stations	6	Hawai'i Ocean Time Series (HOT)		
PacIOOS	Observing	Fixed Station	6	NWLON		
PacIOOS	Observing	High-Frequency Radar	3	University of Hawaii		
PacIOOS	Observing	Current meter	1		PacIOOS	
PacIOOS	Observing	Water level station	1		PacIOOS	
PacIOOS	Observing	Inshore Receiver	4	HIMB Shark Research Group		
PacIOOS	Observing	LIDAR	3	University of Hawaii		
PacIOOS	Glider	Gliders	2	University of Hawaii		
PacIOOS	Observing	Nearshore Reef Observatory	1	Kilo Nalu Nearshore Reef Observatory		
PacIOOS	Observing	Near-shore sensors; 5 in Hawaii; 5 outside Hawaii; 4 forthcoming	14	PacIOOS funded purchase by UH	University of Hawaii	
PacIOOS	Observing	Rain Gauge	22	U.S. Geological Survey		
PacIOOS	Observing	Stream Gauge	52	U.S. Geological Survey		
SCCOOS	Model	CDIP/SIO Experimental Southern California Swell Model	1	CDIP-Scripps		
SCCOOS	Model	Regional Ocean Modeling System (ROMS)	1			
SCCOOS	Model	Ship Tracking (AIS) Tool	1	SCCOOS		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
SCCOOS	Observing	Automated Shore Stations	4	SCCOOS		temperature, salinity, chlorophyll, turbidity, water level ; real-time
SCCOOS	Observing	Coastal Data Information Program (CDIP) Wave Buoys	15	CDIP/US Army Corps of Engineers (USACE)/California Department of Boating and Waterways		waves, sea surface temperature, air temperature; near real-time
SCCOOS	Observing	Manual Shore Stations	19	California Department of Boating and Waterways		temperature, salinity ; delayed mode
SCCOOS	Observing	Harmful Algal Bloom (HAB) Monitoring Pier Sites	5	SCCOOS/Cal Poly/UCSB/USC/UCLA/Scripps Institution of Oceanography (SIO)		sea surface temperature, salt, phytoplankton species (8), ammonia, chlorophyll, phaeophytin, nitrate, phosphate, silicate; delayed mode
SCCOOS	Observing	Meteorology Stations	1656	Meteorological Assimilation Data Ingest System (MADIS)		air temperature, sea surface temperature, waves, accumulated precipitation, altimeter, barometric pressure, dew point temperature, elevation, precipitation rate, relative humidity, solar radiation, visibility, wind direction at gust, wind direction, wind gust, wind speed, sea level pressure; near real-time
SCCOOS	Observing	Spray Glider Transects	3	SCCOOS/SIO/Instrument Development Group (IDG)		temperature, salinity, optical properties, backscatter, water velocity; delayed mode

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
SCCOOS	Observing	California Cooperative Oceanic Fisheries Investigations (CalCO-FI) - nearshore stations	9	SCCOOS/CalCOFI/California Department of Fish and Game/NOAA Fisheries Service/SIO		temperature, salinity, oxygen, nutrients, phytoplankton, zooplankton; quarterly
SCCOOS	Observing	Seabird and Marine Mammal Surveys	2	SCCOOS/Farallon Institute for Advanced Ecosystem Research		quantity of seabirds and marine mammals along CalCOFI transects; bi-annually
SCCOOS	Observing	Erosion and Inundation Project	1	SCCOOS/CDIP/SIO/USACE/ California Department of Boating and Waterways		wave conditions, water level, sand level, inundation; delayed mode
SCCOOS	Remote Sensing	High Frequency (HF) Radars	23	SCCOOS/State of California/Coastal Observing Research and Development Center (CORDC)		surface currents; near real-time
SCCOOS	Remote Sensing	GOES (Geostationary Operational Environmental Satellite)	1	NOAA		water vapor, visible, infrared; near real-time
SCCOOS	Remote Sensing	OI SST (Optimally Interpolated Sea Surface Temperature)	1	Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA)/National Centre for Ocean Forecasting (NCOF)		sea surface temperature; delayed mode
SCCOOS	Remote Sensing	MODIS (Moderate Resolution Imaging Spectroradiometer)	1	NASA MODIS		sea surface temperature, chlorophyll, normalized water-leaving radiance; delayed mode
SCCOOS	Model	Weather Research and Forecasting Model (WRF)	1	UCLA Department of Atmospheric and Oceanic Sciences, Climate Sensitivity Research Lounge.		winds and rainfall forecast; near real-time
SCCOOS	Model	COAMPS (Coupled Ocean/Atmosphere Mesoscale Prediction System)	1	Naval Research Laboratory		winds and rainfall forecast; near real-time (3hr lag)
SCCOOS	Model	Stormwater Plume Tracking	1	SCCOOS		
SCCOOS	Model	Surface Current Mapping	1	Coastal Ocean Currents Monitoring Program (COCMP)		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
SCCOOS	Model	Optimally Interpolated High Frequency Radar Surface Currents	1			
SCCOOS	Model	Weather Research and Fore-casting Model (WRF)	1	University of California, Los Angeles		
SCCOOS	Model	Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS)	1	Naval Research Labora-tory		
SCCOOS	Model	Optimally Interpolated Sea Surface Temperature (OI SST) from the Operational Sea Sur-face Temperature and Sea Ice Analysis (OSTIA)	1	SCCOOS		
SCCOOS	Observing	Buoy	39	CDIP-Scripps		
SCCOOS	Observing	Buoy Shallow Water Mooring	1	Scripps Institute of Oceanography		
SCCOOS	Observing	Cast Water Quality (Ship Cast Station)	137	California Cooperative Oceanic Fishereis Investigations (CalCOFI)		
SCCOOS	Observing	Fixed Station Nearshore Au-tomated	7			Temperature, salinity, chlorophyll, turbidity and water level
SCCOOS	Observing	Fixed Station Nearshore Manual	11			Temperature, salinity
SCCOOS	Observing	Glider	3	Scripps Institute of Oceanography		
SCCOOS	Observing	High-Frequency Radar	83			
SCCOOS	Observing	Outfall Station	5			
SCCOOS	Observing	Shoreline Water Quality Sam-pling Station	417			
SCCOOS	Observing	Stream Gauge	83	U.S. Geological Survey		
SCCOOS	Observing	Survey Cruise Stations	94	California Cooperative Oceanic Fisheries Investigations (CalCOFI)		
SCCOOS	Observing	Survey Cruise Tracks	9	California Cooperative Oceanic Fisheries Investigations (CalCOFI)		
SCCOOS	Observing	Underway CTD	1	University of California, Santa Barbara		
SECOORA	Model	ADCIRC	1	University of North Caro-lina		
SECOORA	Model	Regional Ocean Modeling System (ROMS)	1	University of South Flori-da		
SECOORA	Model	South Atlantic Bight and Gulf of Mexico Circulation Nowcast/Forecast Modeling System (SABGOM)	1	North Carolina State University		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
SECOORA	Model	Tampa Bay Nowcast/Forecast Modeling System	1	University of South Flori-da		
SECOORA	Model	Storm Surge Modeling	1	University of South Flori-da		
SECOORA	Model	Beach/Water Quality Advisory Modeling.	1	(University of South Caro-lina)		
SECOORA	Observing	Buoy	34	National Data Buoy Center		
SECOORA	Observing	Buoy	3	National Estuarine Research Reserve System		
SECOORA	Observing	Buoy	4	U.S. Army Corps of Engineers		
SECOORA	Observing	Buoy	1	NSU Oceanographic Center		
SECOORA	Observing	Buoy	3	Scripps Institute of Oceanography		
SECOORA	Observing	Buoy	1	Skidaway Institute of Oceanography		
SECOORA	Observing	Buoy	1	University of North Carolina at Chapel Hill		
SECOORA	Observing	Buoy	4	University of North Carolina Wilmington		
SECOORA	Observing	Buoy	8	University of South Carolina		
SECOORA	Observing	Buoy	8	University of South Florida		
SECOORA	Observing	Fixed Station	49	National Ocean Service CO-OPS		
SECOORA	Observing	Fixed Station	2	National Park Service - Southeast Coast Network		
SECOORA	Observing	Fixed Station	186	National Weather Service		
SECOORA	Observing	Fixed Station	1	National Weather Service/USMC		
SECOORA	Observing	Fixed Station	3	NCSU - Neuse Estuary Monitoring and Research Program		
SECOORA	Observing	Fixed Station	1	South Carolina Algal Ecology Laboratory		
SECOORA	Observing	Fixed Station	1	South Carolina Department of Natural Resources		
SECOORA	Observing	Fixed Station	17	South Florida Water Management District		
SECOORA	Observing	Fixed Station	11	Southwest Florida Water Management District		
SECOORA	Observing	Fixed Station	6	St. John River Water Management District		

Table A-1. Summary of RA Assets

RA	General asset type	Asset description/name	Number	Owner/provider	Maintainer	Data collected
SECOORA	Observing	Fixed Station	1	St. Johns River Water Management District		
SECOORA	Observing	Fixed Station	3	Tampa Bay PORTS		
SECOORA	Observing	Fixed Station	5	University of North Carolina at Chapel Hill		
SECOORA	Observing	Fixed Station	2	University of North Carolina Wilmington		
SECOORA	Observing	Fixed Station	2	University of South Carolina		
SECOORA	Observing	Fixed Station	12	University of South Florida		
SECOORA	Observing	Fixed Station	25	WeatherFlow, Inc.		
SECOORA	Observing	Fixed Station	25	National Park Service Everglades Marine Monitoring Network.		
SECOORA	Observing	Fixed Station	8	Sanibel-Captiva Conservation Foundation River, estuary, and Coastal Ocean Observing Netowrk		
SECOORA	Observing	High-Frequency Radar	2	University of Miami		
SECOORA	Observing	High-Frequency Radar	2	University of North Carolina at Chapel Hill		
SECOORA	Observing	High-Frequency Radar	3	University of South Florida		
SECOORA	Observing	High-Frequency Radar	2	University of South Florida WERA		
SECOORA	Observing	High-Frequency Radar	1	University of South Carolina		
SECOORA	Observing	Land Station	41	National Estuarine Research Reserve System		
SECOORA	Observing	Land Station	15	Florida Coastal Everglades LTER		
SECOORA	Observing	Land Station	2	Florida Department of Environmental Protection		
SECOORA	Observing	Land Station	1	Florida Institute of Technology - Coastal Engineering Lab		
SECOORA	Observing	Land Station	9	Georgia Coastal Ecosystem LTER		
SECOORA	Observing	Land Station	3	MOTE Marine Lab		
SECOORA	Observing	Offshore Platform	5	Skidaway Institute of Oceanography		
SECOORA	Observing	River Gauge	68	U.S. Geological Survey		
SECOORA	Observing	Survey Cruise	2	NCDENR, NC DOT Ferry Div., DUML, UNC-IMS		
SECOORA	Observing	Survey Cruise	1	University of Miami		

ALASKA REGION—ALASKA OCEAN OBSERVING SYSTEM

The Alaska Ocean Observing System (AOOS) is the regional association for the statewide coastal and ocean observing system and three regional observing systems (Gulf of Alaska, Bering Sea/Aleutian Islands and Arctic) being developed for the Alaska region as part of the U.S. IOOS. The AOOS proposal to IOOS was endorsed by the AOOS board, which includes representatives of nearly all federal agencies in Alaska, the three State of Alaska resource agencies, and the major research institutes in Alaska, including the University of Alaska.

Funding:

- FY10—$1,400,000 RCOOS award, $399,985 RA planning grant award.
- FY09—$1,000,000 RCOOS award, $399,969 RA planning grant award.
- FY08—$1,000,000 RCOOS award, $399,976 RA planning grant award.

Point of Contact:

- Molly McCammon, Executive Director (mccammon@aoos.org).
- www.aoos.org.

Regional Priorities and Objectives:

AOOS) is focused on four key issues:

- Climate change and its impacts
- Sustainability of fisheries and marine ecosystems
- Mitigation of natural hazards, especially coastal erosion
- Safety of marine operations and health of coastal communities.

Regional IOOS objectives are developed through close engagement with stakeholders. Key AOOS board objectives for 2010 are identified as follows:

- Establish the AOOS data and web portal as the regional coastal and ocean information system for Alaska, increasing statewide capacity in data management, modeling, and product visualization
- Expand ocean literacy in Alaska and stakeholder use of ocean observing products, including specific tools for educators, by leveraging other coastal and ocean education and outreach activities in Alaska

- Continue to test and assess enhanced observations and a suite of regional ocean, wave, and weather forecast models as a demonstration of an end-to-end observing system in Alaska's Prince William Sound

- Improve regional forecasts in Cook Inlet and Resurrection Bay by adding new observing platforms and expanding models established in PWS to the northern Gulf of Alaska (GOA) and continue long time series ocean monitoring in the Gulf of Alaska, including monitoring for ocean acidification

- Continue testing a prototype ocean and weather station for use at Alaska harbors and add two new locations to improve safety at sea

- Provide real-time information on Arctic Ocean conditions (physical, biological, and chemical) with the addition of new observing platforms to develop near-shore weather and ocean forecasts and monitor climate change impacts.

Limited funding has precluded a number of components originally proposed by AOOS, specifically, major expansion of AOOS in Cook Inlet, contributions to Southeast Alaska and Bering Sea ocean circulation models, passive acoustic monitoring in the Bering Sea, and sea ice thickness and motion measurements in the Arctic.

Caribbean Region—Caribbean Regional Association

The Caribbean Regional Association (CaRA) is the regional association for the coastal and ocean observing system being developed for Puerto Rico and the U.S. Virgin Islands. Initial implementation of the Caribbean Integrated Coastal Ocean Observing System (CarICOOS) is focused on meeting identified stakeholder needs for improved real-time data products and forecasts of coastal weather (winds), currents, waves, water quality, and hurricane-driven inundation for the U.S. Caribbean Exclusive Economic Zone (EEZ).

Funding:

- FY10—$1,000,000 RCOOS award, $399,824 RA planning grant award.
- FY09—$527,016 RCOOS award, $399,826 RA planning grant award.
- FY08—$499,999 RCOOS award, $399,699 RA planning grant award.

Point of Contact:

- Julio M. Morell (julio.morell@upr.edu).
- www.caricoos.org.

Regional Priorities and Objectives:

CaRA has engaged stakeholders from various sectors pertaining to tourism and marine recreation, maritime transportation, security, human and ecosystem health, and economics, and whose decisions are based on coastal seas and weather information. To meet both stakeholder needs and national program requirements, CaRA will focus on the following activities:

- Enhancement or installation of essential in situ (in the water) observational assets
- Operational implementation of modeling tools
- Partnering with NOAA Coast Watch and European Space Agency to produce regionally focused remote sensing products
- Processing and archiving of IOOS-compliant data
- Dissemination of data and products to agencies and stakeholders to ensure a user-responsive, operational RCOOS.

Now entering the third year of its project, CaRA will continue progress in the following areas:

- Completion of a coastal data buoy network
- Sustained operation and maintenance of all observational assets (coastal buoys and meteorological mesonet) and sustained dissemination of data streams and data products
- Integration and optimization of observational and modeling components through data assimilation
- Operational implementation of surface tide and coastal circulation modeling (ADCIRC)
- Implementation of regional ocean modeling (HYCOM-ROMS) for the high-resolution western PR and VI grids
- Full implementation and publication of IOOS-compliant web-based tools and data products
- Operational implementation and optimization of coastal wave modeling (SWAN) and product suite
- Improvement of coastal inundation products through optimization of the computational grid for PR and USVI.

CENTRAL AND NORTHERN CALIFORNIA REGION—CENTRAL AND NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

The Central and Northern California Ocean Observing System (CeNCOOS) spans the coastal ocean from the California/Oregon border south to Point Conception. The fundamental CeNCOOS approach is to develop long-term monitoring of environmental conditions such as water quality, productivity, and connectivity in support of marine-protected area (MPA) management in central and northern California.

Funding:

- FY10—$1,402,000 RCOOS award, $399,619 RA planning grant award.
- FY09—$1,281,529 RCOOS award, $397,308 RA planning grant award.
- FY08—$1,000,000 RCOOS award, $395,763 RA planning grant award.

Point of Contact:

- Steve Ramp, Executive Director (sramp@mbari.org).
- www.cencoos.org.

Regional Priorities and Objectives:

The CeNCOOS proposal for 2008–10 outlined the following goals:

- Monitor the water quality, productivity, and population connectivity in the coastal ocean from Point Conception to the Oregon border out to 200 km offshore
- Implement data-assimilating numerical forecast models to act as dynamical interpolators of sparse ocean data sets and allow prediction of ocean properties from days to decades
- Develop a DMAC system to move data seamlessly from the sensor to the product developer and allow easy access to the data and products for all CeNCOOS partners and end users
- Develop information products specifically targeted to support management decisions in state and federal marine-protected areas within the region, defined here to include national marine sanctuaries and MPAs designated by the State of California under the Marine Life Protection Act.

This proposal, originally written for $3.5 million per year for 3 years, was funded at lower levels than anticipated. In coordination with stakeholders, in response to lower funding levels, and still in keeping with the original CeNCOOS objectives, the revised work plan and priorities for 2010 were as follows:

- As a top priority, maintain the pan-regional backbone, DMAC system, and data products
- Maintain MPAs
- Continue HFR support at the same level as in 2009 ($282,000)
- Invest in numerical modeling and prediction, with a goal of starting work that CeNCOOS can build upon with future funding.

GULF OF MEXICO REGION—GULF OF MEXICO COASTAL OCEAN OBSERVING SYSTEM

The Gulf of Mexico Coastal Ocean Observing System (GCOOS) includes the coastal states from Florida to Texas.

Funding:

- FY10—$1,000,000 RCOOS award, $399,960 RA planning grant award.
- FY09—$573,085 RCOOS (2 awards), $399,998 RA planning grant award.
- FY08—$573,085 RCOOS (2 awards), $399,986 RA planning grant award.

Point of Contact:

- Ann Jochens (ajochens@tamu.edu).
- www.gcoos.org.

Regional Priorities and Objectives:

GCOOS is being developed as a sustained observing system that will provide data, information, and products on marine and estuarine systems of the Gulf to a wide range of users. The GCOOS RA, established in January 2005, is working to bring GCOOS to maturity to provide observations and products needed by users in this region for the following:

- Detecting and predicting climate variability and consequences
- Preserving and restoring healthy marine ecosystems
- Ensuring human health
- Managing resources
- Facilitating safe and efficient marine transportation
- Enhancing national security
- Predicting and mitigating against coastal hazards.

The goal of the RA support project is to maintain and strengthen the RA so it can build a comprehensive, sustained, operational GCOOS to meet the needs of many different stakeholders. The objectives are as follows:

- Maintain and further develop the RA's infrastructure

- Identify regional and local stakeholder needs and priorities
- Identify and maintain an inventory of observations and products from the region
- Identify gaps in observations and products needed to meet stakeholder needs
- Select and prepare projects to fill gaps and to provide for enhancements to observing systems, products, and data management
- Strengthen regional involvement with the evolution of and compliance with the DMAC plans of U.S. IOOS
- Coordinate and collaborate with other observing system entities.

Considering inputs from the broad community of GCOOS stakeholders, the RA has identified five thematic areas, each with many associated issues, as priorities for building GCOOS:

- Safe and efficient marine operations (e.g., marine transportation, recreational boating, and pollutant spill tracking)
- Mitigation of effects of coastal hazards (e.g., monitoring and forecasting of storm surge and inundation, impacts of hurricanes on communities and offshore industries, and urban development impacts to ecosystems)
- Public health and safety (e.g., SAR; HAB detection, monitoring, and forecasting; hypoxia monitoring at regional and local levels; and monitoring and prediction of risks from rip currents or strong currents or waves)
- Healthy ecosystems and water quality (e.g., hypoxia monitoring, pollutant tracking, monitoring to maintain healthy ecosystems for fisheries)
- Gulf-wide ocean literacy and climate literacy (e.g., increasing public knowledge to improve decisions on recreational activities, hurricane evacuation, and urban development and flood zones, as well as to promote sustainable use of resources and protect life and property in the face of natural and human-induced threats).

The RA is also continuing work, started in January 2008, to build a centralized regional data portal to harmonize the data delivery systems of non-federal, voluntary data providers to the GCOOS; to develop an integrated data framework for data streams, quality assurance procedures, and data delivery in the region; and to provide public products needed by the broad community of stakeholders. The RA is standardizing elements of the near real-time marine data delivery systems of the data providers to maximize interoperability within the region, between regions, and with U.S IOOS and to facilitate the production of operational data and model products in support of the regional and national needs. The RA is developing an integrated data framework for data streams, quality assurance procedures, and data delivery. Objectives for this activity are as follows:

- Maintain and enhance the data portal, including the addition of new voluntary data providers, data types, and products
- Develop and refine a comprehensive data management system
- Build a pre-operational Regional Operations Center (ROC)
- Develop educational resources for significant IOOS outreach efforts.

GREAT LAKES REGION—GREAT LAKES OBSERVING SYSTEM

The Great Lakes Observing System (GLOS) provides coverage for the coastal zone within the states of New York, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, Minnesota, and Michigan, all bordering on the Great Lakes and St. Lawrence River.

Funding:

- FY10—$1,080,815 RCOOS award (plus $1,896,185 to GLOS partner, the Cooperative Institute for Limnology and Ecosystem Research, with $313,000 staying within NOAA for complementary observing and modeling activities), $400,000 RA planning grant award. (Much of the increased funding for Great Lakes activities in 2010 was through a $3 million award to GLOS that NOAA is administering from the Environmental Protection Agency for observing activities associated with the Great Lakes Restoration Initiative.)
- FY09—$350,000 RCOOS award, $400,000 RA planning grant award.
- FY08—$350,000 RCOOS award, $400,000 RA planning grant award.

Point of Contact:

- Jennifer Read, Executive Director (jenread@umich.edu).
- www.glos.us.

Regional Priorities and Objectives:

GLOS is dedicated to providing access to real-time and historic data on the hydrology, biology, chemistry, geology, and cultural resources of the Great Lakes, its interconnecting waterways, and the St. Lawrence River to meet the following regional priorities:

- Improve early identification of climate change impacts on the thermal structure and chemistry of the Great Lakes
- Reduce risks of contaminated water supplies and improve predictive capabilities to protect public use of bathing beaches
- Enhance understanding of nutrient dynamics, algal blooms, and other factors adversely affecting a viable fishery

- Reduce loss of life and property damage to commercial navigation and recreational boating, while increasing economic efficiencies of commercial navigation operations.

Since 2008, GLOS has focused on four primary tasks:

- Implementation of prototype near-shore buoys on lakes Superior, Michigan, Erie, and Ontario to collect meteorological, wave information, and vertical lake temperature observations

- Development of public domain three-dimensional hydrodynamic modeling for the lakes Huron-to-Erie Corridor (HEC), including Lake St. Clair

- Expansion of the development, user assessments, and market analysis of customized integrated harbor-specific products (Great Lakes Harbor View)

- Implementation of the Great Lakes Modeling and Assessment Center (GLMAC).

In 2010, GLOS will use U.S. IOOS funds, as well as funds received through the Great Lakes Restoration Initiative, to continue these activities. Critical information needs for the four GLOS priorities will be addressed by implementation of an array of integrated observations, including new moorings and additional sensors, AUV/glider technologies, cross-lake ferry instrumentation, and satellite remote sensing products. In addition, hydrodynamic model development will be advanced in key interconnecting waterways between the lakes and along near-shore areas where protection of public health and maritime safety are of high concern. The proposed work will include coordination of information resources and implementation of service-oriented data integration and delivery approaches. Finally, an outreach and education program will be conducted, including curricula development, teacher education, GLOS product promotion, and periodic user-needs assessments.

Activities for 2010 were selected because they build on successes already achieved under the cooperative agreement, help meet priorities identified in the GLRI action plan, initiate the implementation of high priorities of the cooperative agreement that have not yet been addressed due to funding constraints, and have emerged as high-priority initiatives in the GLOS strategic planning process with stakeholders. This work will provide significant benefits to a wide array of users across the region and are critical components of the region's long-term vision for advancing resource management and use.

MID-ATLANTIC REGION—MID-ATLANTIC COASTAL OCEAN OBSERVING SYSTEM

The Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) includes the coastal ocean states from Cape Cod to Cape Hatteras, representing roughly one-fourth of the U.S. population and comprising nine states and the District of Columbia and five major urban estuaries, including the Hudson River estuary, the Delaware River estuary, the Long Island Sound, and the Chesapeake Bay. The region has 7 of the 12 largest ports in the United States and over 110 congressional districts. The Mid-Atlantic Bight alone is roughly 1,000 km long. MACOORA coordinates, facilitates, and links observations of the watershed, estuary, and ocean in this footprint as part of a national effort to improve scientific observations of our coastal oceans. It accomplishes these activities though its observing arm, the Mid-Atlantic Coastal Ocean Observing System (MARCOOS).

Funding:

- FY10—$1,700,000 RCOOS award, $400,000 RA planning grant award.
- FY09—$1,700,000 RCOOS award, $400,000 RA planning grant award.
- FY08—$1,700,000 RCOOS award, $400,000 RA planning grant award.
- FY07—$1,700,000 RCOOS award, $400,000 RA planning grant award.

Point of Contact:

- Judith Krauthamer, Executive Director (judith.krauthamer@macoora.org).
- www.macoora.org.

Regional Priorities and Objectives:

MACOORA/MARCOOS resources include 30 coastal HFRs, a fleet of ocean gliders, buoys, and a trio of data assimilation models. Priority areas of focus include coastal inundation, maritime safety, ecosystem decision support (such as fisheries), water quality, and offshore renewable energy. MACOORA/MARCOOS observations and modeling information streams are also relevant to and critical in the discussion of climate change, ocean acidification, and marine spatial planning. Benefitting from extensive outreach, education, and user interactivity, MACOORA/MARCOOS observations and observation products provide decision-making input for port management, search and rescue, power utility restoration, reservoir, storm- and wastewater management, and local and state regulation of beaches and fisheries.

In its first years of funding, MACOORA/MARCOOS focused on delivering real-time information products to improve SAR activities at sea and aid ecosystem-based management of fisheries. Two primary sets of observing assets were established:

- Operational array of HFRs for hourly mapping of surface currents over the Mid-Atlantic region
- Ensemble of ocean forecast models that assimilate data from a fleet of autonomous ocean gliders and satellite sensors.

The MACOORA/MARCOOS surface-current radar data product is now an officially recognized component of the U.S. Coast Guard Search and Rescue Optimal Planning System and is helping to save lives at sea. Collaborating with NOAA Fisheries, MACOORA/MARCOOS has increased model forecasts that are relevant to fisheries in the region. These successes are due in part to its ability to leverage federal interagency investments and activities with the Coast Guard, Navy, National Science Foundation, Department of Homeland Security, NASA, U.S. Geological Survey, and Environmental Protection Agency, among others.

Considering ongoing feedback from users, MACOORA/MARCOOS has begun to enhance its activities in water quality, coastal inundation, and offshore renewable energy. Regionally distributed administrative, scientific, and operational expertise is being used to coordinate an extensive array of observation, data management, and modeling assets in these areas. MACOORA/MARCOOS will generate and disseminate real-time data, nowcasts, and forecasts of the Mid-Atlantic coastal ocean. Specific goals include the following:

- Broadened ensemble of regional weather forecasts linked to a growing regional weather network for assimilation and validation through collaborations with NOAA weather forecast offices, academia, and industry
- Ensemble of regional nowcasts and forecasts of 2-D surface currents with the operational Mid-Atlantic HFR network
- Ensemble of 3-D circulation, temperature, and salinity nowcasts and forecasts derived from three dynamical data-assimilative ocean models
- Informational outreach to nearly 4,000 Mid-Atlantic stakeholders
- Workshops on water quality, fisheries, and coastal inundation
- Continued strategic relationships with NGOs and other data and policy providers
- Alliances and close interaction with governance entities, such as the Mid-Atlantic Region Council on the Ocean (MARCO)
- Continued leveraging of regional observation and modeling assets to support the three U.S. IOOS subsystems.

Pacific Northwest Region—Northwest Association of Networked Ocean Observing Systems

The Northwest Association of Networked Ocean Observing Systems (NANOOS) is the U.S. IOOS RA in the Pacific Northwest (PNW), primarily Washington and Oregon. NANOOS has strong ties with other West Coast observing systems, particularly AOOS, CeNCOOS, and observing programs in British Columbia (e.g., the Victoria Experimental Network Under the Sea, or VENUS) through common purpose and the occasional overlap of data and products.

Funding:

- FY10—$1,700,000 RCOOS award, $400,000 RA planning grant award.
- FY09—$1,500,000 RCOOS award, $400,000 RA planning grant award.
- FY08—$1,500,000 RCOOS award, $400,000 RA planning grant award.
- FY07—$1,500,000 RCOOS award, $400,000 RA planning grant award.

Point of Contact:

- Jan Newton, Executive Director (newton@apl.washington.edu).
- www.nanoos.org.

Regional Priorities and Objectives:

NANOOS is a partnership of over 40 entities, including industry, state agencies, local governments, tribes, NGOs, and educational institutions. Established in 2003, NANOOS has used results of nearly 3 years of NOAA-funded planning efforts and ongoing regional contributions to build regional association partnerships in the PNW and to identify high-priority user needs and requirements.

To progress on the NANOOS regional priorities of maritime operations, fisheries, ecosystem impacts, climate, and coastal hazards, this project will continue to develop the essential subcomponents of the PNW RCOOS: observing systems, modeling and products, DMAC, and education and outreach. The work will be applied in four observational domains: coastal ocean shelf, coastal ocean surface currents, estuaries, and shorelines.

NANOOS identified eight initial objectives for the RCOOS. While budgetary levels were reduced, seven of those objectives were retained and have been met to date. In 2010, NANOOS continued progress on those seven objectives and added two new objectives to guide future build-out and focus. The nine current objectives are as follows:

- *Maintain surface current mapping capability.* This activity is a foundational block for the coastal ocean observing system serving diverse users spanning maritime operations to ecosystems and fisheries.
- *Sustain buoys and gliders in the PNW coastal ocean, in coordination with national programs.* These assets give advance information on hypoxia and anoxia, ocean acidification, and HABs.
- *Maintain observation capabilities in PNW estuaries.* These address sustainable use and management.
- *Maintain core elements of beach and shoreline observing programs.* This helps hazard mitigation by providing better decision support tools for coastal managers, planners, and engineers.
- *Sustain a system of numerical models of PNW circulation.* This covers from the head of tide of estuaries to the outer edges of the EEZ. Modeling tools support users such as marine operators, first responders, and environmental managers.
- *Maintain NANOOS's DMAC system for routine operational distribution of data and information.* This dynamic distributed system of systems supports users' needs and allows free access to the IOOS backbone and national information infrastructure.
- *Sustain and strengthen NANOOS education and outreach efforts.* This work fosters ocean literacy and use of NANOOS products.
- *Make selected improvements to RCOOS (new for 2010).* The focus of this activity is on NANOOS-identified priority areas of improvement in all of the subsystems of the RCOOS and a modular plan.
- *Quantitatively evaluate assets, products and efforts of the RCOOS, in light of stakeholder input and evaluations, to assess payoffs and see where improvements and/or redirection are needed (new for 2010).* This activity will support NANOOS planning.

NANOOS places a priority on sustaining the leveraged coastal observations that its RCOOS has integrated and on developing the most informative and useful products for regional users, as advised by its governing council and active standing committees (DMAC, user products, education and outreach) that prioritize work efforts.

In late 2009, NANOOS launched its online system-wide data viewing and access tool, known as the NANOOS Visualization System (NVS). NVS, available at http://www.nanoos.org/nvs, allows easy access to ocean observing data in the PNW. NVS gathers data across a wide range of sources (federal and non-federal), including buoys and shore- and land-based stations throughout the NANOOS region (Canada to California). NVS is continually being improved and refined as new data streams are brought in and as the NVS development team receives feedback from users. Released in 2010, NVS 1.6 adds access to surface currents from HFRs, temperature and ocean color from satellites, and improved filters, legends, and data plots. Users can also find data from research cruises and forecast information on water levels and waves for many locations.

NANOOS developed a wide variety of user products and educational materials centered on its five regional priorities. Examples are online tsunami evacuation/inundation maps; forecast information products developed for commercial and recreational albacore tuna fishers; real-time water quality information optimized for shellfish growers; blended tide, current, and weather conditions forecasts for mariners; and online “theme pages” for issues of regional interest, such as ocean acidification and hypoxia, with direct links to data, educational content, and regional activities. A variety of lesson plans, some using real-time data, and learning resources are available and being used and evaluated by teachers at various levels.

NORTHEAST ATLANTIC REGION—NORTHEASTERN REGIONAL ASSOCIATION OF COASTAL OCEAN OBSERVING SYSTEMS

The Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS) spans coastal waters from the Canadian Maritime Provinces to the New York Bight. NERACOOS provides weather and ocean data to fishermen and commercial shippers determining if conditions are safe for passage and to emergency managers issuing storm warnings. It is also advancing efforts to use these data for water quality monitoring, HAB predictions and warnings, and coastal flooding and erosion forecasting systems.

Funding:

- FY10—$1,400,000 RCOOS award plus $49,000 for HFR support, $400,000 RA planning grant award.
- FY09—$1,324,787 RCOOS award, $400,000 RA planning grant award.
- FY08—$1,200,000 RCOOS award, $400,000 RA planning grant award.
- FY07—$1,200,000 RCOOS award, $400,000 RA planning grant award.

Point of Contact:

- Ru Morrison, Executive Director (ru.morrison@neracoos.org).
- www.neracoos.org.

Regional Priorities and Objectives:

The Northeast Atlantic region of the U.S. IOOS is geographically complex, with five states and two Canadian provinces and coastal waters and watersheds of the Scotian Shelf, Gulf of Maine, Southern New England Bight, and Long Island Sound. Regional user requirements identified inundation, HABs, water quality, and living marine resources as specific concerns. The NERACOOS project, as originally proposed in April 2007, had three goals: (1) operate a core of observing elements; (2) establish new observing capabilities for inundation, water quality, and HAB; and (3) develop the design for the user-driven core observing system. In response to the budget limitations, the focus for the past 3 years has been on continued operation of selected elements of the regional observing system, with a modest commitment to enhancement of observing capabilities.

In 2010, NERACOOS continued the improvement and integration of the coastal ocean observing system through close collaboration with regional organizations, especially the Northeast Regional Ocean Council (NROC). The NROC is a state-federal partnership that provides a forum for tackling and prioritizing regional scale problems. This collaboration will help ensure that NERACOOS directly addresses pressing regional issues of societal benefit. To that end, NERACOOS adopted four NROC priority theme areas and formalized the collaboration with a memorandum of understanding. The highly leveraged observing, modeling, data integration, and product development infrastructure provides practical operational capacity in each priority area, and 2010 activities sought to maintain the capacity previously developed.

The NROC and NERACOOS key themes for 2010—and the associated NERACOOS activities—are as follows:

- Maritime safety and security—provide real-time observations and forecasts directly for maritime operational safety, inform U.S. and Canadian Coast Guard SAR operations, and introduce new and enhance existing weather forecast products
- Ocean and coastal ecosystem health—improve HAB monitoring and forecasting, enhance monitoring and integration of water quality information, enable ecosystem-based fisheries management and marine spatial planning, and monitor ocean acidification
- Ocean energy—provide the necessary oceanographic information to facilitate the renewable energy sector and the data integration framework required for a regional approach to facilities sighting
- Coastal hazards resiliency—enhance and evaluate street-level inundation forecasting, expand forecasts for coastal flooding and erosion, and support emergency spill response.

In addition, climate change and coastal and marine spatial planning are central and cross-cutting themes.

Finally, continued development and implementation of a data integration framework is central to the delivery of information and products to users of the system, performance and evaluation metrics will enable tracking the return on investment, and education and outreach will engage NERACOOS users to ensure information and products meet their needs.

PACIFIC ISLANDS REGION—PACIFIC ISLANDS OCEAN OBSERVING SYSTEM

The Pacific Islands Ocean Observing System (PacIOOS) region is defined as the commonwealth and territories of the United States in the Pacific and the freely associated states in the Pacific.

Funding:

- FY10—$1,700,000 RCOOS award, $399,973 RA planning grant award.
- FY09—$1,869,134 RCOOS award, $398,802 RA planning grant award.
- FY08—$1,700,000 RCOOS award, $397,909 RA planning grant award.
- FY07—$1,700,000 RCOOS award.

Point of Contact:

- Chris Ostrander (chriso@hawaii.edu).
- www.pacioos.org.

Regional Priorities and Objectives:

PacIOOS is a partnership of data providers and users working together to enhance ocean observations and develop, disseminate, evaluate, and apply ocean data and information products designed to address the needs of stakeholders who call the Pacific Islands home. This integrated observing and information system provides information to related the following:

- Coastal hazards resilience—providing predictions of high water level and inundation events in coastal areas, developing maps of coastline change and identifying areas of vulnerability, and providing beach condition forecasts to users and lifeguards in an effort to promote public safety and community resilience
- Maritime safety and security—serving timely, reliable, real-time information on harbor conditions, coastal and open ocean currents, waves, and weather to improve SAR operations, spill response, optimized shipping routes, and predictions of severe weather events
- Coastal water quality—supplying real-time observations of biological, chemical, and physical water parameters to improve the understanding of ocean acidification, more effectively protect healthy coastal marine ecosystems, and enhance the understanding of and response to marine events that affect human health

- Ocean planning and management—integrating information for effective coastal and marine spatial planning (CMSP), measuring and modeling parameters necessary for the development of climate change mitigation and adaptation plans, and collecting and serving necessary information for renewable energy development

- Education and outreach—working to promote the understanding and stewardship of the Hawaiian and insular Pacific's coastal waters and build capacity for the continued expansion of ocean observations and informational products.

Initial PacIOOS observing efforts have focused on the development of an end-to-end observational system confined to the island of Oahu, Hawaii. This focused pilot project is exploring the operability of various observational systems in an island setting to help determine the ideal design for a full PacIOOS observational network.

Data system development, modeling, education and outreach, and stakeholder engagement through a collaborative governance framework are focused not only on the Hawaiian Islands, but each of the PacIOOS jurisdictions through the Pacific. Targeted deployment of instrumentation to address local stakeholder needs has begun in the western and southern Pacific jurisdictions with deployments to expand under future funding cooperative agreements.

SOUTHERN CALIFORNIA REGION—SOUTHERN CALIFORNIA REGIONAL COASTAL OCEAN OBSERVING SYSTEM

The Southern California Regional Coastal Ocean Observing System (SCCOOS) provides coverage from Point Conception to the Mexico border.

Funding:

- FY10—$1,400,000 RCOOS award (plus $11,900 to support a shellfish industry ocean acidification workshop and $510,000 to continue support for HFR for SAR operations), $395,210 RA planning grant award.
- FY09—$1,341,466 RCOOS (3 awards), $393,093 RA planning grant award.
- FY08—$500,000 RCOOS award, $353,785 RA planning grant award.

Point of Contact:

- Julie Thomas, Executive Director (jot@cdip.ucsd.edu).
- www.sccoos.org.

Regional Priorities and Objectives:

SCCOOS works to inform short-term decision making and long-term assessment of the coastal ocean through sustained physical and biological observations. Priorities of the SCCOOS stakeholder community include supporting the southern California beach water quality management community with issues related to HABs; maintaining area wide ocean assessment to identify secular trends in the environment and their relationship to ecosystem variability; supporting operational users, such as SAR, oil spill response, and marine safety; and managing and distributing ocean information of public interest.

FY10 funds supported ongoing operations and maintenance for underwater gliders, the HFR system, and automated shore stations. Continued funding will be provided for an augmentation to the California Cooperative Fisheries Investigation (CalCOFI) and the SCCOOS HAB surveillance program. Model evaluation and forecasts will continue with both the fine resolution and real-time Regional Ocean Modeling System. Data management funds will be utilized for participating in the IOOS regional observation registry, adapting to industry standards, restructuring the storage and archival formats of core variables, and establishing cross-compatibility between significant programs. Education and outreach, as well as the development of new data products, will continue to be supported by leveraging the SCCOOS RA grant.

To quantify trends in ocean acidification and upwelling-induced hypoxia, SCCOOS will initiate observations of dissolved oxygen on glider transects with the installation of new sensors on those platforms. Observations of seabird and marine mammals will be added through a partnership with the Farallon Institute for Advanced Ecosystem Research to maintain a valuable time record of top predatory species that are indicators of marine ecosystem health and climate change. SCCOOS will also develop integrated, customized products for alongshore currents and inundation that promote safe recreational use of beaches. These products will be provided to the National Weather Service for coastal flooding and rip current predictions.

SOUTHEAST ATLANTIC REGION—SOUTHEAST COASTAL OCEAN OBSERVING REGIONAL ASSOCIATION

The Southeast Coastal Ocean Observing Regional Association (SECOORA) is the regional solution to integrating coastal and ocean observing data and information in the Southeast Atlantic region. SECOORA supports the need of the southeastern United States to have real-time, or near real-time, marine information on coastal and ocean conditions that protects people, the environment, and the economy.

Funding:

- FY10—$1,680,000 RCOOS award, $399,670 RA planning grant award.
- FY09—$500,000 RCOOS (plus three additional implementation awards totaling $2,444,150), $391,991 RA planning grant award.
- FY08—$400,000 RCOOS award, $384,535 RA planning grant award.

Point of Contact:

- Debra Hernandez, Executive Director (debra@secoora.org).
- www.secoora.org.

Regional Priorities and Objectives:

As part of a recent strategic planning process, SECOORA reviewed stakeholder needs assessments of the southeast region. Themes that regularly appear in these assessments include climate change and its impacts on habitats and sea level, marine weather and operations, and ecosystem management, including fisheries and water quality. Another important expression of regional priorities was articulated by the Governors' South Atlantic Alliance. The alliance has identified four initial priorities: healthy ecosystems, working waterfronts, clean coastal and ocean waters, and disaster-resilient communities. These priorities are incorporated into SECOORA's four main thematic areas:

- Marine operations—safety, including support of SAR operations; improved marine weather forecasting; and offshore energy
- Ecosystems—living marine resources and water quality (fish and water quality, including beach advisories and HABs)
- Coastal hazards—inundation and rip currents
- Climate change—long-term data collection and analysis and ocean acidification.

This project originally is consolidating Coastal Ocean Observing System (COOS) assets and products in the Carolinas with those in Georgia and Florida to establish a user-driven observing system that spans the entire SECOORA footprint. The foundation of SECOORA was built initially upon six primary elements: (1) maintenance and development of existing observing assets and consolidation of existing subregional observing systems, (2) construction of an integrated and embedded modeling system, (3) development of ecosystem models targeted at predicting the characteristics of regionally important fish stocks, (4) establishment of a data management system designed to disseminate rapid, high-quality products, (5) establishment of a systems engineering-based structure to the observing system architecture that enables the seamless interoperability, and (6) integration of an end-user community into the fabric of SECOORA to ensure responsiveness to regional needs. Due to funding limitations, elements 1, 4, and 6 have been the only ones implemented to date.

In FY10, SECOORA supported ongoing activities, giving priority to those that will

- serve important user groups identified in the SECOORA strategic priorities plan,
- provide efficiency by maintaining existing observing assets and ongoing activities,
- serve the region as a whole, and
- integrate and provide access to data and related products.

In particular, SECOORA will seek to maintain and enhance the existing data management system for SECOORA and the HFR systems operating in the Southeast. In addition, SECOORA will seek to (1) support 23 existing moored and coastal observing stations; (2) provide funding for limited modeling and product development efforts to improve operation of a regional-scale circulation model, with a focus on supporting fisheries management needs; and (3) increase stakeholder education and outreach activities.

Appendix B

Observing Operational and Research Systems

ARGO

The Argo[1] program is a key contributor to the global component of U.S. IOOS. The United States is one of 22 countries contributing to the international Argo program, and NOAA's Climate Program Office, through the Climate Observation Division, has primary responsibility for implementing the U.S. component. The Argo array of profiling floats is designed to provide essential broad-scale, basin-wide monitoring of the upper ocean heat content. As the ocean's temperature rises, water expands, causing a rise in sea level and potential risks to public safety. Because the numbers and distribution of existing buoys and other related systems were insufficient to provide the detailed measurements needed to address climate issues, Argo floats were designed to capture data on unmeasured parts of the ocean. To date, NOAA has contributed more than half of the 3,000 Argo floats currently in operation.

The U.S. Argo program is funded under a 5-year competitively procured research grant, and is a partnership of five institutions—AOML, PMEL, the University of Washington, the Woods Hole Oceanographic Institution (WHOI), and the Scripps Institution of Oceanography. As part of the grant, and in an effort to sustain a consistent flow of data from the array, grantee institutions build Argo floats and arrange for their deployment. The program is enabled by the Law of the Sea treaty, which defines the rights and responsibilities of nations' use of the world's oceans. The treaty "allows marine scientific research to be carried out exclusively for peaceful purposes and for the benefit of mankind as a whole." Through this treaty, the Argo program has been able to establish agreements with other nations that allow them to collect ocean data off their shores and share it for research purposes. These laws also do not require retrieval of expired Argo research equipment. Although the average life cycle of an Argo float is 4 to 5 years, current plans call for deploying approximately 400 floats per year to maintain the array.

[1] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-7–2-8.

Although the Argo program has existed since 1999, it is only one piece of a larger Climate Observation Division goal to better understand and predict changes in climate. Despite the significant progress made on the Argo system, scientists are still grappling with the question of whether it is measuring the right things in the right places. Argo scientists are attempting to refine the system specifications to enable them to answer the basic questions that inspired the development of the Argo system. At the time the *Buoy Strategic Plan: Review of Current Processes* document was completed in 2009, researchers were discussing a change to Argo requirements that would allow profiling down to 3,000 meters, instead of the originally specified 2,000 meters. Because of the international nature of this system, these changes must be vetted with the partner countries before they can be implemented.

GLOBAL DRIFTER PROGRAM

The Global Drifter Program[2] (GDP), established in 1988, is a component of GOOS. NOAA's global drifter program is managed jointly by AOML and Scripps. Twelve other countries also contribute to this system. Drifters are designed to travel the oceans taking measurements of sea surface temperatures, ocean currents, air pressure, and other parameters to help scientists obtain a more complete and accurate map of the sea surface temperature worldwide. Drifters enable measurement of ocean conditions in areas of the world that could not previously be monitored because of limited ship travel to those locations. Data from drifters are used to validate weather and climate forecasting models, calibrate satellite performance, and provide critical details on ocean processes to support ongoing research endeavors. The global drifting array reached its initial design goal of 1,250 drifting buoys and has been in sustained service since 2005. Today, NOAA contributes 80 percent of new drifters required to maintain the global array.

The GDP is funded through the Climate Program Office. AOML coordinates deployments, processes and archives the data, and distributes data-based products. Drifters are primarily deployed using ships of opportunity, NOAA research vessels, and sometimes aircraft, when hurricane measurements are required. The GDP has been able to leverage the ship resources acquired by other research programs, thus avoiding deployment costs. The GDP team expects to continue to deploy approximately 85 drifters per month to maintain the current array.

When identifying the placement of a new drifter, scientists attempt to determine where gaps may be created by existing drifter patterns. Currently, scientists are determining whether additional research measurements are needed to support operational requirements, e.g., addition of heat intake data to forecast models. The

[2] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-9.

continuation of research measurement is likely to drive growth in the size and scope of the GDP array over the next 5 to 10 years.

OCEAN REFERENCE STATIONS

ORS, Ocean Reference Stations[3], is part of a larger effort between NOAA and its international partners to implement a global network of ocean reference moored buoys to collect long-term climate data from key ocean sites. The ORS network contributes to the OCEAN Sustained Interdisciplinary Timeseries Environment observation System (OceanSITES). ORS sites are chosen because they represent the diverse meteorological regimes of the world's oceans and provide data for the science community, policymakers, and the public to monitor global climate and ecosystem changes and to develop a capability to predict them.

ORS was originally funded by the National Science Foundation (NSF) and is now part of the Climate Program. The ORS system is supported by a number of participants that operate separate components. Surface systems such as the Kuroshio Extension Observatory and PAPA are managed by PMEL, while the Northwest Tropical Atlantic Station, Stratus Cloud Deck, and WHOI Hawaii Ocean Time-Series Stations are managed by Woods Hole. Bottom systems Western Boundary Time Series and South Atlantic Meridian are managed by AOML; the Indonesian Through Flow is managed by the Cooperative Institute for Climate and Applications Research (Columbia University); and the Meridional Overturning Variability Experiment station and California Current station are managed by Scripps.

The work performed by ORS scientists includes construction, deployment, and recovery of ORSs and processing of the recovered time series data. Typically, ORS researchers make annual trips to the ORS stations to recover operating stations (and data) and deploy replacements. As part of station recovery, researchers compare meteorological sensors on the buoy and the standard meteorological sensors on the ship. They also take conductivity-temperature-depth (CTD) profiles of buoys to be recovered. Ship time to support these trips comes from a variety of sources. NOAA and partner vessels are the primary source of ship time for the ORS program. However, University-National Oceanographic Laboratory or charter vessels are enlisted whenever ship-time allotments are insufficient to complete research activities.

[3] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-10.

PHYSICAL OCEANOGRAPHIC REAL-TIME SYSTEM

PORTS®[4] is a decision support tool that improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts and other geospatial information. PORTS measures and disseminates observations and predictions of water levels, currents, salinity, and meteorological parameters (e.g., winds, atmospheric pressure, air and water temperatures) that mariners need to navigate safely. PORTS promotes navigation safety, improves the efficiency of U.S. ports and harbors, and ensures the protection of coastal marine resources.

Navigation Safety: The real-time tide and current data provided through PORTS represents one component of NOAA’s National Ocean Service (NOS)'s integrated program to promote safe navigation. PORTS data, when combined with up-to-date nautical charts and precise positioning information, can provide the mariner with a clearer picture of the potential dangers that may threaten navigation safety.

Improved Economic Efficiency: Our nation's waterfronts, ports and harbors have historically been centers of rapid industrial and urban growth, and have advanced critical national objectives by promoting energy exploration, fishery production, commerce, and recreation. In 2002 alone, commercial port activities provided employment for 1.1 million Americans and $44 billion in personal income, and generated approximately $16 billion in federal, state and local taxes. Increasingly, shipping companies are implementing new navigation systems aboard ships to maximize cargo load while reducing uncertainties in under keel clearances. These new systems rely on the availability of real-time tide/current and other information. One additional foot of draft may account for between $36,000 and $288,000 of increased profit per transit. Knowledge of the currents, water levels, winds, and density of the water can increase the amount of cargo moved through a port and harbor by enabling mariners to safely utilize every inch of dredged channel depth.

Coastal Resource Protection: Most ports are located at the mouths of major estuaries, which provide critical habitat for many important biological resources. For example, coastal waters provide nurseries and spawning grounds for 70 percent of U.S. commercial and recreational fisheries. Commercial fishing employs over 350,000 people in vessel- and shore-related fisheries work. An additional 17 million people participate in recreational saltwater fishing, spending $7.2 billion annually. Activities at ports can greatly affect these critical resources; dredging is but one such activity. Each year in the U.S., approximately 400 million cubic yards of dredged material are removed from navigation channels, berths, and terminals.

The prevention of maritime accidents is the most cost-effective measure that can be taken to protect fragile coastal ecosystems. In 2004 alone, NOS's Office of Response and Restoration responded to over 120 events, including the release of

[4] http://tidesandcurrents.noaa.gov/ports.html

270,000 gallons of crude oil into the Delaware River near Philadelphia, and spill of over 400,000 gallons of bunker oil in Alaska. One major oil spill (e.g., the 1989 Exxon VALDEZ accident) can cost billions of dollars and destroy sensitive marine habitats critical to coastal ecosystems. PORTS® provides information to make navigation safer, thus reducing the likelihood of a maritime accident, and also provides information to mitigate the damages from a spill, should one occur

PORTS® provides accurate real-time oceanographic information, tailored to the specific needs of the local community. PORTS® systems come in a variety of sizes and configurations, each specifically designed to meet local user requirements. The largest of NOS's existing PORTS® installations is comprised of over 50 separate instruments; the smallest consists of a single water-level gauge and associated meteorological instruments (e.g., winds, barometric pressure, etc.). Regardless of its size, each PORTS® installation provides information that allows mariners to maintain an adequate margin of safety for the increasingly large vessels visiting U.S. ports, while allowing port operators to maximize port throughput.

There are currently PORTS installations at the following locations:

- Cherry Point
- Chesapeake Bay North
- Chesapeake Bay South
- Delaware Bay
- Gulfport
- Houston/Galveston
- Lake Charles
- Los Angeles/Long Beach
- Lower Columbia River
- Lower Mississippi River
- Mobile Bay
- Narragansett Bay
- New Haven
- New York/New Jersey Harbor
- Pascagoula
- Port of Anchorage
- Sabine Neches
- San Francisco Bay
- Soo Locks
- Tacoma.

PREDICTION AND RESEARCH MOORED ARRAY IN THE TROPICAL ATLANTIC

The Prediction and Research Moored Array in the Tropical Atlantic[5] (PIRATA) was developed as a multinational observation network by Brazil, France, and the United States; it is now operated jointly by AOML and PMEL. PIRATA—part of the GOOS and the Global Climate Observing System—began in the mid-1990s as a research endeavor to improve knowledge and understanding of ocean-atmosphere variability in the tropical Atlantic Ocean. It is now an international array of 16 surface moorings and 1 subsurface mooring.

PIRATA's design is largely based on the TAO system operating in the Pacific Ocean; however, its major scientific objectives and the array design itself have evolved with improved understanding of the tropical Atlantic climate system. Today, PIRATA data are widely used in operational weather, ocean, and climate forecasting. An MOU between NOAA and its international partners ensures the continuation of ship support in future years, with NOAA providing most of the equipment.

NOAA manages the maintenance and repair needed to sustain PIRATA operation. Maintenance labor costs for this system are less than for other moored buoy systems, and its ship time arrangement with its partners keeps its costs from ballooning. However, acquisition and maintenance costs for the PIRATA system are likely to increase in the short term, given the impending obsolescence of its components, as evidenced by the maintenance and refresh requirements of the TAO system. Refreshing TAO components has already begun, but a PIRATA refresh is planned to begin in FY11. Discussions with NDBC and PMEL personnel did not indicate that refresh efforts and lessons learned are being coordinated, which creates a risk to the system's operation if a decision is made to transition PIRATA to operations.

[5] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-12.

RESEARCH AFRICAN-ASIAN-AUSTRALIAN MONSOON ARRAY

Efforts to establish the Research African-Asian-Australian Monsoon Array[6] (RAMA) began in earnest in 2004, with the goal to establish a system for comprehensive, long-term, high-quality, real-time measurements in the Indian Ocean to help predict East African, Asian, and Australian monsoons.

RAMA, the technical equivalent of the TAO and PIRATA arrays, comprises 13 surface moorings and 1 subsurface mooring, with a goal of having 38 surface and 8 subsurface moorings when complete in FY12.

The RAMA program is managed by PMEL, using funds provided by the Climate Program Office. NOAA purchases most of the equipment for RAMA, but it is not required to provide NOAA ship time to support the system. Partners were initially expected to provide 150–200 ship days per year for RAMA maintenance and deployments; however, through FY11, partner ship days are likely to be fewer than planned and will be supplemented by using charter vessels. RAMA scientists visit the platforms annually to replace mooring lines and ensure that the systems are operating properly. The RAMA program expects to replace approximately 25 percent of its systems every year due to vandalism.

The cost profile of the RAMA system is similar to that of PIRATA. RAMA's acquisition costs are higher due to a higher number of system losses and replacements attributable to at-sea vandalism. These costs will begin to escalate again in FY11 to address the impending obsolescence of RAMA's components, as evidenced by the maintenance and refresh requirements of the TAO system. Discussions with NDBC and PMEL personnel did not indicate that refresh efforts and lessons learned are being coordinated, which creates a risk to the system's operation if a decision is made to transition RAMA to operations.

[6] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-13–2-14.

FISHERIES OCEANOGRAPHY COORDINATED INVESTIGATIONS

NOAA established the Fisheries Oceanography Coordinated Investigations[7] (FOCI) in 1984 to study the factors that cause variability in the abundance of commercially valuable fin and shellfish in Alaskan waters and to provide this information to fishery managers. FOCI, a joint project between OAR and the National Marine Fisheries Service, operates in the Bering Sea and Gulf of Alaska. The FOCI project uses both surface and subsurface moorings to collect the data needed to evaluate the changes in environmental conditions, such as temperature and salinity changes, fluctuations in sea-ice extent, atmospheric forcing, tidal influences, freshwater influx, productivity, and mixed-layer depth. FOCI, currently has four moored buoys in operation. Because of the extensive ice conditions, surface moorings are deployed during the summer and replaced with subsurface moorings during the winter.

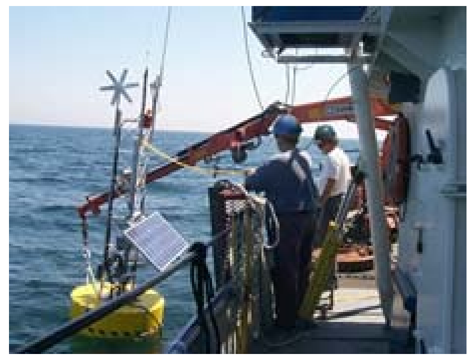
Although FOCI has been in operation for 15 years and provides data to fishery models, scientists and researchers are still attempting to decipher the underlying conditions causing changes in the fish population. Changing environmental conditions, such as a retreat of ice, continue to alter the "test conditions" under which FOCI research is performed, creating the needs to periodically relocate deployed mooring and/or change the parameters being measured. Scientists visit the FOCI moorings twice a year to collect data, change out sensor systems, and perform CTD testing. If a sensor fails following a visit, it may be unavailable for up to a year, until the next scheduled cruise.

The FOCI program, while primarily managed by PMEL, depends upon in-kind services provided by the North Pacific Research Board for maintenance and field services, and funding support from the NSF for mooring deployment. PMEL retains responsibility for building the buoys and moorings. Since NOAA ship time is not available to support O&M, FOCI maintenance is done either by piggybacking on other cruises or arranging for contract vessel support.

[7] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-15.

REAL-TIME ENVIRONMENTAL COASTAL OBSERVATION NETWORK

The Real-time Environmental Coastal Observation Network[8] (ReCON) is a research effort that leverages off-the shelf networking technology to create a capability to easily connect coastal systems and enable the transfer and sharing of data in more usable formats. ReCON uses wireless technology to support a communications network among ocean observing assets, which has historically been very difficult to establish. ReCON connects buoys to shore stations at distances up to 32 kilometers, to other buoys in an array, or to vessel-based data collection systems through offshore buoys or direct connection to shore. Currently, ReCON consists of 15 surface moorings in the Great Lakes—7 buoys and 8 pier-based stations—providing operational National Weather Service marine weather forecasts and experimental rip current warnings. ReCON is managed and maintained by GLERL, which also procures ship-time support.



INTEGRATED CORAL OBSERVING NETWORK

The Integrated Coral Observing Network[9] (ICON), part of the Coral Health and Monitoring Program, is a coastal system initiated in 2000. It was designed to deliver near-real-time data on coral bleaching. Specifically, ICON provides research data to better understand the influence of cal and oceanographic factors on coral bleaching, and other biogeochemical processes occurring on coral reefs. The data enable analysis of patterns and trends and the prediction of the effects of environmental events on coral reefs such as bleaching, fish and invertebrate spawning, and migration. Currently, three stations are operating in coral reef areas: St. Croix, U.S. Virgin Islands; Lee Stocking Island, Bahamas; and La Parguera, Puerto Rico. (A fourth station was damaged by a hurricane off the coast of Jamaica and has yet to be returned to NOAA.) The ICON program is working with Taiwan and Guam to develop MOUs to install additional stations.

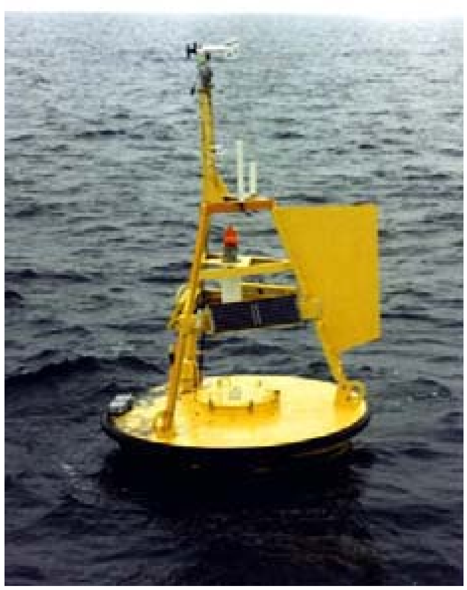
[8] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-16.

[9] Buoy *Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-17.

A joint effort between OAR/AOML and NESDIS, ICON supports the Coral Reef Conservation Program's efforts to perform eco-forecasting. Funding for the ICON systems has historically been shared between NOAA and its partners, with NOAA paying the cost of team member salaries and ICON instrumentation, and partners funding the maintenance. Because of the high maintenance requirements—sites must be visited weekly to clean debris from sensing devices, with total instrument swap-out once a year—the ICON program has arranged with local divers to maintain and install pylons. In Puerto Rico, the University of Puerto Rico provides maintenance support at no cost, and in St. Croix, the University of the Virgin Islands is expected to pay for maintenance.

Coastal Weather/Moored Buoys

Coastal weather/moored buoys[10] (CWBs) are the weather sentinels of the sea. They 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. NDBC's moored buoys measure and transmit barometric pressure; wind direction, speed, and gust; air and sea temperature; and wave energy spectra from which significant wave height, dominant wave period, and average wave period are derived. Even the direction of wave propagation is measured on many moored buoys.[11] The majority of CWBs are about 50 miles off the coast, but some are as much as 3,600 miles offshore. NDBC began operating weather buoys in 1970 and, as of May 2009, manages an array of 114.



Data from weather buoys were collected primarily for weather service operations, feeding the models and forecast tools that drive NOAA products and services. These data are also used by a number of other groups, including the U.S. Coast Guard (USCG), Army Corp of Engineers, regional and coastal entities, academic organizations, and private-sector concerns.

CWB operations are performed by NDBC's support contractor, with the Coast Guard providing ship resources to service the buoys. The contractor is responsible for monitoring buoy performance; creating maintenance plans, including ship needs; coordinating trip planning with Coast Guard personnel; performing at-sea maintenance; and reporting any issues or lessons learned while at sea. NDBC conducts between 100 and 150 field visits per year to the CWBs. During field

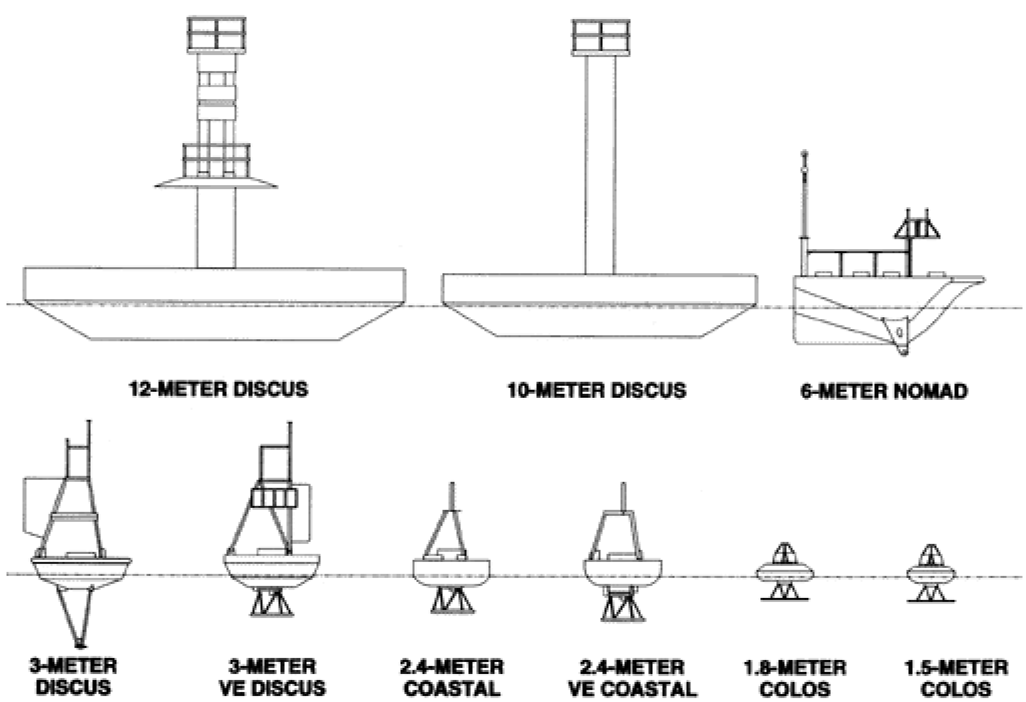
[10] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-19–2-20.

[11] See http://www.ndbc.noaa.gov/mooredbuoy.shtml.

visits, the contractor retrieves a buoy from its mooring and replaces it with a refurbished one. NDBC schedules biannual buoy service visits, as funds permit. Budget limitations have caused NDBC to move toward an 8-month planned maintenance schedule. Discrepancy maintenance is scheduled when unplanned maintenance is needed to restore buoy system operation. Buoys retrieved during swapouts are disassembled and refurbished for reuse.

NDBC's fleet of moored buoys includes six types: 3-meter, 10-meter, and 12-meter discus hulls; 6-meter boat-shaped (NOMAD) hulls; and the newest, the Coastal Buoy and the Coastal Oceanographic Line-of-Sight buoy. Figure B-1 depicts the designs of the moored buoys deployed by NDBC. The choice of hull type usually depends on the intended deployment location and measurement requirements. To ensure optimum performance, a specific mooring design is produced based on hull type, location, and water depth. For example, a small buoy in shallow coastal waters may be moored using an all-chain mooring, while a large discus buoy deployed in the deep ocean may require a combination of chain, nylon, and buoyant polypropylene materials designed for many years of service. Some deep ocean moorings have operated without failure for over 10 years.[12] In addition to their use in operational forecasting, warnings, and atmospheric models, moored buoy data are used for scientific and research programs, emergency response to chemical spills, legal proceedings, and engineering design.[13]

Figure B-1. Moored Buoy Designs Deployed by the NDBC



[12] See http://www.ndbc.noaa.gov/mooredbuoy.shtml.

[13] See http://www.ndbc.noaa.gov/mooredbuoy.shtml.

COASTAL MARINE AUTOMATED NETWORK

The Coastal-Marine Automated Network [14] (C-MAN)—a system of marine weather stations on fixed platforms—was established by NDBC for the NWS in the early 1980s. The development of C-MAN was in response to a need to maintain meteorological observations in U.S. coastal areas. Such observations would have been lost as the USCG removed station keepers from the coastal lighthouses and automated navigational aids under the Lighthouse Automation and Modernization Program. NDBC installed its first fixed station for the C-MAN network in 1983. Now, approximately 60 stations make up C-MAN. [15]

C-MAN stations have been installed on lighthouses, at capes and beaches, on near-shore islands, and on offshore platforms.[16] The C-MAN network is operated and maintained by NDBC, with maintenance activities being performed by NDBC's support contractor. The data reported by C-MAN stations, like CWB data, enable weather and ocean forecasting and modeling.[17]

C-MAN station data typically include barometric pressure, wind direction, speed and gust, and air temperature; however, some C-MAN stations are designed to also measure sea water temperature, water level, waves, relative humidity, precipitation, and visibility. These data are processed and transmitted hourly to users in a manner almost identical to moored buoy data. In addition to the conventional method of data transmission, certain C-MAN stations are equipped with telephone modems that allow more frequent data acquisition, data quality checking, and remote payload reconfiguration or restarting.[18]

DEEP-OCEAN ASSESSMENT AND REPORTING OF TSUNAMIS

To ensure early detection of tsunamis and to acquire data critical to real-time forecasts, NOAA has placed Deep-ocean Assessment and Reporting of Tsunamis (DART®)[19] stations at sites in regions with a history of generating destructive

[14] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-21.

[15] See http://www.ndbc.noaa.gov/cman.php.

[16] See http://www.ndbc.noaa.gov/cman.php.

[17] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-21.

[18] See http://www.ndbc.noaa.gov/cman.php.

[19] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-22.

tsunamis. NOAA completed the original six-buoy operational array in 2001 and completed the full network of 39 stations in March 2008.[20]

Originally developed by NOAA as part of the U.S. National Tsunami Hazard Mitigation Program, the DART project was an effort to maintain and improve the capability for the early detection and real-time reporting of tsunamis in the open ocean.[21]

DART constitutes a critical element of the NOAA Tsunami Program, which is part of a cooperative effort to save lives and protect property through hazard assessment, warning guidance, mitigation, research capabilities, and international coordination. NOAA's NWS is responsible for the overall execution of the Tsunami Program. This includes operation of the U.S. Tsunami Warning Centers as well as leadership of the National Tsunami Hazard Mitigation Program. It also includes the acquisition, operations, and maintenance of observation systems required in support of tsunami warning such as DART stations, local seismic networks, and coastal and coastal flooding detectors. NWS also supports observations and data management through the NDBC.[22]

The DART network is managed by NDBC and its support contractor. With the declining availability of NOAA ship time, DART maintenance is now performed using commercial charters, which required 210 ship days in FY08. The DART maintenance plan calls for one 220-day cruise per year to visit each buoy for repair and maintenance. An additional 80 days at sea is planned annually to handle unplanned maintenance of failed systems. Most of the fabrication and testing are done shore side, and while at sea, old buoys are retrieved and replaced by refurbished ones.

TROPICAL ATMOSPHERIC OCEAN

The Tropical Atmospheric Ocean[23] (TAO) array (renamed TAO/TRITON) was designed to study and predict year-to-year climate variations related to the El Niño Southern Oscillation. Development of TAO began in 1984, following the 1982–83 El Nino event, the strongest of the century up to that time, which was neither predicted nor detected until nearly its peak. Today, the array consists of 55 NOAA-owned moored buoys that span the eastern and central Equatorial Pacific Ocean and the seven Japanese TRITON moorings in the western Pacific. TAO/TRITON moorings measure surface meteorological parameters, such as

[20] See http://www.ndbc.noaa.gov/dart/dart.shtml.

[21] See http://www.ndbc.noaa.gov/dart/dart.shtml.

[22] See http://www.ndbc.noaa.gov/dart/dart.shtml.

[23] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-23–2-24.

wind speed, wind direction, air temperature, and relative humidity, as well as ocean current profiles and upper ocean temperatures. Success of the TAO/TRITON array was proven when NOAA's Climate Prediction Center was able to forecast the 1997–98 El Niño (and the subsequent La Niña) 6 months in advance.

In 2004, NDBC and PMEL began planning for the transition of TAO, when NOAA initiated a focused effort to transition research systems to operations. In the early stages of transition planning, insufficient funding was available to support the required knowledge transfer or engineering activities related to "operationalizing" the system. As a result, this transition has been difficult to execute, has affected system performance, and is not scheduled to be completed until FY15.

Approximately one-third of the TAO/TRITON array is operated and maintained by Japan, with the remaining two-thirds operated and maintained by NDBC. NOAA's research ship *Ka'imimoana* is dedicated to servicing TAO moorings and spends about 250 days at sea; however, NDBC is evaluating the use of contract charter vessels for the future cruises to improve NDBC response to unplanned maintenance requirements. Until 2009, the maintenance plan called for visiting each TAO buoy every 6 months, with every other visit being only a "pass by" unless a known or visual problem required a full maintenance stop. NDBC has recently decreased the visit frequency to 8 months, due to budget constraints.

MARINE OPTICAL BUOY

The Marine Optical Buoy[24] (MOBY) was deployed off the coast of Lanai, HI, on February 21, 1994. The primary purpose of MOBY, a joint effort of NASA and NOAA, is to measure visible and near-infrared radiation entering and emanating from the ocean. MOBY is a single mooring project that supports the validation of satellite ocean color imagery data. MOBY is primarily funded by NASA's Earth Observing System Program.

[24] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-25.

NATIONAL CURRENT OBSERVATION PROGRAM

Managed by the NOS Center for Operational Oceanographic Products and Services (CO-OPS), the National Current Observation Program[25] (NCOP) collects, analyzes, and distributes observations and predictions of currents. CO-OPS provides end-to-end service to maritime data users, predicting tides and currents to enable the safe transport of cargo to destination ports. Changes to the configuration of ports and harbors, along with coastal development, sediment loading, and channel dredging, all have significantly altered the physical oceanography, and as a result, many of the existing tidal current predictions may be inaccurate. Approximately 70 percent of the stations in the 2001 tidal current tables are more than 30 years old. NCOP facilitates the collection and analysis of more-current survey information and the dissemination of updated observations and predictions of tidal currents for more than 2,700 locations throughout the United States.

CO-OPS purchases and maintains the equipment, and typically performs three or four surveys per year, with ship-time arrangements handled by a contractor. Surveys are performed by deploying current meters to profile the vertical water column at a specific location. Survey periods last 30 to 90 days, on average, after which the instruments are retrieved.

[25] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-26–2-27.

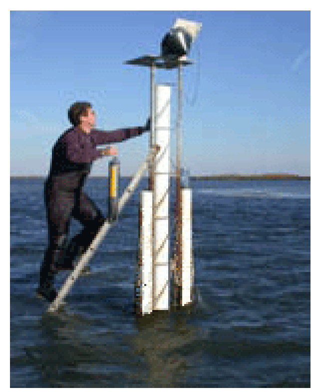
NATIONAL WATER LEVEL OBSERVATION NETWORK

The National Water Level Observation Network[26] (NWLON) is the fundamental component of the National Water Level Program, which consists of networks of long- and short-term water-level stations and is an end-to-end system of data collection, quality control, data management, and product delivery. The tide and water-level data traditionally have been important primarily for navigation and shoreline boundary purposes. For example, the tidal datum of mean lower low water is used as the reference datum, or chart datum, for U.S. nautical chart products in tidal waters. Similarly, mean high water is used as the reference datum for the national shoreline. The NWLON consists of 201 long-term, continuously operating water-level stations throughout the United States, including its island possessions and territories and the Great Lakes.

CO-OPS manages NWLON and primarily uses contractor resources for required maintenance.

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

The National Estuarine Research Reserve System[27] (NERRS) is a network of 27 areas representing different bio-geographic regions of the United States that are protected for long-term research, water-quality monitoring, education, and coastal stewardship. Established by the Coastal Zone Management Act of 1972, as amended, NERRS is a partnership program between NOAA and the coastal states. NOAA provides funding, national guidance, and technical assistance. Each reserve is managed daily by a lead state agency or university, with input from local partners.



NOAA provides technical leadership and resource support to the states for the maintenance of a network of reserves that have been set aside for research, stewardship, and education. Each reserve is owned and operated by the state through an agreed-upon partner such as a state environmental agency or an academic institution. To develop a new reserve, a state's governor may submit a nomination to the Secretary of Commerce, which NOAA may (or may not) approve. If the nomination is accepted, an area is designated as a new reserve within 3 to 5 years.

[26] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-27–2-28.

[27] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, pp. 2-28–2-29.

Once a part of the system, all reserves and their state sponsors are required to comply with various standards and regulations in order to get federal support, which according to the legislation, is supposed to account for 70 percent of a given reserve's resource needs. This support is provided through annual grants.

One of the conditions for awarding support is maintenance of the System-wide Monitoring Program (SwMP) according to certain base standards which define the current system. The NERRS SwMP has been operating since 1995. It tracks short-term variability and long-term changes in estuarine waters to understand how human activities and natural events can change ecosystems. The program provides valuable long-term data on water quality and weather at frequent time intervals. Coastal managers use these monitoring data to make informed decisions on local and regional issues, such as "no discharge" zones for boats, and to measure the success of restoration projects. The reserve system currently measures physical and chemical water quality indicators, nutrients, and the impacts of weather on estuaries.

The SwMP is managed by NERRS, which provides funds through the Coastal Zone Management Program to states that perform maintenance and other activities. Guidance by NOAA specifies how grants should be expended, including for maintenance.

Chesapeake Bay Interpretive Buoy System

The Chesapeake Bay Interpretive Buoy System[28] (CBIBS) provides real-time meteorological, oceanographic, and water quality information at different points along the Captain John Smith Chesapeake National Historic Trail. The Chesapeake Bay Office of NMFS deployed three buoys in 2007 to begin development of CBIBS. Today, eight CBIBS buoys are in operation off Jamestown, VA, in the James River; at the mouth of the Potomac River; and at the mouth of the Patapsco River near Baltimore, MD. CBIBS is a trail guide and observing system that uses on-the-water platforms to merge the modern technologies of cellular communications and Internet-based information sharing. CBIBS buoys report real-time weather and environmental information like wind speed, temperature, and wave height. Data users can use a cell phone to access information collected at each buoy's position.

[28] *Buoy Recapitalization Strategic Plan: Review of Current Processes,* August 2009, p. 2-30.

CBIBS is part of the Chesapeake Bay Observing System and is a component of U.S. IOOS. CBIBS is owned by NMFS and managed in coordination with NOS, which facilitates the deployment and maintenance activities.

CORAL REEF ECOSYSTEM INTEGRATED OBSERVING SYSTEM

The Coral Reef Ecosystem Integrated Observing System[29] (CREIOS) is an important component of NOAA's Coral Reef Conservation Program (CRCP) and contributes to GEOSS. The CRCP was established in 2000 to help fulfill NOAA's responsibilities under the Coral Reef Conservation Act and Executive Order 13089, "Coral Reef Protection." The mission of the CRCP is to protect, conserve, and restore coral reef resources by maintaining healthy ecosystem function. Since 2001, the CRCP has supported a variety of international initiatives to build human and institutional capacity to support integrated coastal management, protected area management, reduction of land-based sources of pollution, and sustainable fisheries in coral reef nations. With U.S. coral reef resources stretching across 13 time zones, NOAA has responsibility for observing and managing coral reefs over a wide area. To carry out this task, NOAA implemented CREIOS to map and monitor coral reefs, their biota, and their environments.

CREIOS provides a diverse suite of long-term ecological and environmental observations and information products over a broad range of spatial and temporal scales to enhance understanding of the coral reef ecosystem condition and processes, to inform stakeholders, and to assist managers with making better and more timely ecosystem-based management decisions to help conserve coral reefs. CREIOS (Pacific) is owned and operated by NMFS; CREIOS (Atlantic), also known as ICON, is owned by OAR. CREIOS data are used to assess and monitor U.S. coral reef ecosystems to enable comparative analyses across geography, environmental conditions, management approaches, and anthropogenic stressors.

The current configuration of CREIOS includes a wide variety of observing platforms that monitor U.S. coral reef resources in the waters of states, territories, U.S. flag islands, and freely associated states in both the Pacific and the Atlantic. Key components include physical and environmental monitoring using satellite, in situ, and paleoclimatic observations; reef mapping and benthic habitat characterization using satellite, airborne, ship-based, and diver observations; ecological monitoring of benthos, mobile invertebrates, and fishes by divers and instruments; and monitoring for coral bleaching and disease outbreaks by divers.

CREIOS field activities consist of deployment, recovery, and field swap-out of near-shore buoys and seafloor instrumentation from the remote islands and atolls of Pacific jurisdictions. Also included are oceanographic site surveys (water quality sampling and analysis, CTDs, etc.) each time the site is visited. CREIOS

[29] *Buoy Recapitalization Strategic Plan: Review of Current Processes*, August 2009, p. 2-32.

instruments require frequent maintenance visits to remove bio-fouling, which can occur within 2 weeks after maintenance. Because CREIOS instrumentation is deployed in sensitive coral reef environments, maintenance is done by scuba divers. NOAA working diver regulations establish dive team requirements, including the number of divers, safety divers, diver-in-charge, and related matters. Ship time for CREIOS maintenance is being provided by the Reef Assessment and Monitoring Program. CREIOS piggybacks on other reef assessment cruises and is currently doing maintenance cruises every 12 months, but it is considering extending the maintenance period to 24 months due to budget constraints.

Appendix C
U.S. IOOS Work Breakdown Structure

1. IOOS
    1.1. Observing subsystems
        1.1.1. Observing subsystem management
            1.1.1.1. Central function
            1.1.1.2. Federal assets
            1.1.1.3. Non-federal assets
        1.1.2. Surveys
            1.1.2.1. Central function
            1.1.2.2. Federal assets
            1.1.2.3. Non-federal assets
        1.1.3. Optimization studies
            1.1.3.1. Central function
            1.1.3.2. Federal assets
            1.1.3.3. Non-federal assets
        1.1.4. Asset management
            1.1.4.1. Central function
            1.1.4.2. Federal assets
            1.1.4.3. Non-federal assets
        1.1.5. Quality assurance and quality control on data
            1.1.5.1. Central function
            1.1.5.2. Federal assets
            1.1.5.3. Non-federal assets
        1.1.6. Transmission of data from assets to data provider data sets
            1.1.6.1. Central function
            1.1.6.2. Federal assets
            1.1.6.3. Non-federal assets
    1.2. DMAC
        1.2.1. Registration and management of data providers
            1.2.1.1. Central function
            1.2.1.2. Federal assets
            1.2.1.3. Non-federal assets
        1.2.2. IT infrastructure
            1.2.2.1. Hardware
                1.2.2.1.1. Central function
                1.2.2.1.2. Federal assets
                1.2.2.1.3. Non-federal assets
            1.2.2.2. Software (including software components)
                1.2.2.2.1. Central function
                1.2.2.2.2. Federal assets
                1.2.2.2.3. Non-federal assets

- 1.2.3. Configuration control
  - 1.2.3.1. Central function
  - 1.2.3.2. Federal assets
  - 1.2.3.3. Non-federal assets
- 1.2.4. Input-output management
  - 1.2.4.1. Central function
  - 1.2.4.2. Federal assets
  - 1.2.4.3. Non-federal assets
- 1.2.5. Provide repository (data, metadata, archives)
  - 1.2.5.1. Central function
  - 1.2.5.2. Federal assets
  - 1.2.5.3. Non-federal assets
- 1.2.6. Protocols and standards
  - 1.2.6.1. Central function
  - 1.2.6.2. Federal assets
  - 1.2.6.3. Non-federal assets

1.3. Modeling and analysis subsystem

- 1.3.1. Customer needs management
  - 1.3.1.1. Central function
  - 1.3.1.2. Federal assets
  - 1.3.1.3. Non-federal assets
- 1.3.2. IOOS sponsored and other model management
  - 1.3.2.1. Central function
  - 1.3.2.2. Federal assets
  - 1.3.2.3. Non-federal assets
- 1.3.3. Partner agreements management (MOUs)
  - 1.3.3.1. Central function
  - 1.3.3.2. Federal assets
  - 1.3.3.3. Non-federal assets
- 1.3.4. Publishing IOOS Standards
  - 1.3.4.1. Central function
  - 1.3.4.2. Federal assets
  - 1.3.4.3. Non-federal assets

1.4. Governance and management subsystem

- 1.4.1. User group feedback mechanisms
  - 1.4.1.1. Central function
  - 1.4.1.2. Federal assets
  - 1.4.1.3. Non-federal assets
- 1.4.2. Financial management
  - 1.4.2.1. Central function
  - 1.4.2.2. Federal assets
  - 1.4.2.3. Non-federal assets
- 1.4.3. Policy
  - 1.4.3.1. Central function
  - 1.4.3.2. Federal assets
  - 1.4.3.3. Non-federal assets

- 1.4.4. Plans and operations management
  - 1.4.4.1. Central function
  - 1.4.4.2. Federal assets
  - 1.4.4.3. Non-federal assets
- 1.4.5. Processes
  - 1.4.5.1.Central function
  - 1.4.5.2. Federal assets
  - 1.4.5.3. Non-federal assets
- 1.4.6. Human resources management
  - 1.4.6.1. Central function
  - 1.4.6.2. Federal assets
  - 1.4.6.3. Non-federal assets
- 1.4.7. Acquisition, grants and cooperative agreement management
  - 1.4.7.1. Central function
  - 1.4.7.2. Federal assets
  - 1.4.7.3. Non-federal assets
- 1.4.8. Marketing, outreach and engagement
  - 1.4.8.1. Central function
  - 1.4.8.2. Federal assets
  - 1.4.8.3. Non-federal assets

1.5.Research and development subsystem

- 1.5.1. Requirements determination
  - 1.5.1.1. Central function
  - 1.5.1.2. Federal assets
  - 1.5.1.3. Non-federal assets
- 1.5.2. Coordinate R&D programs
  - 1.5.2.1. Central function
  - 1.5.2.2. Federal assets
  - 1.5.2.3. Non-federal assets
- 1.5.3. Conduct R&D programs
  - 1.5.3.1.Federal assets
  - 1.5.3.2. Non-federal assets
- 1.5.4. Create a process to manage R&D pilot projects
  - 1.5.4.1. Central function
  - 1.5.4.2. Federal assets
  - Non-federal assets
- 1.5.5. Create a capability to conduct technology assessments
  - 1.5.5.1. Central function
  - 1.5.5.2. Federal assets
  - 1.5.5.3. Non-federal assets
- 1.5.6. Develop technology enhancements
  - 1.5.6.1. Central function
  - 1.5.6.2. Federal assets
  - 1.5.6.3. Non-federal assets
- 1.5.7. Manage transition of technology from R&D to operational use
  - 1.5.7.1.Central function

1.5.7.2. Federal assets
1.5.7.3. Non-federal assets
1.6. Training and education subsystem
1.6.1. Develop training strategy and plans
1.6.1.1. Central function
1.6.1.2. Federal assets
1.6.1.3. Non-federal assets
1.6.2. Develop training and curriculum
1.6.2.1. Central function
1.6.2.2. Federal assets
1.6.2.3. Non-federal assets
1.6.3. Conduct training and education pilot projects
1.6.3.1. Central function
1.6.3.2. Federal assets
1.6.3.3. Non-federal assets
1.6.4. Conduct assessments of training and education
1.6.4.1. Central function
1.6.4.2. Federal assets
1.6.4.3. Non-federal assets
1.6.5. Conduct training requirements assessments
1.6.5.1. Central function
1.6.5.2. Federal assets
1.6.5.3. Non-federal assets
1.6.6. Collaborate with education delivery managers
1.6.6.1. Central function
1.6.6.2. Federal assets
1.6.6.3. Non-federal assets
1.6.7. Manage professional certifications
1.6.7.1. Central function
1.6.7.2. Federal assets
1.6.7.3. Non-federal assets
1.6.8. Conduct training and education activities
1.6.8.1. Central function
1.6.8.2. Federal assets
1.6.8.3. Non-federal assets
1.6.9. Develop educational audience
1.6.9.1. Central function
1.6.9.2. Federal assets
1.6.9.3. Non-federal assets
1.6.10. Create a workforce to staff the audience
1.6.10.1. Central function
1.6.10.2. Federal assets
1.6.10.3. Non-federal assets
2. Operations and Sustainment
2.1. Systems engineering and program management
2.1.1. Central function

- 2.1.2. Federal assets
- 2.1.3. Non-federal assets

2.2. System operations [replication of 1.X functions in sustain mode]
- 2.2.1. Sustain past archival data
  - 2.2.1.1. Central function
  - 2.2.1.2. Federal assets
  - 2.2.1.3. Non-federal assets
- 2.2.2. Increase archived data
  - 2.2.2.1. Central function
  - 2.2.2.2. Federal assets
  - 2.2.2.3. Non-federal assets
- 2.2.3. Sustain asset data flows
  - 2.2.3.1. Central function
  - 2.2.3.2. Federal assets
  - 2.2.3.3. Non-federal assets
- 2.2.4. Sustain protocols and standards for format and speed
  - 2.2.4.1. Central function
  - 2.2.4.2. Federal assets
  - 2.2.4.3. Non-federal assets
- 2.2.5. Maintain the R&D pipeline
  - 2.2.5.1. Central function
  - 2.2.5.2. Federal assets
  - 2.2.5.3. Non-federal assets
- 2.2.6. Sustain the educational audience
  - 2.2.6.1. Central function
  - 2.2.6.2. Federal assets
  - 2.2.6.3. Non-federal assets
- 2.2.7. Systems administration
  - 2.2.7.1. Central function
  - 2.2.7.2. Federal assets
  - 2.2.7.3. Non-federal assets
- 2.2.8. Database administration
  - 2.2.8.1. Central function
  - 2.2.8.2. Federal assets
  - 2.2.8.3. Non-federal assets
- 2.2.9. Help desk
  - 2.2.9.1. Central function
  - 2.2.9.2. Federal assets
  - 2.2.9.3. Non-federal assets

2.3. Maintenance
- 2.3.1. Repairs (e.g., federal assets)
  - 2.3.1.1. Central function
  - 2.3.1.2. Federal assets
  - 2.3.1.3. Non-federal assets
- 2.3.2. HW/SW refresh
  - 2.3.2.1. Central function

- 2.3.2.2. Federal assets
- 2.3.2.3. Non-federal assets

2.4. Sustaining support/engineering
- 2.4.1. Responding to changes in operating environment
  - 2.4.1.1. Central function
  - 2.4.1.2. Federal assets
  - 2.4.1.3. Non-federal assets
- 2.4.2. Accommodating growth
  - 2.4.2.1. Central function
  - 2.4.2.2. Federal assets
  - 2.4.2.3. Non-federal assets

2.5. Indirect continuing support
- 2.5.1. Workforce pipeline
  - 2.5.1.1. Central function
  - 2.5.1.2. Federal assets
  - 2.5.1.3. Non-federal assets
- 2.5.2. Training and education
  - 2.5.2.1. Central function
  - 2.5.2.2. Federal assets
  - 2.5.2.3. Non-federal assets
- 2.5.3. Follow on user training
  - 2.5.3.1. Central function
  - 2.5.3.2. Federal assets
  - 2.5.3.3. Non-federal assets
- 2.5.4. Asset maintenance
  - 2.5.4.1. Central function
  - 2.5.4.2. Federal assets
  - 2.5.4.3. Non-federal assets

2.6. Continuing system improvements
- 2.6.1. Central function
- 2.6.2. Federal assets
- 2.6.3. Non-federal assets

Appendix D
Ground Rules and Assumptions

DEFINITION OF U.S. IOOS

The U.S. Integrated Ocean Observing System is a complex collaboration between federal and non-federal entities that share an interest in or have responsibilities for maritime observations as a means to provide societal benefits. Although the concept for U.S. IOOS dates back many years, the first foundational document is known as the Airlie House Report published in 2002.[1] Over the ensuing years, many amplifying studies and reports have continued to develop the concept. As a result, while all the documents share the original intent of U.S. IOOS, there are also some conflicting details as thinking continued to evolve over time.

The two most current and authoritative documents describing U.S. IOOS are *U.S. IOOS: A Blueprint for Full Capability*, Version 1.0 (November 2010, referred to here as the Blueprint), and the Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009. Other foundational documents can provide elaboration on the rationale and some high-level system requirements, but in case of a conflict between documents, the Blueprint and the ICOOS Act are the authoritative sources.

U.S. IOOS represents a national consortium of governmental and nongovernmental stakeholders with specific interest in marine environmental phenomena occurring in the open ocean, U.S. coastal waters, and the Great Lakes. The core mission of U.S. IOOS is the systematic provision of ready access to this marine environmental data and data products in an interoperable, reliable, timely, and user-specified manner to end users/customers in order to serve seven critical and expanding societal needs:

- Improve predictions of climate change and weather and their effects on coastal communities and the nation
- Improve the safety and efficiency of maritime operations
- More effectively mitigate the effects of natural hazards
- Improve national and homeland security
- Reduce public health risks

[1] National Office for Integrated and Sustained Ocean Observations, *Building Consensus: Toward An Integrated and Sustained Ocean Observing System,* Ocean.US Workshop Proceedings, March 10–15, 2002.

- More effectively protect and restore healthy coastal ecosystems
- Enable the sustained use of ocean and coastal resources.[2]

The Blueprint is guided by the ICOOS Act of 2009, which addresses the need for centralized coordination and stewardship of U.S. IOOS development and sustainment that enables distributed national and regional U.S. IOOS implementation. U.S. IOOS broadly consists of both federal and non-federal assets and capabilities that contribute to the U.S. IOOS in the areas of governance and management, observing systems, data management and communication, modeling and analysis, education and training, and research and development. These six areas of collaboration, between federal and non-federal partners, constitute the six subsystems of U.S. IOOS. U.S. IOOS is considered to contain all assets that contribute to these six subsystems (hardware, software, personnel, facilities, functions and activities) regardless of the owning organization or the source of funding.

U.S. IOOS Components

Participants in U.S. IOOS are grouped into three major components:

Program Management and Coordination

The ICOOS Act defines three levels of program management and coordination:

1. The highest level is the Council which is charged with policy and coordination oversight for all aspects of the system.
2. Interagency Ocean Observation Committee (IOOC), a federal interagency committee, which is charged with policy development and coordination
3. NOAA, the lead federal agency for U.S. IOOS, which is charged with implementation of approved policy, coordination between U.S. IOOS partners and U.S. IOOS customers, and day-to-day management of the system.

To carry out its lead federal agency responsibilities as defined in the ICOOS Act, NOAA relies upon the U.S. IOOS Program Office. This office's central function is to serve as the executive agent for the IOOC. In this capacity, the U.S. IOOS Program Office exercises oversight and serves a coordination role to support system integration requirements as defined in the Blueprint, directed by the IOOC and/or called for in the ICOOS Act. Key responsibilities of the central function include the following:

- Collect and consolidate system requirements
- Recommend priorities and proposed solutions to the IOOC

[2] National Office for Integrated and Sustained Ocean Observations, *The First U.S. Integrated Ocean Observing System (IOOS) Development Plan*, Ocean.US Publication, January 2006, p. viii.

- Manage development and execution of DMAC
- Manage day-to-day operations of the system
- Execute development and sustainment plans to enhance capability in all six subsystems
- Provide funding, through a competitive grants process, to non-federal RAs/RCOOSs
- Manage system architecture, build-out plans, and technology integration
- Manage coordination and IOOS participation in national-level plans such as High Frequency Radar (HFR).

The U.S. IOOS Program Office is unique in that it does not fund or own the majority of the assets in the system. While it is a source of funding to the RAs/RCOOSs, its financial impact on the total system is small. The U.S. IOOS Program Office has greater impact as the creator of procedures, standards, and business processes, as well as the coordinator of federal and non-federal participant contributions to the system. The scope of U.S. IOOS Program Office coordination and oversight includes the 37 functions (hereafter referred to as central functions) described in the Blueprint.

Federal Agencies

Seventeen federal agencies have a mission interest in ocean observing. Many of them are members of the IOOC. Each federal partner is funded by Congress to meet its organizational needs and in accord with their operational mandates. Federal agencies may have assets, functions, or activities that contribute to one or more of the U.S. IOOS subsystems. Although these assets are owned and funded by the federal agency that has budget authority, they are counted as part of U.S. IOOS if they contribute to the U.S. IOOS subsystems. Significantly, observing assets, such as buoys or gliders, count as participants in U.S. IOOS if their core variable ocean observing data are provided, or planned to be provided, in U.S. IOOS DMAC-compliant format.

Non-Federal Entities

Non-federal partners are critical to U.S. IOOS's performing its intended mission of delivering societal benefits. The various coastal regions of the United States have unique geography and environmental aspects. To serve the needs of the American people, requirements, products, and services must be tailored to the individual needs of the region in which they reside. To this end, 11 RAs/RCOOSs currently participate as teammates in U.S. IOOS at a regional level. For purposes of this document, the terms RA and RCOOS are used interchangeably.

The ICOOS Act identifies entities termed Regional Information Coordination Entities. For purposes of the cost estimate, all references to RICEs in the act apply to the existing RAs. Also, one non-federal U.S. IOOS partner—Alliance for Coastal Technologies (ACT)—is not an RA. Although ACT is the only non-RA, non-federal partner, the possibility exists that in the future there may be others. None are currently planned.

Like federal partners, all assets of the members of the RA that contribute to an U.S. IOOS subsystem are considered to be part of the system regardless of who owns the asset or the source of funding. RAs differ from federal partners in that they are dependent on federal funding administered by the U.S. IOOS Program Office for a significant portion of their activities. RAs may also be funded by other sources, such as member organizations or other state or federal programs.

While the U.S. IOOS Program Office is the primary executor of the central functions for U.S. IOOS at the national level, RA coordination and oversight includes most of the central functions executed on a regional scale. The RAs also serve as the conduit to the national-level U.S. IOOS functions performed by the U.S. IOOS Program Office. In this sense, RAs are distinctive in that they function as regional-level IOOS program offices for their members and U.S. IOOS.

RAs functioning is dependent on highly skilled ocean research staff. Fielding and management of observation and model assets and RA-based outreach, education and other activities are limited by the staff they have or can reasonably add. RAs will not be able to consistently add more than 20% staff year upon year due to the high time demand to locate and place such skilled staff. This staffing constraint will constrain observational and function growth in the near term.

SCOPE

Assets and activities that currently contribute to, or are projected to contribute to, U.S. IOOS are considered "in scope," regardless of the source of funding to procure and maintain the asset or activity. "Contributing" to U.S. IOOS means to provide resources or products in some meaningful manner to accomplish one of the central functions of the system or to provide assets or capabilities that meet the needs of one or more of subsystems of U.S. IOOS. "Projected to contribute" means not currently contributing as described above, but identified by the owning organization as planned to contribute and consistent with the central functions of the system or required capabilities for one or more IOOS subsystems.

Current and planned contributions are within scope regardless of asset ownership, operational control, source of funding, life-cycle management responsibility, or intended purpose (i.e., operational support or R&D). Dual-use assets (e.g., assets that meet U.S. IOOS needs as well as other partner/participant needs) are considered in scope as long as they provide non-redundant capability to U.S. IOOS, excluding the desired redundancy of in situ and satellite observations. Minimizing unnecessary redundancy and unnecessary taxpayer expense is one of the key reasons to have a central coordinating function; however, scientific research often requires overlapping measurements to achieve verifiable observations. Through full capability (FC), redundant measurements of parameters that are measured by both satellite and in situ sensors are desired to provide verification of satellite measurements and assist with formulating models.

U.S. IOOS is concerned with the observation of U.S. coastal waters encompassing the Exclusive Economic Zone and the Great Lakes. The Global Ocean Observing System (GOOS) observes waters outside the United States. Ocean observing assets outside the United States that do not provide information to U.S. IOOS should not be considered part of U.S. IOOS. Some assets, such as satellites, contribute to both U.S. IOOS and GOOS, and they are considered part of U.S. IOOS.

COSTABLE ELEMENTS

U.S. IOOS includes the following costable elements:

- Program Office, ACT, and RA office expenses
- Labor and materials required to fulfill the central functions and to pay service providers to help fulfill central functions
- Labor, materials, and facilities used by the RAs and the ACT to address all relevant IOOS subsystem activities, including education, training, and research and development
- Computer software and hardware to upgrade and enhance existing data repositories to ensure access and availability
- Maintenance of data assets and observing assets, including vehicles, equipment, or platforms needed to maintain or host observing assets
- Acquisition of new or replacement observing assets when necessary to fulfill U.S. IOOS goals
- Labor required to obtain, emplace, coordinate, and secure observing assets
- Labor, hardware, and software associated with building, maintaining, improving, and providing access to needed models and applications.

The foregoing list is a representative rather than complete enumeration of costs. It is intended as a guide to assist with the identification of cost elements. Strict lines of demarcation are difficult to draw around the program, partly because many of the contributing elements are funded elsewhere, and also partly because the seven critical societal needs of U.S. IOOS are broadly written. The following paragraphs contain statements of assumption to assist with bounding the cost estimation of U.S. IOOS.

A cost estimate must predict costs on the basis of what is known now and must make judgments about the availability of future assets. To reduce variability in cost estimates, it should be assumed that an asset contributing to U.S. IOOS will continue to contribute unless there are definite indications otherwise. For example, a buoy owned by Scripps whose data is provided to IOOS will continue to provide those data year to year. The reality is that the buoy could be pulled back at any time, but we assume it will not.

Similarly, it should be assumed that an asset maintained with U.S. IOOS funds will continue to be maintained by those funds, regardless of who owns the asset. It should be assumed that an asset leveraged from another entity reaching end of life will be replaced by a similar asset also provided by that other entity. The exception is programs whose purpose explicitly includes remaining in situ only for a limited period of time and whose purpose has been accomplished.

Where a gap in full operational capability has been identified, and a federal asset could remediate or mitigate the information gap, it should be assumed that the federally owned observing platform will be leveraged to fill the gap. This includes federal assets that are not currently part of U.S. IOOS.

Where a gap in full operational capability has been identified and a participating known asset could be retrofitted to remediate or fill the information gap, the cost of modifying the asset should be considered. If the cost of modifying a participating asset is less than buying a new asset, then it should be assumed that the asset will be modified to suit. For example, modifying a series of National Buoy Data Center buoys with an additional sensor may provide needed oceanographic variables and may be less costly than acquiring and maintaining a new series of buoys.

LIFE-CYCLE ASSUMPTIONS

The U.S. IOOS life cycle extends from the present up to full capability (FC), which will be reached in 10 years, and for 5 years beyond FC. FC is the point at which

- all designated U.S. IOOS data providers are integrated and making accessible all appropriate, non-classified ocean observing core variables in a U.S. IOOS-compliant manner to end users/customers,
- all U.S. IOOS services are available and functioning at the desired level determined by the IOOC, and
- a fully capable U.S. IOOS Program Office is providing system oversight and coordination.

Any assets expected to be procured to reach FC are within scope.

The following assumptions govern the life cycle of observing assets:

- The life cycle of a buoy platform is 5–10 years.
- The life cycle of a buoy sensor is 2 years.
- The life cycle of a buoy battery is 1 year.
- The life cycle of a satellite is 3–5 years.
- The life cycle of a glider is 2–4 years. To provide continuous operation of one glider, 2 to 3 gliders are needed to provide for repair time.
- The life cycle of an HFR in a marine environment is 10 years.
- The life cycle of an aircraft is 20 years.
- The life cycle of a maintenance ship is 20–25 years.

Lifecycle assumptions presume operation in the intended environment and regular scheduled maintenance.

Financial Assumptions

Assets of U.S. IOOS are presumed to be sustained by the organization that lists that asset on its property books unless otherwise identified.

U.S. IOOS includes functions and assets that are already funded by federal agencies. The cost estimate must identify, in separate line items, those functions and assets, including maintenance, with existing funding and those functions and assets that are not currently funded. The cost estimate should use the current budget-year funding status as the indication of already having funding.

The U.S. IOOS cost estimate must also have separate line items for the central functions, the federal contributions, and the non-federal contributions. The CARD has been structured with this division to aid in that estimation.

The U.S. IOOS Program cost estimates should be enumerated in government fiscal year dollars, with the base year being the year in which the initial estimate is completed, and the final estimate should be budget year phased to provide budget request totals and justification.

U.S. IOOS Program cost estimates should be given in both 50 percent confidence and 80 percent confidence levels.

TECHNICAL ASSUMPTIONS

The following assumptions govern technical aspects of U.S. IOOS:

- Nonportable computer equipment will be refreshed every 5 years.
- Portable computer equipment and phones will be refreshed every 3 years.

Models will be partially recoded every 5 years to accommodate changing operating systems and completely recoded every 10 years.

Appendix E
Abbreviations

ACT	Alliance for Coastal Technologies
ADCP	Acoustic Doppler Current Profiler
AOOS	Alaska Ocean Observing System
AUV	Autonomous Underwater Vehicle
AVHRR	Advanced Very High Resolution Radiometer
BOB	Basic Observation Buoy project
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BP	British Petroleum
CaRA	Caribbean Regional Association for Ocean Observing
CARD	Cost Analysis Requirements Description
CBIBS	Chesapeake Bay Interpretive Buoy System
CDIAC	Carbon Dioxide Information Analysis Center
CeNCOOS	Central and Northern Coastal Ocean Observing System
C-MAN	Coastal-Marine Automated Network
CMOP	Center for Coastal Margin Observation & Prediction
CO-OPS	Center for Operational Oceanographic Products and Services
COSEE	Centers for Ocean Sciences Education Excellence
CRCP	Coral Reef Conservation Program
CREIOS	Coral Reef Ecosystem Integrated Observing System
CSREES	Department of Agriculture, Cooperative State Research, Education, and Extension Service
CTD	conductivity-temperature-depth
CWB	coastal weather/moored buoy
DAC	data assembly center
DART	Deep-Ocean Assessment and Reporting of Tsunamis®
DAS	Days At Sea
DIF	Data Integration Framework

DMAC	data management and communication
DOE	Department of Energy
DOS	Department of State
EARTH	Education and Research, Testing Hypotheses
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
ESR	Earth Space Research
FDA	Food and Drug Administration
FOCI	Fisheries Oceanography Coordinated Investigations
GCOOS	Gulf of Mexico Coastal Ocean Observing System
GEOSS	Global Earth Observation System of Systems
GLOS	Great Lakes Observing System
GOES	Geostationary Operational Environmental Satellite
GOOS	Global Ocean Observing System
HAB	harmful algae bloom
HFR	high-frequency radar
HOV	human occupied vehicle
ICON	Integrated Coral Observing Network
ICOOS	Integrated Coastal and Ocean Observation System
IEA	Integrated Ecosystem Assessment
IGOS	Integrated Global Observing Strategy
INS	Inertial Navigation System
IOOC	Interagency Ocean Observation Committee
IOOS	Integrated Ocean Observing System
IT	information technology
IWGOO	Interagency Working Group on Ocean Observations
JCS	Joint Chiefs of Staff
MACOORA	Mid-Atlantic Coastal Ocean Observing Regional Association
MMC	Marine Mammal Commission
MOA	Marine Operations Center, Atlantic
MOBY	Marine Optical Buoy
MOP	Marine Operations Center, Pacific

NANOOS	Northwest Association of Networked Ocean Observing Systems
NASA	National Aeronautics and Space Administration
NCOP	National Current Observation Program
NDBC	National Data Buoy Center
NERACOO	Northeastern Regional Association of Coastal Ocean Observing
NERRS	National Estuarine Research Reserve System
NESDIS	National Environmental Satellite Data and Information Service
NGO	nongovernmental organization
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NOSA	NOAA Observing System Architecture
NPS	National Park Service
NSF	National Science Foundation
NWLON	National Water Level Observation Network
NWS	National Weather Service
O&M	operations and maintenance
OAR	Office of Oceanic and Atmospheric Research
ONR	Office of Naval Research
ORS-B	Ocean Reference Stations–Bottom
ORS-S	Ocean Reference Stations–Surface
PacIOOS	Pacific Islands Ocean Observing System
PIRATA	Prediction and Research Moored Array in the Atlantic
PMEL	Pacific Marine Environmental Laboratory
POES	Polar-orbiting Operational Environmental Satellite
QA/QC	quality assurance/quality control
R&D	research and development
RA	regional association
RAMA	Research African–Asian–Australian Monsoon Array
RCOOS	Regional Coastal Ocean Observing System
ReCON	Real-Time Environmental Coastal Observation Network

RICE	regional information coordination entity
RMC	risk management coordinator
RMT	risk management team
ROV	remotely operated vehicle
SAR	search and rescue
SCCOOS	Southern California Coastal Ocean Observing System
SECOORA	Southeast Coastal Ocean Observing Regional Association
SIO	Scripps Institution of Oceanography
SkIO	Skidaway Institute of Oceanography
SLO	San Luis Obispo California Polytechnic Sate University
SWMP	System-wide Monitoring Program
TAO	Tropical Atmospheric Ocean
TOVS	Tiros Operational Vertical Sounder
UNOLS	University National Oceanographic Laboratory System
USACE	U.S. Army Corps of Engineers
USARC	U.S. Arctic Research Commission
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
VOS	Voluntary Observing Ship
WHOI	Woods Hole Oceanographic Institute