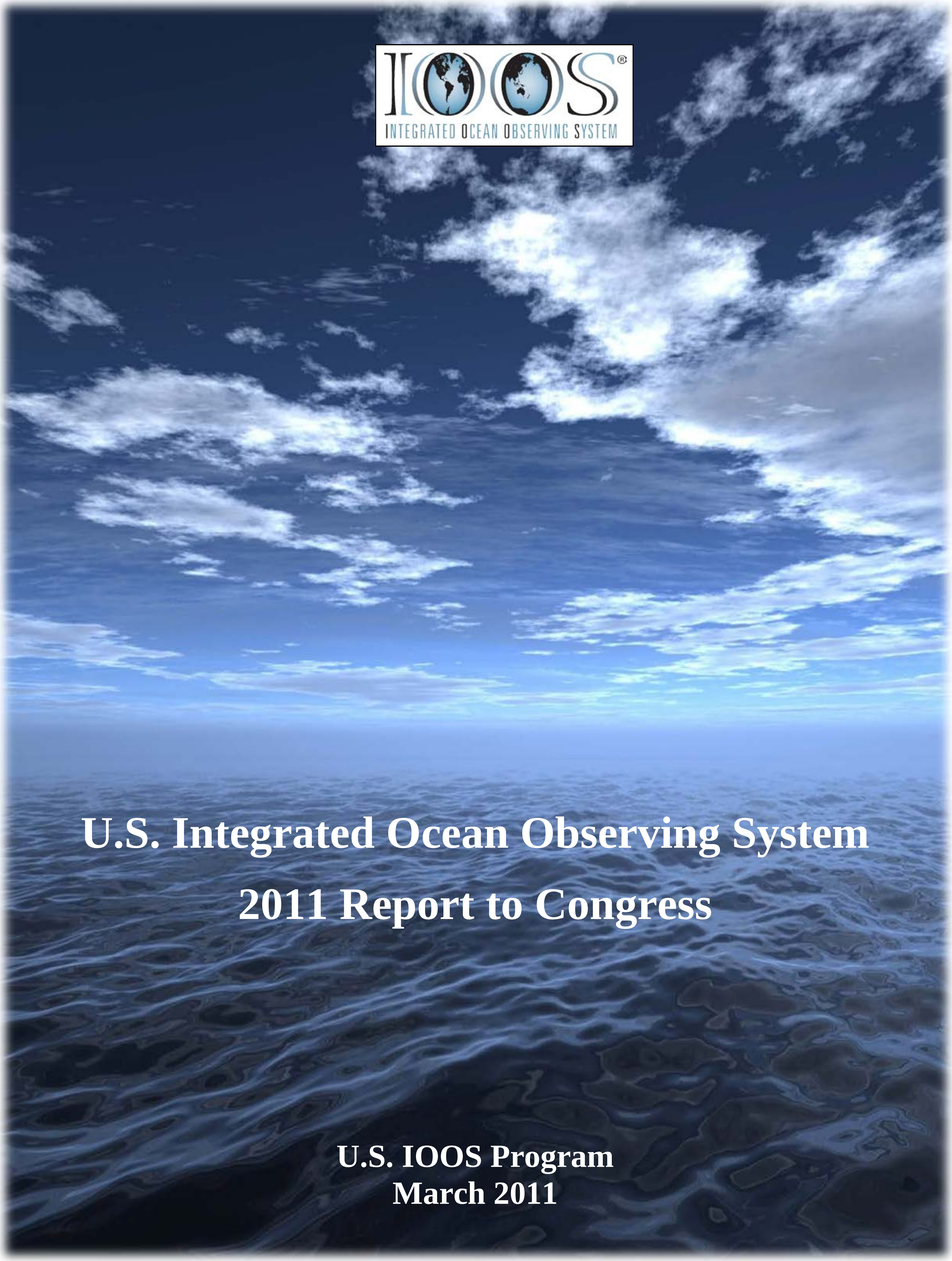

U.S. Integrated Ocean Observing System

2011 Report to Congress

U.S. IOOS Program

March 2011

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Executive Summary

On March 30, 2009, President Obama signed into law the Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009 (P.L. 111-11, Title XII, Subtitle C), with the following overarching purposes:

- "Establish a national integrated System of ocean, coastal, and Great Lakes observing systems comprised of federal and non-federal components …" "… designed to address regional and national needs for ocean information, to gather specific data on key coastal, ocean, and Great Lakes variables, and to ensure timely and sustained dissemination and availability of these data" to support national defense, marine commerce, navigation safety, weather, climate, and, marine forecasting, energy siting and production , economic development, ecosystem-based marine, coastal, and Great Lakes resource management, public safety, and public outreach training and education;"

- "improve the Nation's capability to measure, track, explain, and predict events related directly and indirectly to weather and climate change, natural climate variability …" and

- "authorize activities to promote basic and applied research to develop, test and deploy innovations and improvements …"[1]

This report describes progress made in implementing the U.S. Integrated Ocean Observing System (U.S. IOOS®) in accordance with the ICOOS Act and toward goals identified in the System Plan, "*The First U.S. Integrated Ocean Observing System (IOOS) Development Plan*,"[2] and covers the period from March 2009 through December 2010, with historical context provided as appropriate. The Act identifies the National Oceanic and Atmospheric Administration (NOAA) as the lead federal agency and directs the NOAA Administrator to prepare a report on progress made in implementing the Act and transmit the report to the National Ocean Research Leadership Council (NORLC) for submission to Congress no later than two years after its enactment. Under the President's National Ocean Policy, the duties of the NORLC will be conducted by the Deputy level of the National Ocean Council. The President's National Ocean Policy acknowledges the importance of robust and integrated observations, mapping, and infrastructure.

U.S. IOOS is comprised of 17 federal agencies, 11 regional associations (RAs), and a technology verification and validation organization (the Alliance for Coastal Technologies (ACT)). Additional partners include a large and growing number of

[1] Omnibus Public Land Management Act of 2009, Subtitle C--Integrated Coastal and Ocean Observation System Act of 2009; www.ioos.gov/icoosact/iccos_act_pl111_11.pdf.

[2] *The First U.S. Integrated Ocean Observing System (IOOS) Development Plan*: www.usnfra.org/documents/IOOSDevPlan_low-res.pdf

organizations including industry, academia, state, local, and tribal governments, and other federal and non-federal organizations. As lead federal agency, NOAA has established an Integrated Ocean Observing System Program, hereafter referred to as the U.S. IOOS Program. The U.S. IOOS Program is supported and staffed by NOAA and has begun incorporating member agency participation with the recent inclusion of a U.S. Army Corps of Engineers representative on the staff.

As the regional component of U.S. IOOS, the 11 RAs and ACT perform a vital role. The RAs identify user needs and demands for ocean observations and information products and how national priorities can be addressed effectively in the different regions. They are charged with designing and implementing the regional coastal ocean observing system infrastructures that complement and contribute to national observing systems. These RAs manage systems development within their regions and work with stakeholders to prioritize observations, products, and services. Today, U.S. IOOS works closely with the National Federation of Regional Associations for Coastal and Ocean Observing (NFRA) and the RAs to establish core capabilities that meet both national priorities and regional user needs. The ACT is also a key U.S. IOOS partner, providing verification and validation of observing sensors to ensure data captured by the sensors are both accurate and reliable.

"*The First U.S. Integrated Ocean Observing System (IOOS) Development Plan*," outlines essential IOOS capabilities. Using this "System Plan" as the baseline, U.S. IOOS recently developed the "*U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*" (*Blueprint*) (www.ioos.gov/library/us_ioos_blueprint_ver1.pdf). The *Blueprint* defines the specific activities and systems that will make up the fully operational U.S. IOOS and guides the efforts of partners and the U.S. IOOS Program. As outlined in the *Blueprint*, U.S. IOOS activities fall into six distinct subsystems—three functional subsystems (observations, data management and communications, and modeling and analysis) to provide the technical capability to readily access Great Lakes and marine environment data and data products and three cross-cutting subsystems (governance and management, research and development, and training and education) that form the programmatic structure of U.S. IOOS to provide for sustainment and improvements to the system.

To date, a main focus of the program has been to identify the diverse needs of the federal government and users in the regions and to develop the hardware and software foundation, as well as the governance and programmatic structure for U.S. IOOS. The Data Management and Communication (DMAC) subsystem serves as a central mechanism for integrating all projected data sources and, as such, is a high priority for U.S. IOOS. The successful Data Integration Framework (DIF) project was a limited-scope, 3-year pilot project to provide an initial nationwide U.S. IOOS DMAC operating capability, to evaluate interoperability specifications, and to demonstrate the feasibility and value of providing integrated ocean observations. It concluded in 2010 with recommendations for standardized coding conventions for a small set of data and provides a baseline for initial U.S. IOOS DMAC capabilities.

Also in 2010, the Integrated Ocean Observing Committee (IOOC) was formed in accordance with provisions of the ICOOS Act. It functions as an interagency group comprised of representatives from federal agencies that will oversee various provisions of the Act for implementing procedural, technical, and scientific priorities to ensure full execution of the system.

Taking U.S. IOOS from its current state to full capability will be guided by the system structure and activities established in the *Blueprint*. One of the next steps currently underway is a comprehensive program assessment to determine the entire population of partners, their assets and needs, and any gaps between current capabilities and the desired end-state described in the *Blueprint*. Armed with this information, planning will commence to address the unfulfilled priorities of U.S. IOOS.

Progress will continue while awaiting the gap analysis. U.S. IOOS will leverage the success of the DIF project by enhancing data services and broadening the scope of the initial project to include more data providers, customers, variables and additional components of the DMAC subsystem. The program also continues to develop a data catalog, which provides users a single location where they can search for and retrieve data.

While the full implementation of U.S. IOOS is still in the future, we are already seeing the benefits of integrating ocean, coastal, and Great Lakes observations. In FY2010, U.S. IOOS allowed key information to be gathered during the Deepwater Horizon oil spill that would not have been possible without this federal and non-federal, regional-to-national partnership. U.S. IOOS activities have also led to improvements in storm surge predictions and water quality monitoring. This report's goal is to show that the vision of U.S. IOOS, delivering ocean information using an integrated approach, provides decision makers with more comprehensive, accurate, timely, and valuable information. The challenge will be to not only sustain the efforts outlined in this report but also incrementally build upon them to achieve our vision for a fully-developed U.S. IOOS.

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Contents

Introduction

The U.S. Integrated Ocean Observing System (U.S. IOOS®) is envisioned as a major improvement to ocean observing, efficiently drawing together the vast network of disparate, federal and non-federal observing systems to produce a cohesive suite of data, information, and products at a sufficient geographic and temporal scale to support decision-making. As the system matures, U.S. IOOS is expected to advance beyond its current state to fulfill regional and national needs for integrated ocean information; to gather specific data on key coastal, ocean, and Great Lakes variables; and to ensure timely and sustained dissemination and availability of these data. U.S. IOOS is comprised of a global and coastal component, and together these constitute the United States' contribution to the Global Ocean Observing System (GOOS), the ocean component of the Global Climate Observing System (GCOS) and the ocean baseline of the Global Earth Observation System of Systems (GEOSS).

Figure 1. Example of an integrated ocean observation system

Entities participating in U.S. IOOS include federal, state, local and tribal governments; regional entities; academia; and the private sector, including non-governmental organizations. With such a broad spectrum of partners comes the challenge of integrating the pieces into a cohesive system with common goals and objectives.

While many gaps still exist, U.S. IOOS has made concrete inroads into establishing baseline capabilities, defining priorities, and charting the way ahead. This report describes the partners involved, summarizes the progress made to date, outlines plans for future progress, and details benefits of this integrated approach to ocean observing.

Chapter 1
U.S. IOOS Partners

U.S. IOOS is a federal, regional, and private-sector partnership working to enhance our nation's ability to collect, deliver, and understand ocean information, as well as to enhance the nation's ability to generate innovations around ocean information. The Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009 mandated the establishment of this national system with the National Oceanic and Atmospheric Administration (NOAA) as lead federal agency. Acting as the program coordinator, NOAA established an Integrated Ocean Observing System Program, hereafter referred to as the U.S. IOOS Program. U.S. IOOS is used to refer to the integrated efforts of all partners.

Internationally, U.S. IOOS is the United States' contribution to the GOOS—the ocean component of a worldwide effort to build GEOSS, a global "system of systems" that integrates thousands of Earth observation technologies. At the national level, U.S. IOOS represents a partnership of 17 federal partners, 11 regional associations for coastal and ocean observing, and a validation and verification testing organization. These organizations share a responsibility for the design, operation, and improvement of both the national and regional network of observations, linking marine data and products in a compatible and easy-to use manner for the wide variety of U.S. IOOS customers.

Beyond federal and regional partners, there is a vast array of organizations that comprise the network of U.S. IOOS contributors and users. These include groups in areas such as industry; academia; state, tribal, and local governments; and additional federal and non-federal organizations.

One of the early tasks for U.S. IOOS is to identify all the members of the U.S. IOOS team and work toward fully integrating the assets of data and product providers and fulfilling the needs of data and data product users.

Federal and Regional Assets

Federal Partners

Federal partners of U.S. IOOS include a variety of departments and agencies—none of which alone has the capacity or resources to fully implement U.S. IOOS on a national scale, but all of whom contribute to the overall mission. Effective and consistent collaboration among these various organizations is essential to support the planning and coordination of national IOOS development.

Currently, there are 17 federal organizations named as partners in U.S. IOOS. These agencies were also members of the statutorily mandated National Ocean Research Leadership Council (NORLC), under 10 U.S.C. § 7902. These organizations provide active support, funding, guidance, or advice to the program. The first 11 federal partners listed here are also part of the Interagency Ocean Observation Committee (IOOC), described in more detail in chapter 2. These 11 members play a direct oversight role in the development of U.S. IOOS.

U.S. IOOS Federal Partners include:

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

Regional Partners

Regional U.S. IOOS partners are essential to building and supporting U.S. IOOS. They provide increased observation density, distinctive knowledge, and technology competencies related to local environments (sea ice, coral reefs, Great Lakes, etc.), as well as support regional and local user needs. Eleven regional associations (RAs) and their associated Regional Coastal Ocean Observing Systems (RCOOS) provide the regional component of U.S. IOOS and, once certified, will serve in the capacity of regional information coordination entities (RICEs) as described in the ICOOS Act. They also "provide a forum for convening regional experts, agencies, industry, and users to discuss mutual needs, leverage assets, and share expert knowledge"[2] to identify regional priorities and gaps, and develop regional-specific products addressing user needs. In FY2011, NOAA will continue to enhance the RA and RCOOS system through the establishment of new 5-year, multi-year cooperative agreements with regional partners (described further in Chapter 2).

U.S. IOOS Regional Partners include:

Alaska Ocean Observing System (AOOS)
www.aoos.org

Caribbean Regional Association for Ocean Observing (CaRA)
cara.uprm.edu

Central and Northern California Ocean Observing System (CeNCOOS)
www.cencoos.org

Gulf of Mexico Coastal Ocean Observing System (GCOOS)
gcoos.org

Great Lakes Observing System (GLOS)
www.glos.us

Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)
www.macoora.org

[2] National Federation of Regional Associations for Coastal and Ocean Observing Report: Providing Coastal Information in a Changing Climate, March 2010; www.usnfra.org/documents/03.10_RCBooklet_lo-res.pdf

Northwest Association of Networked Ocean Observing Systems (NANOOS)
www.nanoos.org

Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)
www.neracoos.org

Pacific Islands Ocean Observing System (PacIOOS)
www.pacioos.org

Southern California Coastal Ocean Observing System (SCCOOS)
www.sccoos.org

Southeast Coastal Ocean Observing Regional Association (SECOORA)
www.secoora.org

Validation and Verification Testing Organization

Another partner working with both the federal and regional ocean observing organizations within U.S. IOOS is the Alliance for Coastal Technologies (ACT). ACT is a competitively selected 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.

Alliance for Coastal Technologies (ACT)
www.act-us.info/

Additional U.S. IOOS Partners

Federal and regional partners form the core of U.S. IOOS, but the scope of the system is much larger. Academia, industry, state, local, and tribal governments, and additional federal agencies also provide observing assets, research and development capabilities, data management and distribution functions, and insight into user needs.

As part of an on-going program assessment (described further in chapter 3), U.S. IOOS is developing an online database to capture the entire population of partners.

CERTIFICATION OF NON-FEDERAL ASSETS FOR INTEGRATION INTO THE SYSTEM

With passage of the ICOOS Act, non-federal assets are required to be certified before formal integration into the system. In 2010, the IOOC began development of a process by which these certification standards would be developed and implemented.

After the chartering of the IOOC in June 2010, a subgroup was commissioned to focus on fulfilling the ICOOS Act requirement to "develop contract certification standards and compliance procedures for all non-Federal assets, including RICEs; to establish eligibility for integration into the system; to ensure compliance with all applicable standards and protocols established by the Council; and ensure that regional observations are integrated into the system on a sustained basis."

The subgroup created charters for two working groups to develop certification standards for data partners (including data collectors and data providers) and for RICEs. These working groups will also recommend a certification process for each and present their results to the IOOC for approval.

- Considerations for certification standards for RICEs may include having defined geographic boundaries, formal management structures, full representation of the region (to include industry, academia, state and local governments, and some federal membership), independent funding, and an ability to participate as an agent of U.S. IOOS.

- Considerations for certification of data partners may include availability of metadata, data quality control measures, data refresh rates, types of observations available, existing data services in use, and maturity of the data management processes in use.

PUBLIC-PRIVATE USE POLICY

The ICOOS Act includes a directive to the NORLC to develop a Public-Private Use Policy. This policy will define the process for making decisions about the roles of the federal government, the states, regional associations, the academic community, and the private sector in providing IOOS related environmental information, products, technologies and services to end-user communities. In July 2010, the IOOC and the Joint Subcommittee on Ocean Science and Technology (JSOST) approved a draft policy defining the process, which was published in the Federal Register for public comment. The comment period closed after 60 days with one comment received and adjudicated. The policy can be found at: www.iooc.us/wp-content/uploads/2010/10/Certifications-FRN-2010-26003.pdf.

Chapter 2
Current Activities

This chapter outlines the current activities of U.S. IOOS. Accomplishing a mission as far-reaching and complex as that of U.S. IOOS requires a clear understanding of the program's envisioned physical infrastructure as well as the underlying governing and programmatic structures. The U.S. IOOS program used the required IOOS capabilities described in the 2006 system plan, "*The First U.S. Integrated Ocean Observing System (IOOS) Development Plan*" as a baseline for developing the "*U.S. Integrated Ocean Observing System: A Blueprint for Full Capability*" (*Blueprint*), www.ioos.gov/library/us_ioos_blueprint_ver1.pdf. The *Blueprint* defines the activities and systems that will make up the fully operational U.S. IOOS Program and guides the efforts of U.S. IOOS partners and the U.S. IOOS Program.

As outlined in the *Blueprint*, U.S. IOOS is composed of six distinct subsystems. Three functional subsystems provide the technical capability to readily access marine environmental data and data products: data management and communications, observations, and modeling and analysis. Three cross-cutting subsystems establish the programmatic structure of U.S. IOOS to provide for sustainment and improvements to the system: governance and management, research and development, and training and education. The current status of activities in each of these subsystems is listed below.

Data Management and Communication (DMAC) Subsystem

Of the three subsystems that form the functional or physical structure of U.S. IOOS, the DMAC subsystem serves as a central mechanism for integrating all existing and projected data sources. Historically, data providers recorded and transmitted data in a variety of ways that, while satisfactory for their own purposes, were often not consistent in content or format with other providers of the same data. As the foundation upon which the entire U.S. IOOS system will rest, establishing initial capabilities of DMAC has been a prime focus of the program and is a major achievement of U.S. IOOS.

Data Integration Framework (DIF) Project

U.S. IOOS began the DIF project in 2007 as a limited-scope, risk reduction, 3-year pilot project to evaluate interoperability specifications for ocean observations data, and to demonstrate the feasibility and value of providing integrated ocean observations. The DIF was designed to establish technical infrastructure, identify standards, and provide guidelines to improve data delivery from selected sources of core IOOS variables: sea temperature, water level, ocean color, currents, salinity, wind, and waves. These initial variables were chosen for their high value to data customers and the ability to make them readily available from a limited number of data providers. Three data providers were selected for the DIF project: NOAA's National Data Buoy Center (NDBC), CoastWatch (CW), and the Center for Operational Oceanographic Products and Services (CO-OPS). The four customer themes for which data interoperability was enabled were coastal inundation, harmful algal blooms, hurricane intensity, and integrated ecosystem assessments.

Through the DIF project, U.S. IOOS developed a standardized and interoperable web service layer allowing key NOAA data providers to provide integrated access to data from both NOAA and the 11 U.S. IOOS RAs.

Of the 16 metrics developed to evaluate the DIF project, eight show a positive impact. This includes earlier and more precise forecast ability for Harmful Algal Blooms; increased efficiency and reliability of access to real-time water level data for Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model initialization; and increased numbers of datasets available to users. The remaining eight metrics were not assessed due to lack of baseline data or an inability to measure the enhanced performance. Specific details on what each metric measured are in the final DIF project report, which can be found at www.ioos.gov/library/ioos_dif_assmnt_report_final.pdf. In addition to the formal metrics, further qualitative benefits resulting from the project are outlined in the final report, with several highlighted below:

- Data Accessibility
    - Standard data services operating at NOAA's NDBC, CW, CO-OPS and 9 of 11 U.S. IOOS regions; providing data on seven IOOS core variables (sea temperature, water level, ocean color, currents, salinity, wind, and waves).
- Increased Efficiency
    - Reduced software coding complexity for application developers due to standardization of data formats and methods for requesting and receiving data. In one case, development time was reduced from 5 to 2 days when adding a data provider; in another, the software modification effort was reduced from 5 days to 1 hour.
    - Successful integration of DIF data into NOAA's National Center for Environmental Prediction's (NCEP) operational data "tanks." This is a major technical achievement for establishing protocols and procedures to accept additional U.S. IOOS data into NCEP operational data streams.

- Safer Coastlines
  - An enhanced understanding of the effect of improved ocean state information on hurricane intensity forecasting.
  - An enhanced storm surge display program, which integrates U.S. IOOS-formatted water level and wind observations with storm surge model output.
- Better Forecasting
  - Enhanced operational Harmful Algal Blooms-Forecast System (HAB-FS) bulletin software. This integrates U.S. IOOS fixed location (*in situ*) currents observations to assist analysts in HAB forecasting, allowing analysts to enhance predictions of harmful blooms.
  - Significant technical refinements to the National Marine Fisheries Service/Ecosystem Research Division software, providing a prototype for integrating selected U.S. IOOS data services into the Integrated Ecosystem Assessment model for the Gulf of Mexico and California Current Regions.

The DIF project concluded in 2010 and is transitioning to a baseline for the initial U.S. IOOS DMAC capability. All documentation regarding the DIF, including the final report issued in November 2010, is available on www.ioos.gov/dif.

National Data Assembly Center (DAC)

The NDBC DAC has been a part of the U.S. IOOS DMAC effort since its inception. The DAC increases the availability of many NOAA and regional observations, now over 700 platforms, making these data available to the public by delivering them to the World Meteorological Organization Global Telecommunications System. Since the establishment of NDBC's U.S. IOOS partnership in 2002, the number of IOOS observations processed has grown from 200,000 to 10 million annually in 2010 (see figure 2). These observations include data sets that were not previously available except to local system users. For example, in addition to regional data, observations from NOAA's National Estuarine Research Reserve System (NERRS) were added in 2007. NDBC also quality controls and maintains subsurface current data and meteorological observations from up to 60 oil and gas platforms located in the Gulf of Mexico. Data from these platforms were made public by the oil companies through a Notice to Lessees issued by BOEMRE, prior to which the oil and gas industry held these data as proprietary.

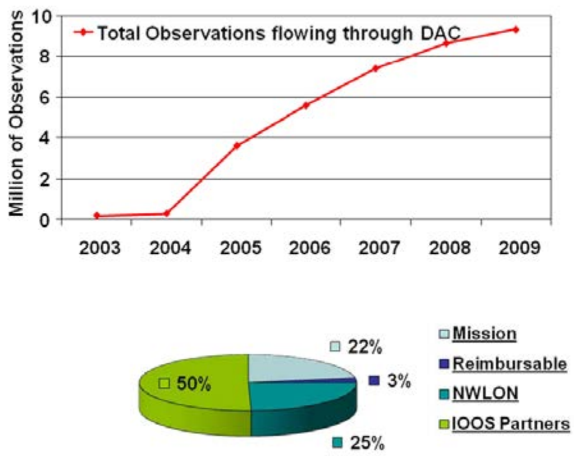

Figure 2. Observations processed at the NDBC DAC and 2009 percentages of observations from various data providers.

Managing Data Providers

Another key aspect of standardized accessibility to data is to establish criteria for the collectors and providers of U.S. IOOS data. In order to ensure quality control of data and the use of common formats, U.S. IOOS established a working group comprised of U.S. IOOS Program and IOOC support staff to develop a certification process for data partners. This group will establish the data criteria (required attributes for any data incorporated into U.S. IOOS) as well as a verification process that will confirm the data are in compliance with the criteria.

Data from independent systems belonging to many organizations (such as state and local governments, industry, and academia) will be incorporated into RA data streams. After RAs are certified, they will assure compliance of the data from participating independent systems served through them. For systems providing data through a certified RA, no separate certification is required. However, for independent collectors and providers not participating through an RA, a separate certification will be required for their data to be part of U.S. IOOS. Recommended certification criteria are expected to be delivered to the IOOC by June 2011.

Observations Subsystem

The second of the three functional subsystems, Observations, will manage the actual collection of ocean observations from systems in the water, as well as land-based, airborne, or satellite platforms for both the global ocean environment and the coastal and Great Lakes environments. The current capabilities listed below are provided by leveraging existing assets of U.S. IOOS partners while establishing the initial guidance and agreements for present and future integration efforts.

Global Observations

The Climate Observation Division of NOAA's Climate Program Office is responsible for establishing and maintaining the U.S. contribution to the sustained global ocean observing system. It provides data for marine weather analysis, climate research and prediction, as well as long-term monitoring for climate change detection and attribution. Through the Climate Program, NOAA provides the major U.S. ocean contribution to the GCOS. This international observation system is based on measuring a set of core variables (for example: ocean temperature, surface winds, salinity, sea level, carbon dioxide) that have been agreed upon nationally and internationally as necessary to provide the information needed by the United States and the other nations to effectively plan for and manage their response to climate variability and change.

More information may be found in the report to Congress on "Implementing the Sustained Global Ocean Observing System for Climate:" www.oco.noaa.gov/docs/Ocean_System_Congress_Report_2008.doc.

National Observing Programs

As part of the vision for U.S. IOOS, outlined in its strategic plan (www.ioos.gov/library/ioos_stratplan_revised_080309.pdf), IOOS includes a national infrastructure of observations, and the program is leveraging current capabilities and building a federal, integrated capacity to deliver data and ensure continuity and sustainability over the long term. The NDBC, CO-OPS, and Coastal-Marine Automated Network (C-MAN) are an essential part of that infrastructure.

NDBC's primary mission is to provide marine meteorological, oceanographic and geophysical observations accurately and in real-time to assist warning centers, marine forecasters, the USCG, ocean platform operators, and the public in making sound decisions to safely operate in the marine environment. Over 75% of NDBC's platforms are part of the offshore and outer-shelf subnet and include over 110 moored buoys, which 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 also maintains a reimbursement program–where other agencies and activities (NASA, U.S. Marine Corps, USCG) purchase buoys while NDBC deploys, operates, and maintains the platforms. The reimbursement program allows other agencies to support the federal ocean observations program while acquiring information that meets their needs.

NOAA CO-OPS is the authoritative source for accurate, reliable, and timely water level and current measurements that support safe and efficient maritime commerce, sound coastal management, and recreation. CO-OPS operates and maintains three major components of the ocean observing backbone for the nation; the National Water Level Program (NWLP), the National Currents

Observation Program (NCOP) and the Physical Oceanographic Real Time System (PORTS®).

NDBC established C-MAN stations for the National Weather Service (NWS) in the early 1980s. C-MAN stations have been installed on lighthouses, at capes and beaches, on near shore islands, and on offshore platforms. 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 at certain locations. C-MAN, the National Water Level Observation Network (NWLON), and PORTS® serve as complementary stations throughout the U.S. and other locations to provide full-spectrum coverage of the near-shore environment.

Wave Observation

The USACE and the NDBC have long led the nation in wave observation programs, but the observation locations were based on local project or user priorities, resulting in a useful but ad hoc network with limited potential for integration. The 2008 National Operational Wave Observation Plan, sponsored by the U.S. IOOS Program and the USACE, addresses this situation by defining a comprehensive wave-observing network for the United States. The plan, available at www.ioos.gov/library/wave_plan_final_03122009.pdf, defines a standard level of wave measurement accuracy, assesses existing measurement locations, adds additional observations in critical "gap" locations, implements a continuous testing and evaluation program, supports the quality assurance/quality control and data integration, and promotes the development of new sensors and measurement techniques.

One outcome of implementing the plan has been the inclusion of the USACE Wave Observation Program in the FY2011 President's Budget. This program funds the Coastal Data Information Program (CDIP) operated by the Scripps Institution of Oceanography, which helps sustain U.S. IOOS (more information is available at: http://cdip.ucsd.edu). In addition, several RAs are working through the USACE and CDIP to fund new wave buoys or to support the maintenance cost of existing buoys. The U.S. IOOS Program will continue to facilitate the advancement of comprehensive wave-observing network capabilities with the USACE, NDBC, and the RCOOSs as resources become available.

High Frequency Radars (HFR)

High Frequency Radar (HFR) systems measure surface current velocities in near real-time. In 2008, the number of HFRs nationally surpassed the 100 mark, however, data from the HFRs were provided by individual operators on a site-by-site basis and were not accessible on a national scale. Recognizing potential benefits of access to national HFR data, a national HFR data delivery system was established at NOAA's NDBC, the Scripps Institution of Oceanography, and

Rutgers University, facilitated by the U.S. IOOS Program. In 2009, the HFR community published "A Plan to Meet the Nation's Needs for Surface Current Mapping." The plan, which can be found at: www.ioos.gov/library/surfacecurrentplan9_3hres.pdf, presents the uses of HFR, the requirements that drive the measurement of ocean surface currents, and the implementation design for a five-year buildout.

It should be noted that more than 95% of the HFR platforms are operated by U.S. IOOS RAs. HFR data are now supplied by 9 of 11 U.S. IOOS regions and support a range of applications, including search and rescue (SAR), spill response, harmful algal bloom monitoring, pollution tracking, larval transport, and coastal water quality assessments. The information can also provide value in ecosystem assessment and fisheries management both in real time applications and climatology. The U.S. IOOS Program also supports multiple facets of technical sustainment and evolution of national and regional HFR capabilities. This support includes ensuring that adequate radio frequency licensing is in place to meet operational and research needs, and hosting a technical steering committee to guide future national system development.

Underwater Robotic Gliders

December 2009 marked the completion of the Atlantic crossing by Scarlet Knight, an unmanned, underwater robotic vehicle, or "glider." Scarlet Knight is a Slocum Glider developed by Teledyne Webb Research and Rutgers University. This effort exemplifies the partnerships that empower U.S. IOOS capabilities by bringing together Rutgers University, NOAA, ONR, Puertos Del Estado (Spanish Port Authority), and Teledyne Webb Research. The glider spent 7 months at sea, repeatedly diving to depths of 200 meters to collect data throughout the water column—such as temperature, salinity, and density—before completing its mission off the coast of Spain. This mission opens up new frontiers in the ocean, advancing an ability to accomplish for deep water oceanography what has already been done in continental shelf oceanography.

The glider served as a major advancement for ocean observing technology, allowing critical data collection in the middle of the ocean at lower cost and risk to human life than ever before. When correlating the data with satellite and model output, discrepancies were found and, as a result, the operational model used by the U.S. Navy was changed and resulted in improved forecasting. With undergraduate students significantly involved in this undertaking, it also advances Science, Technology, Engineering, and Mathematics education initiatives.

Collectively the U.S. IOOS regional and industry partners have flown over 15,000 glider days in the past three years. Examples include:

- In the Mid-Atlantic Regional Coastal Ocean Observing System (MARCOOS), gliders have been conducting regional surveys of the mid-Atlantic Bight. The existence of the mid-Atlantic glider observatory provided a unique test-bed for cyber-infrastructure tools being developed as part of the NSF's Ocean Observatory Initiative (OOI). MARCOOS has also teamed up with the CaRA to study the mixing processes in the coastal waters offshore Puerto Rico.

- PacIOOS uses gliders to provide input to the Hawaii subsurface ocean model. The glider is the only measure of temperature and salinity below the mixed layer.

- In 2010 AOOS partner University of Alaska Fairbanks flew 69 days of glider missions, covering 800 kilometers to study the dynamics of the polar oceans.

- SCCOOS and CeNCOOS gliders have been used to augment the California Cooperative Oceanic Fisheries Investigations (CalCOFI) and continuously monitor coastal velocity, temperature, salinity and phytoplankton, and measure the influence of El Niño off the California coast.

- Currently the University of Minnesota-Duluth is operating one glider system in Lake Superior with basic equipment leveraged through other sources and an upgraded environmental sensor package supported with GLOS funds.

- NANOOS is incorporating a glider into its new buoy array system launched in 2010 and has experimented with acoustic modems to track fish.

Data Collection Sensors

From 2006 to 2008, regional observing capability decreased by up to 50% in some regions as the federal funding regime changed from Congressionally-directed funding to competitively-awarded grants for the RCOOS network. Moving to competitively awarded cooperative agreements has resulted in more cohesive regional implementation which is more coordinated within each region and more coordinated with the national priorities of the U.S. IOOS Program. While some regional data collection capabilities have not been regained, efforts have been made to increase regional observing capabilities by using existing federal funds and by leveraging local assets. Examples of increased data collection capabilities include:

- PacIOOS deployed water quality systems in Guam, Palau, the Marshall Islands, American Samoa, and the Federated States of Micronesia to collect real-time and near real-time views of coastal and lagoon water properties. Two additional buoys will be deployed in Hawaii and the insular Pacific.

- NANOOS, with the MJ Murdock Charitable Trust, deployed a buoy system off the coast of La Push, Washington which measures meteorological quantities, chlorophyll, turbidity, dissolved oxygen, temperature, salinity, partial pressure carbon dioxide (pCO2) and pH.

- CaRA worked closely with the NWS Weather Forecast Office San Juan and deployed a mesonet (a network of automated weather stations) consisting of eight coastal weather stations in collaboration with WeatherFlow, Inc., and two coastal data buoys off the southern and northern coasts of Puerto Rico.

- SCCOOS and CeNCOOS added sampling capacity with an additional site at Gaviota Pier for capturing harmful algal bloom dynamics.

- NERACOOS added a DeepCWind Consortium buoy measuring wave heights and wind speed, and right whale detection network buoys.

- MACOORA initiated efforts resulting in the June 2010 placement of a new buoy off Long island to provide continuous, real-time offshore ocean conditions.

- GLOS, with funding made available through the Great Lakes Restoration Initiative managed by the EPA, is deploying up to ten near shore moorings to monitor waves, temperature profiles, meteorological parameters, and some chemistry (e.g. photosynthetic chlorophyll).

- GCOOS incorporated real-time data streams from 10 local observing systems into U.S. IOOS by helping programming activities meet DMAC data standards.

- AOOS, in collaboration with the USACE and NWS, will deploy a CDIP buoy, collecting wave height and direction data in lower Cook Inlet in spring 2011.

Sensor Verification and Validation

In total, ACT has conducted 226 instrument performance tests in the laboratory and the field under a wide range of environmental conditions and different deployment applications. The focus in 2009 and 2010 was performing validation tests on *in situ* pCO_2 sensors. The results of these tests, the Performance Demonstration Statements, are available at: www.act-us.info/evaluation_reports.php.

MODELING AND ANALYSIS SUBSYSTEM

The modeling and analysis subsystem is the customer end of the physical infrastructure of U.S. IOOS. It provides the data, data products, and services used by federal and non-federal organizations and agencies, industry, academia, nongovernmental organizations, tribal entities, professional organizations, and the general public. Intermediate users or 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.

The U.S. IOOS community held a Modeling and Analysis Workshop in 2008. This was the second meeting for the interagency Modeling and Analysis Steering Team, comprised of over 50 representatives from U.S. IOOS national and regional modeling and analysis communities. They, along with NSF OOI investigators and various programmatic observers, met to review their collective progress and develop a plan for implementing the prediction and analysis component of U.S. IOOS. During the course of the workshop, it became clear that progress is being made towards prediction of the ocean's physical state at both the national level as well as at the regional level. The stage has also been set for coupling physical predictions to biogeochemical, ecological, and other applications models in the foreseeable future. The complete report from the workshop can be read at: www.iooc.us/about/ocean-us/.

The U.S. IOOS Program, in partnership with the USGS, improved model output interoperability through a focused one year project in 2009. The project addressed the many regional and national providers of oceanographic model data, each having their own unique file conventions, distribution techniques and analysis tools that made it difficult to compare model results and observational data. To solve this problem, a distributed system was built using a customized middleware layer and a common data model. This allowed each model output provider to keep existing model and data files unchanged, yet deliver model data via web services in a common form. With standards-based applications that use these web services, end users have a common way to access data from any of the models. All U.S. IOOS regions and the NOAA National Coastal Data Development Center (NCDDC) implemented this system, allowing common delivery of regional and national oceanographic model forecast and archived results covering all U.S. waters.

In 2010, with funds appropriated in FY2010, U.S. IOOS initiated a project under the Southeastern Universities Research Association (SURA) to evaluate the readiness of marine forecasts along the Atlantic and Gulf of Mexico coasts and improve them for operational use. This project creates an objective environment to compare the latest models for improved forecasting of chronic issues of high relevance in the Atlantic and Gulf regions such as flooding from storm surge and seasonal depletion of oxygen in shallow waters. Through this project, methods will also be explored for effectively delivering model results to regional centers, scientists, and managers relying on U.S. IOOS.

The RAs are also engaged in various modeling activities. One such activity is a pilot project to evaluate and improve circulation models for the Gulf of Mexico. The concept was generated by GCOOS and is based on the needs of several stakeholder communities. The oil and gas industry in the Gulf provided matching funding to the DOE for the $1.56M, two and a half year Gulf of Mexico Pilot Prediction Project. The project goals are to evaluate the many circulation models for the Gulf to determine the best path to an operational circulation model system, to demonstrate the prototype ocean prediction system, and to recommend a transition from research and development (R&D) to the operational system.

GOVERNANCE AND MANAGEMENT

Achieving an effective U.S. IOOS requires a clear governance and management structure in addition to building the physical infrastructure and solving the technical aspects of data and product integration. The *Blueprint* provides a structure for identifying the requisite governance and management to support an efficient and effective U.S. IOOS. By defining the functions and activities needed to reach initial capability, future system governance requirements may be prioritized and addressed. The following functions are currently in place.

Federal Interagency Governance

INTERAGENCY OCEAN OBSERVATION COMMITTEE (IOOC)

As directed by the ICOOS Act, the IOOC was chartered in June 2010 as a federal interagency committee that oversees and coordinates U.S. IOOS development efforts. Under their new charter, the IOOC assumed and is expanding the role of the former Interagency Working Group on Ocean Observations (IWGOO), which was originally established by the JSOST under the previous Administration's Ocean Action Plan. Under the National Ocean Policy established in July 2010, the IOOC will carry out various provisions of the Act for implementing procedural, technical, and scientific requirements to ensure full execution of the system. The IOOC is led by three federal co-chairs and is comprised of representatives from the first 11 federal agency partners listed in chapter 1. The other members of the statutorily mandated NORLC are also eligible to join the IOOC.

SYSTEM ADVISORY COMMITTEE

The ICOOS Act requires the NOAA Administrator to establish a System Advisory Committee to provide additional advice to NOAA and the IOOC on the administration, operation, management, maintenance, expansion, and modernization of U.S. IOOS. This committee will be composed of members appointed by the NOAA Administrator who are qualified by education, training, and experience to evaluate scientific and technical information related to the design, operation, maintenance, or use of U.S. IOOS, or use of data products provided through U.S. IOOS.

Following the steps outlined by the U.S. General Services Administration (GSA) for establishing a Federal Advisory Committee (FAC), an initial charter for the committee has been approved, and a notice was published in the *Federal Register*, announcing establishment of the committee and calling for applications for membership.

MARINE PROTECTED AREA IOOS TASK TEAM

U.S. IOOS also receives input from federal interagency working groups. In 2008, the Marine Protected Area (MPA) FAC determined that building a relationship between U.S. IOOS and the National System of MPAs would be mutually beneficial. The MPA FAC felt the value of enhanced coordination with the information and data linkages of U.S. IOOS to the MPA Center could not be underestimated. In turn, the value of U.S. IOOS would be enhanced greatly by including reference sites (including the National Marine Sanctuary System and the NERRS) provided by an effective National System of MPAs.

In 2010, the MPA IOOS Task Team was formed to recommend priorities for information and data to be gathered, identify key environmental parameters and processes that would be most important to MPA managers, and recommend how climate reference networks could be expanded to include marine sites. The task team is currently moving forward to identify common and existing linkages between U.S. IOOS and the National System of MPAs, in addition to developing short-term and long-term recommendations for expanding and strengthening these linkages.

Regional Governance

U.S. IOOS has a regionally distributed structure to ensure broad coverage of the nation's oceans, coasts, and Great Lakes. In 2006, the First IOOS Development Plan (available at: www.iooc.us/about/ocean-us/) called for an integrated system of observations to support national and regional priorities. Regional priorities were to be determined by a comprehensive effort to engage stakeholders at the local and regional level. The responsibility for this engagement was directed to U.S. IOOS RAs, which were charged with designing and implementing the regional coastal ocean observing system infrastructures that complement and contribute to national observing systems. The eleven RAs were established around the country and are currently addressing stakeholder needs for data and information products.

U.S. IOOS supports all coastal regions in the U.S. including the Great Lakes and the island territories. Prior to 2007, Congressionally-directed funds were allocated to support a collection of regional projects. This created localized observation capability and showed the viability of regional coastal observing systems; however, with limited opportunity for regional or national direction, these investments did not result in a cohesive program. Also, this approach did not provide a consistent means of funding operations and maintenance activities to sustain these capabilities. In 2007, the U.S. IOOS Program centralized these efforts and transitioned to competitively-awarded funds for the development of U.S. IOOS. Today, U.S. IOOS works closely with the NFRA and the RAs to establish core capabilities that meet both national priorities and regional user needs.

RAs represent a partnership of marine and estuarine data providers with users from federal, state, local, and tribal agencies; private industry; non-governmental institutions; and academia that provide a connection to and understanding of regional and local user needs. Regional efforts are intended to determine the appropriate resolution at which variables are measured, supplement the variables measured by federal agencies, provide data and information tailored to the requirements of stakeholders in the region, and implement programs to improve public awareness and education.

RAs are responsible for managing system development within the region and working with stakeholders to prioritize observations, products, and services that are most important, given available resources. Each has an established governance structure guided by a Memorandum of Understanding, Memorandum of Agreement, or non-profit organization guidance to formalize relationships among the many partners involved in the region. See the following table for distribution of board members.

Region	Type of Governance	Distribution of Regional Association Governance Board Membership								Total Number of Board Members
		Government				Non-Government				
		State[1]	Local	Tribal	Federal	Research Institute	Industry	NGO[2]	Foreign (all sectors)	
AOOS	MOU	4			4	7		1		16
CaRA	MOA	3				1	6	2		12
CeNCOOS	MOU	2			2	8		3		15
GCOOS	MOA	2			2	3	5	3		15
GLOS	501C3		1		3	1	4		1*	10
MACOORA	501C3	2			3	8		2		15
NANOOS	MOA	2		2	2	4	3	2		15
NERACOOS	501C3	5			2	6	4	1	2	20
PacIOOS	MOA	5			2	1	3	1	2	14
SCCOOS	MOU				1	7		1	2	11
SECOORA	501C3	2			1	13	6	3		25
ACT						4	1			5

1 includes Sea Grant and territorial governments
2 includes Fishery Management Councils
** "bi-national" International Joint Commission*

Table 1. Regional Association Governance Board Membership

On behalf of U.S. IOOS, the RAs:

- Provide federal agencies with an understanding of the diverse user needs for coastal and ocean observing and identifies regional priorities;
- Bring regional data providers and users together to collectively identify needs and priorities through the development of regional governing boards, and stakeholder and advisory committees, which can lead to the identification of gaps in the system;
- Deliver information products tailored to address national priorities in each region;
- Establish regional data portals for the integration of non-federal data into U.S IOOS;
- Serve as the regional fiscal authority to ensure accountability for revenue streams and other arrangements;
- Manage development and operation of their respective RCOOS in accordance with U.S. IOOS principles;

- Manage RA membership to ensure that the interests of diverse regional data providers and user groups are heard; and
- Solicit information, product, and service requirements from diverse regional stakeholders, and trace the end-to-end linkage from requirements to observations, data, products or services delivered to the stakeholders.

In FY2011, NOAA will continue to enhance the RA and RCOOS system through the establishment of new 5-year, multi-year cooperative agreements with regional partners. U.S. IOOS anticipates receiving proposals from the 11 RAs, among others, in response to the FY2011 Federal Funding Opportunity (FFO). RAs are required to play a strong governance role in support of U.S. IOOS, which includes planning for the continued development and operation of the regional observing system, as well as mechanisms to address evolving stakeholder requirements and regional and national priorities. RAs are evaluated based on performance metrics developed by NOAA in coordination with the NFRA.

Research and Development

The R&D subsystem is comprised of the functions and activities required to gather requirements for R&D, analyze and prioritize those requirements, and facilitate cooperation among partners with R&D capabilities to satisfy identified requirements. The U.S. IOOS Program does not anticipate directly running R&D laboratories or facilities, but will engage such institutions to act as its agents to perform designated R&D activities that will benefit the system. U.S. IOOS has engaged the OOI, supported by the NSF Division of Ocean Science, as a research agent of U.S. IOOS. U.S. IOOS will also actively seek and employ the results of independent R&D activities that have direct benefit to the system.

The NSF's OOI, driven by the needs of the research community, will construct a networked infrastructure of sensor systems to measure physical, chemical, geological and biological variables in the ocean. It is designed to understand and predict diverse ocean processes, ranging from climate change to coastal ecosystems to seafloor dynamics. OOI will provide infrastructure to enable hypothesis-driven basic research by fostering specialized observations, instruments, and activities to answer research questions. Data will be available as close to real-time as possible. Although the primary motivation behind U.S. IOOS and OOI efforts differs, both recognize there are critical areas where the two efforts come together and create powerful synergies. Current U.S. IOOS and OOI collaboration is enabling development and use of new tools to improve access to and use of ocean observations. The OOI project will also employ an ensemble of new sensor technologies and analytical techniques that will eventually become operational components of the U.S. IOOS enterprise. Additional information about the OOI project can be found at: www.oceanleadership.org/programs-and-partnerships/ocean-observing/ooi/.

Additionally, the RAs play a role in R&D by identifying the needs for R&D to meet user needs, acting as a pathway to the transfer of technology from research to operations, and through conducting specific R&D projects.

TRAINING AND EDUCATION

The focus of the training and education subsystem is to deliver products, information, and data useful to educators and trainers who use U.S. IOOS information to achieve their education and training objectives. This subsystem also creates the workforce needed to develop and sustain U.S. IOOS and produce its information products, services, and tools.

National Education Activities

National level education efforts include the U.S. IOOS partnership with NOAA's Chesapeake Bay Office on the second workshop demonstrating the use of Autonomous Underwater Vehicles (AUVs) to fill data gaps between static observation buoys. The Bay and Estuarine Sensor Technology workshop, held in July 2010, involved federal and academic scientists; and buoy, sensor, and vehicle industry representatives. A major component of this workshop involved secondary students, their teachers, and a group of Boy Scouts working side-by-side with the AUV professionals. The student group also spent time building buoys and Remotely Operated Vehicles (using Aquabotz ™). Aquabotz is a program that gives students an opportunity to design, build and launch working underwater robots in about an hour.

Another national level education effort involved the Atlantic crossing of the glider, Scarlet Knight, as mentioned in the Observing Subsystem section. The Scarlet Knight achievement was highlighted at the national level through the participation of the White House Office of Science and Technology at the recovery ceremony and by participation of the lead scientists and students during the 'Scientist is In' program at the Smithsonian National Museum Natural History for World Ocean Day in June 2010. In December 2010, an exhibit highlighting the Scarlet Knight mission opened at the Smithsonian National Museum of Natural History within the Sant Ocean Hall. The exhibit highlights the glider's mission as it relates to climate change understanding and is viewed by as many as 8 million visitors per year.

Regional Education Activities

Several recent U.S. IOOS educational activities have been led by the RAs, with collaborative efforts coordinated by the NFRA Education and Outreach Committee (EOC). In 2010, the EOC submitted a proposal for a NOAA Environmental Literacy Grant to educate citizens about how the state of the oceans and coasts varies across time and space, focusing on two components of climate change, sea level change and ocean acidification, and incorporating comprehensive data sets to communicate information. Although the proposal was not selected for funding, it is noteworthy as it involved all 11 RAs, indicating the maturation of the RAs as a networked system.

Other regional efforts include SECOORA partnering with several universities and the Centers for Ocean Sciences Education Excellence (COSEE) Southeast, on the Basic Observation Buoy (BOB) project, a student driven coastal monitoring project that gives high school and college students hands-on research using observing technology. BOB is a student assembled buoy that serves as a platform for a simple data logger and sensors that monitor various water quality parameters. The third BOB workshop convened in 2010 at Jacksonville University, Florida. Participants included academics, industry, and federal agency and regional representation.

Each of the RAs has education and training activities specific to their regions. A sampling of these are:

- CeNCOOS, SCCOOS – partnered with the COSEE Networked Ocean World to create a podcast that documents how different people use California's Ocean Observing Systems.

- GCOOS – developed education kiosks for five of the Coastal America Learning Center-designated aquariums and marine education centers along the Gulf Coast.

- GLOS – held workshops that provided a hands-on approach to introducing data integration concepts and mapping products to those working to protect and manage the Great Lakes. Participants were taught how to integrate maps and data "on-the-fly" and develop decision-making tools.

- PacIOOS – created a climate change unit for the Navigating Change Curriculum Program, a program that combines scientific, cultural, and stewardship principles into a hands-on course. The PacIOOS unit includes lesson plans, handouts, activities, and video to address both sea level rise and ocean temperature and coral health.

- A number of RAs have compiled theme pages to explain issues in their regions. For example, NANOOS has a theme page on Ocean Acidification.

- A number of RAs have developed lesson plans and are linking their real-time data to those lesson plans.

The *Blueprint* defines additional functions and activities that will need to be developed in order to advance current and build future training and education capacity for U.S. IOOS.

Chapter 3
System Assessments

The ICOOS Act calls for an external independent programmatic audit of the System. While progress has been made in establishing the infrastructure for U.S. IOOS both programmatically and technically, it is a complex system that will take multiple years to fully implement. As such, it has not reached the maturity or functionality that would make an independent program assessment beneficial at this time.

U.S. IOOS, however, is fully committed to providing an unbiased evaluation of progress and capabilities, and therefore is currently undertaking two mandated reviews: 1) an assessment of U.S. IOOS observation coverage; and 2) independent cost estimate of operations and maintenance of existing Federal assets of the System, and planned or anticipated acquisition, operation, and maintenance of new Federal assets for the System.

Assessment of Capabilities

Upon formal acceptance of the *Blueprint*, the U.S. IOOS Program began an assessment to determine how much IOOS capability already exists among U.S. IOOS partners. These analyses will support satisfaction of the ICOOS Act requirements regarding identification of gaps in observation coverage, as well as serve to evaluate the performance and effectiveness of the RAs.

The desired functionality described in the *Blueprint* is used as the basis for the assessment. Specifically, partners will provide information on what they are already doing, or plan to do, relative to *Blueprint* activities. Given the geographic diversity of U.S. IOOS partners, an assessment tool was developed in Fall 2010 and hosted online, where U.S. IOOS partner inputs can be recorded and analyzed.

In addition to the online assessment tool, U.S. IOOS assessment team members will contact each individual partner to ensure all requested information was gathered and to provide an opportunity for partners to provide any additional relevant information.

Also, the U.S. IOOS Program conducted an in-house assessment of its current capabilities. The results of the U.S. IOOS Program assessment will be combined with the results of the partner assessments to determine the composite capabilities of U.S. IOOS based on all contributions to the System.

Once all the data are gathered, they will be compiled and compared to the desired functionality called for in the *Blueprint* to determine what remains to be accomplished to achieve full U.S. IOOS capability. Armed with this information, planning will commence to address how the unfulfilled requirements of U.S. IOOS can be attained.

Presently, the assessment of the USACE is underway as a test to ensure the assessment tool meets all its design requirements. Upon successful completion of this pilot test, the full assessment of U.S. IOOS partner capabilities will commence. The timeframe for completion of the assessment will be a function of the ability to engage all U.S. IOOS partners, but initial results are expected to be gathered and analyzed during calendar year 2011.

Subsequent to the assessment and identifying system gaps, U.S. IOOS will be better able to prioritize activities based on available resources. U.S. IOOS resource scenarios may also be constructed based on this gap analysis for future near-, mid- and long-term system modifications, allowing for a comprehensive review of initiated and planned procurements.

COST ESTIMATES

The IOOC is committed to supporting an independent cost estimate in order to establish realistic goals and timelines for developing U.S. IOOS.

The activities to be included are those performed as part of the national system of U.S. IOOS and of the U.S. IOOS Program (defined in the ICOOS Act as the integrated ocean observing program office in NOAA). These activities, listed in the *Blueprint*, will define what elements to include in the cost estimate.

The cost estimate will be developed for the following three U.S. IOOS components:

- <u>Federal assets</u>. The cost estimate will include the contributions of IOOC members. The federal agencies or IOOC members will provide the input for their systems for this component of the estimate, to include:
    - operations & maintenance (O&M) of existing assets of the system
    - planned or anticipated 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

- Central system. The cost estimate will include functions necessary to develop, manage and operate a national integrated ocean observing system, as described in the *Blueprint*. The estimate will be provided by an independent entity commissioned by the IOOC.

- Non-federal assets. Although not required by the ICOOS Act, cost estimates will consider the assets of the 12 non-federal entities with an existing U.S. IOOS relationship—the 11 regional components and the ACT. All 12 are candidates for inclusion in the system in accordance with the ICOOS Act, pending certification.

Chapter 4
Planned Improvements for the System

A major achievement of U.S. IOOS in 2010 was the finalization and approval of the *Blueprint*. This document guides the on-going efforts of all U.S. IOOS partners, providing the strategic framework for conceptual, organizational, planning, and developmental efforts. Following the *Blueprint*, U.S. IOOS will continue its progress with the planned improvements described below.

PLANS TO ENHANCE THE GLOBAL COMPONENT

Enhancement of the U.S. IOOS global component will continue by building and sustaining a global ocean and climate observing system to respond to long term observational requirements of forecast centers, international research programs, and major scientific assessments. The focus is on building the *in situ* ocean component while sustaining the required satellite observations. The NOAA's Climate Observation Division's objectives are to document:

- Long term trends in sea level change
- Ocean carbon sources and sinks
- Ocean's storage and global transport of heat and fresh water
- Ocean-atmosphere exchange of heat and fresh water

Though NOAA's climate mission is the primary driver for implementation, many non-climate users depend on the system, as it also supports weather prediction, global and coastal ocean prediction, marine hazard warning systems (e.g., tsunami warning), transportation, marine environment and ecosystem monitoring, and naval applications.

NOAA presently contributes nearly half of the total international effort. The intended outcome of the implementation plan is a sustained global system of complementary *in situ*, satellite, data, and modeling subsystems adequate to accurately document the state of the ocean and to force climate models.

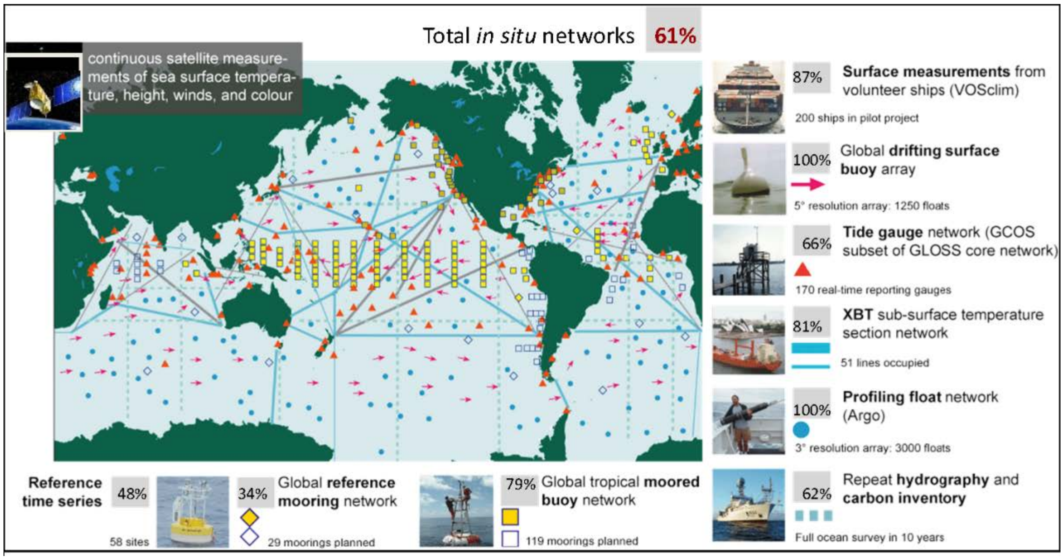

Figure 3. Initial Global Ocean Observing System for Climate

Figure 3 shows a schematic of the initial composite ocean observing system. It includes the current status against the targets of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) and the GCOS Implementation Plan, maintained by the international GOOS Project Office.

Plans to Enhance the DMAC System

As the foundation for integrating data, the DMAC system remains a priority for U.S. IOOS, and near-term plans include building on the progress federal and regional IOOS partners have already made. Leveraging the success of the DIF pilot project, data services will be retained and enhanced with previous limitations on the scope no longer applying—that is, the effort is broadening to include more data providers, customers, variables and additional components of the DMAC subsystem.

Data Provider Implementations

The three data providers involved in the DIF pilot project (NDBC, CW, CO-OPS) were all federal centers of data within NOAA that provided IOOS DAC functions. Future plans include coordinating with other federal agencies to increase availability of standardized data. Two of the projects already underway include coordination with USACE and USGS to standardize or interoperate with their data management practices. Both the USACE Mobile District and the USGS have collaborative projects with U.S. IOOS to establish a Sensor Observation Service (SOS) to provide interoperable water level data.

The U.S. IOOS RAs were not originally included in the scope of DIF, but the DIF activity served as a catalyst to guide them in implementing standard methods of serving their data. As a result, there is now more uniformity of services and data formats across the RAs.

Data Source Enhancements

Another planned enhancement is the addition of data from moving platforms such as gliders or Volunteer Observing Ships, where sampling is along a trajectory rather than a single point or profile. Gliders, in particular, were found to be very important in observing the Deepwater Horizon oil spill in the Gulf of Mexico. The NDBC SOS is now beginning to provide such data.

All data considered so far have been sensor measurements of physical properties. To enhance system capabilities in the biological realm, a biological data project was initiated in 2010 to provide fisheries-independent survey data in a manner compatible with U.S. IOOS physical observations. Towed-diver surveys of species abundance in the Hawaiian Islands region will be the first focus of this project.

Archives have yet to be handled explicitly as a data source, only as a data sink. One can think of an archive as a customer that wishes to obtain all of the data and store it forever. Many of the federal observations, but not all of the regional observations and model outputs, are provided to the National Oceanographic Data Center (NODC) for permanent storage. As with all other IOOS-type data, the methods are provider-dependent and at times ad hoc, once again resulting in non-standardized data. U.S. IOOS has begun discussions to standardize the regular transfer of data and metadata from NDBC to NODC using U.S. IOOS services. U.S. IOOS is planning to ensure that in the future, all IOOS-related observations and model outputs are archived, and to standardize interfaces for getting data into or out of the archives.

IOOS Data Catalog and Service Registry

An important next step in the evolution of DMAC is the continuing development of a catalog of available U.S. IOOS data and a functional registry for DMAC-certified web services that enable access to observations data. The U.S. IOOS program established the first version of the IOOS Data Catalog in June 2010 to provide users a single location where they can search for and retrieve data. The goal is to maximize the availability of data by allowing users to find the data they want, for the location and time period of interest, from all available U.S. IOOS partners without having to know in advance what partners actually operate the observing systems and data servers.

While the IOOS Catalog provides integrated data discovery, it does not yet provide integrated data. In other words, it is possible to find data for the desired time period and location from multiple data providers at once, but it is not yet possible to make a single request that obtains data from multiple providers and returns a single bundle to the user. U.S. IOOS will begin establishing such a capability by the end of calendar year 2011.

The IOOS Catalog was constructed to be intuitive, employing recognizable and user-friendly conventions for enhancing the U.S. IOOS data user experience. A map shows dots representing *in situ* sensors and rectangles indicating areas for gridded datasets. Clicking on a sensor or grid boundary in the catalog pops up a balloon with basic metadata about the dataset and provides links to obtain additional metadata or data values. The user may choose particular variables, such as time periods, regions, and data providers.

The catalog is web-based, accessible at www.ioos.gov/catalog/.

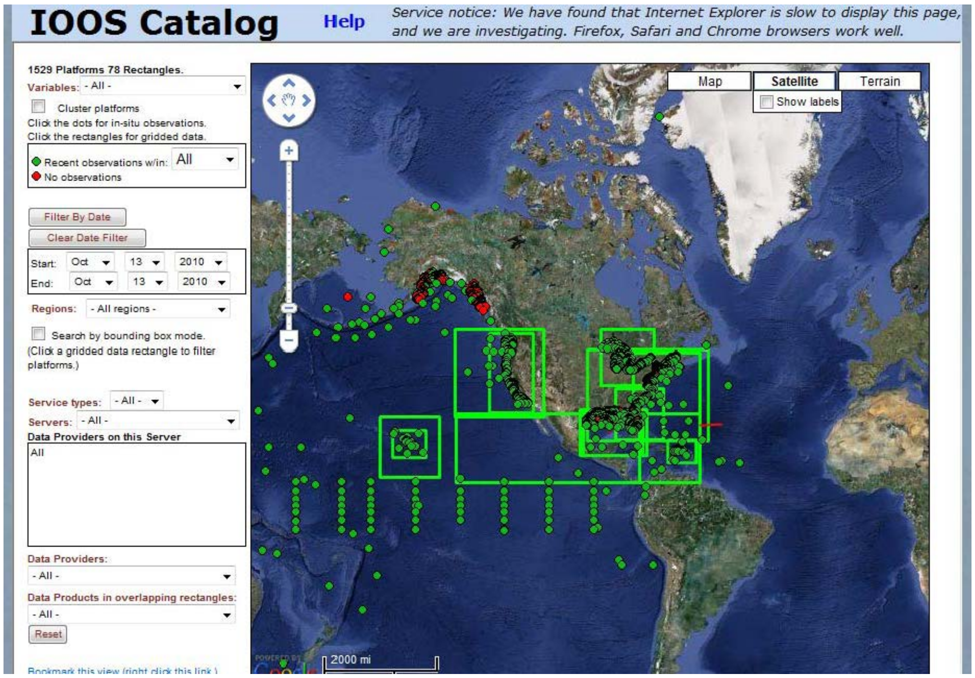

Figure 4. IOOS Data Catalog Webpage

Data holdings are now searchable from NOAA's NDBC, CO-OPS, and CW, as well as three regional partners of U.S. IOOS. Other regional and interagency U.S. IOOS partner data are gradually being added. The U.S. IOOS Program is in the process of defining system metrics to automatically capture the number of added capabilities.

REGIONAL PLANS FOR U.S. IOOS

Through a FY2011 FFO, U.S. IOOS partner agencies seek to continue the implementation and development of the regional component of U.S. IOOS. On behalf of the National Oceanographic Partnership Program (NOPP), NOAA and several of its partner agencies, including NASA, ONR and DOE, requested proposals for coordinated regional efforts that further improve U.S. IOOS. In addition, the agencies have identified several related topic areas for which they are requesting proposals, including verification and validation of observing technologies for studying and monitoring coastal and ocean environments; improved and routine production, stewardship, and coastal application of the Group for High Resolution Sea Surface Temperature data; and study of marine animal interactions with offshore renewable energy devices.

The FFO builds upon progress made to date on the development of regional coastal ocean observing systems, continuation of a national-scale effort for verification and validation of observing technologies, increased use of community standards and best practices for data management and interoperability, and improved sustained generation and long-term stewardship of sea surface temperature data and their application within U.S. IOOS.

The 11 RAs have also defined high priority observing needs within each of the U.S. IOOS regions. To continue planning and improving the system, RAs held workshops during their 2009 meeting to quantify the regional contribution to the national system. The regions are uniquely positioned to provide the information needed to address five broad themes identified by users and stakeholders throughout the nation:

- Marine Operations
- Climate Variability and Change
- Ecosystems, Fisheries and Water Quality
- Coastal Hazards
- Coastal and Marine Spatial Planning

Within the context of these five themes, the RAs are developing long-term plans to establish regional data information centers; deliver regional scale observations of climate variables; support regional modeling capacity to predict and forecast future conditions; provide the nation with new observing, modeling, and visualization technologies; and provide multi-purpose observing platforms.[3]

[3] National Federation of Regional Associations for Coastal and Ocean Observing Report: Providing Coastal Information in a Changing Climate, March 2010; www.usnfra.org/documents/03.10_RCBooklet_lo-res.pdf

Chapter 5
Benefits of U.S. IOOS

While the foundation for U.S. IOOS is still being laid, initial projects are already demonstrating the value of integrating data from varied sources and using them to inform decision making. The following sampling details just some of the ways in which the nation is reaping benefits from the coordinated efforts of national, regional, and local ocean observing partners.

DEEPWATER HORIZON OIL SPILL

The most visible and nationally recognizable benefit of U.S. IOOS was the response to the April 2010 Deepwater Horizon oil spill in the Gulf of Mexico. The U.S. IOOS response was two-tiered: immediate access to non-federal data in the region impacted by the spill, and a project that tracked surface and subsurface oil.

First, GCOOS integrated non-federal observing resources, such as data on currents, into a system that provided routine, reliable, high-quality observations in real time for rapid dissemination to decision-makers for use in models, analyses, and monitoring. These resources had been deployed by GCOOS partners to meet their own data requirements and since the data were already in the U.S. IOOS data stream, no effort had to be made by the oil spill responders to find these data sets. When this national emergency struck, U.S. IOOS was ready with interoperable assets immediately.

Second, with the unprecedented threat to the waters and coastal regions of the Gulf of Mexico, the U.S. IOOS community came together to initiate an immediate deployment of additional assets to capture data to assist in the tracking of oil flows at various levels in the water column and on the surface. U.S. IOOS partners, including GCOOS-RA, SECOORA, MACOORA, NERACOOS, SCCOOS, NANOOS and the U.S. Navy, all participated in the coordinated effort to provide decision makers with near real time information in an integrated manner. Aircraft Expendable Profilers of temperature, current, and conductivity were deployed from NOAA aircraft. The current and conductivity profilers were purchased by BOEMRE for the deployments. These data provided valuable information on the internal temperature, density and current structure over most of the Eastern Gulf of Mexico, and were critical to the improvements of the U.S. Navy ocean model to accurately estimate the oil spill pathways.

In addition to the basic oceanographic observations, gliders were equipped with fluorometers and used in a sentinel mode to help determine the extent of any concentrated oil in the sub-surface environment. The cost-effectiveness of this technology was also demonstrated with the capture of data at over 40,000 observation locations for a fraction of the cost of deploying similar instruments from research vessels.

Up to seven gliders at one time collected data to help indicate the presence of oil in the water. They collected temperature, salinity, currents, density and additional variables that described conditions below the surface. Some gliders operated no deeper than 100 to 200 meters, while others collected data 1,000 meters below the surface. This was the first oil spill response in the U.S. to apply this technology.

NOAA and the U.S. Navy used the three-dimensional variables provided through U.S. IOOS to update daily models to predict where the oil was moving and provide insights into how it may move through the water column. In keeping with the mission of U.S. IOOS to maximize access to data and generation of information products, all data and information from the gliders is available on a single website portal operated by U.S. IOOS partner Rutgers University Coastal Ocean Observation Lab, located at rucool.marine.rutgers.edu/deepwater.

U.S. IOOS also coordinated and employed HFR technology to measure surface current speed and direction in near real time. This information was incorporated into daily oil spill trajectory forecasts by NOAA's Office of Response and Restoration (ORR). Managers and officials in coastal communities used this information to better prepare by focusing efforts where it was clear oil would come ashore.

Private sector ocean observing contributions were also made during the spill response. Response teams deployed high-endurance wave gliders to provide observations in the central Gulf of Mexico. The resulting data were incorporated into U.S. IOOS (via NDBC) using established data management protocols, such as web services.

The U.S. IOOS community played a pivotal role in further engaging the academic community during the response efforts with several ocean models from university partners in Gulf states providing key inputs to the ORR daily forecasts of oil trajectories. Members of U.S. IOOS contributed directly to the planning, implementation, and management of sub-surface mission guidance, sample location selection, and techniques. In addition, the existing ties between U.S. IOOS and the research community allowed for the broad dissemination of information about the spill response activities.

U.S. IOOS-compliant data management protocols (e.g., web services and other access tools) are being used to relay ocean observing information from the response to the public and academic sectors. These efficient data feeds minimize user effort and allow for effective machine-to-machine processing, saving both time and resources.

Search and Rescue Operations

For effective and timely search and rescue operations, the USCG requires specific information on winds, currents, and a host of other variables to determine the location and size of a search area. U.S. IOOS, through NOAA, provides environmental data to the Search and Rescue Optimal Planning System (SAROPS). The USCG estimates that search areas can be reduced by as much as two-thirds after a 96 hour period when the SAROPS system is linked to the U.S. IOOS surface current monitoring data, thereby leading to greater number of lives saved and significantly reducing search costs.

Storm Surge Display Program Improved

The National Hurricane Center (NHC) runs a computerized model, the Sea, Lake, and Overland Surges from Hurricanes (SLOSH), to predict storm surge. Using a complex set of variables and modeling techniques, it allows the NWS to provide emergency managers with the potential surge for an area, assisting them in preparedness and evacuation planning. Forecasters and emergency managers have the ability to interface with SLOSH model simulations and output through the SLOSH Display Program.

Through a U.S. IOOS customer project within NOAA, real-time water level and wind data were incorporated into the SLOSH Display Program. As of the 2010 hurricane season, forecasters now have access to time series graphs of NOAA CO-OPS water level observations, predictions, and winds, as well as NDBC winds, and are able to display these along with surge information from the SLOSH model. In addition, improvements provide additional Geographic Information System capabilities and options for displaying roads, populated areas and city boundaries to assist the NWS's NHC to make better use of the SLOSH Display Program for media briefings. The CO-OPS produced two new water level reference points, highest astronomical tide and lowest astronomical tide, to assist forecasters and emergency managers with their warnings to the public.

Water Quality Monitoring Network

The National Water Quality Monitoring Network (NWQMN) provides information about the health of our oceans and coastal ecosystems, as well as inland influences on coastal waters for improved resource management. U.S. IOOS partners, EPA, USGS, and NOAA, co-lead this effort with participation from other federal agencies. Each year, government agencies, industry, academia, and private organizations devote significant time, energy, and money to monitor, protect, manage, and restore water resources and watersheds. However, differences in project design, methods, data analysis, and data management have often made it difficult for monitoring information and results to be shared and used by all. The restoration and protection of water quality is dependent upon detailed, understandable, and easily accessible data and information, which will be provided through the full implementation of U.S. IOOS.

Since 2007, the NWQMN has piloted and implemented concepts in San Francisco Bay, the Delaware River Estuary, and the Great Lakes in coordination with the CeNCOOS, MACOORA and GLOS regional associations. The projects have demonstrated the added value of real-time monitoring with sensors and autonomous underwater vehicles alongside more traditional monitoring.

Additional examples of regional water monitoring by U.S. IOOS partners include:

- SECOORA, the University of South Carolina, University of Maryland, South Carolina Department of Health and Environmental Control, and Raytheon Corporation developed an assessment tool, which has resulted in improved accuracy and timeliness of swimming beach and shellfish bed closure forecasts.

- NERACOOS, the University of New Hampshire, and the New Hampshire Department of Environmental Services demonstrated an integrated approach in their use of data from multiple observation platforms in research in New Hampshire's Great Bay that resulted in development of eelgrass based nutrient criteria.

- In MACOORA, the USGS and the Delaware River Basin Commission demonstrated the combined use of different types of water quality monitoring data to characterize the spatial and temporal distributions of dissolved oxygen and nutrient concentrations in the Delaware River Estuary. The long-term data sets have revealed improvements in the dissolved oxygen concentrations in the estuary following wastewater treatment facility upgrades.

San Francisco Bar Forecast

The ocean entrance to San Francisco Bay hides an underwater horseshoe-shaped sandbar that straddles the entrance, curving approximately five miles out to sea and back. When waves in deeper water reach this sandbar, treacherous breakers can form that present a significant hazard to any vessel entering or departing the Golden Gate. CeNCOOS and SCCOOS pulled together a team of maritime operators in SF Bay, including the SF Bar Pilots and the U.S. Coast Guard to coordinate the purchase and deployment of a Datawell Waverider buoy for improved real-time and forecasted wave information. Datawell Waverider buoys were identified in the 2008 National Operational Wave Observation Plan and are operated by CDIP in collaboration with California's two Ocean Observing

Systems, using resources provided by the USACE and the California Department of Boating and Waterways.

Key data from this San Francisco Bar buoy are used to inform the "Bar Forecast" provided by the NWS Weather Forecast Office in Monterey. Since the start of this forecast, the number of Coast Guard rescue incidents in this area has dramatically decreased each year. This success story exemplifies the regional to national partnership of U.S. IOOS as local and regional funding, expertise, and operations are leveraged to provide better data and information to support local user needs while supporting national mission needs.

Partnership with Shellfish Growers

An example of a direct benefit to the economic well-being of our nation is evident in the U.S. IOOS partnership with shellfish growers in the Pacific Northwest. NANOOS has partnered with the NERRS to offer real-time water quality data to shellfish growers located near selected monitoring sites in Oregon, Washington, and Alaska. The water quality data are delivered to shellfish growers via websites linked to time-series graphs. They can also download raw water quality data and view real-time weather data for most of the sites. In central California, CenCOOS has designed a web page for shellfish growers in Humboldt Bay which provides three site-specific data feeds as well as an upwelling index (http://cencoos.humboldt.edu/?content=data_oyster_main). Oyster growers successfully use it to make real-time operational decisions for their industry.

In July 2010, U.S. IOOS representatives participated in a workshop between oyster growers; scientists; and federal, state, and industry representatives to frame the problems, assess what information is available, and determine what is needed to understand the effects of ocean acidification on shellfish. One workshop recommendation was to integrate existing ocean acidification data streams with U.S. IOOS, creating a single point of entry for data sets and information relevant to the West Coast fish and shellfish community. The workshop report can be found at: ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/624_OA_ShellfishProceedings.pdf.

Although less than a year old, the mutual benefit of the U.S. IOOS-shellfish grower partnership is already clear. Shellfish growers can access regional and local information to help detect water conditions that can make or break their business. Direct feedback from one grower extols the benefits of being able to monitor pCO_2 levels in coastal waters—knowing when the water quality is appropriate for shellfish larvae has made a huge positive impact on production. U.S. IOOS also benefits by having a clear relationship with customers at the coast, providing them a partner to consult to ensure the program remains relevant and useful.

ARCTIC RESEARCH ASSETS

With the increase in scientific research and monitoring in the Arctic, AOOS launched the Arctic Research Assets Map (ARAM), a web-based, interactive tool (http://data.aoos.org/maps/arctic_assets.php) that gives resource managers and community members a visual inventory of where oceanographic data are being gathered during the open water field season. ARAM will assist with region-wide planning, research logistics, public education and outreach, and support for other collaborations. Accessible through the AOOS website, the map features locations and metadata for moorings, buoys, AUVs and ship transects, and other instrumentation in Arctic waters. The map can be queried by time period, parameters being measured, or owner of the asset. As development of ARAM continues, links to actual data, including real-time data, will be provided.

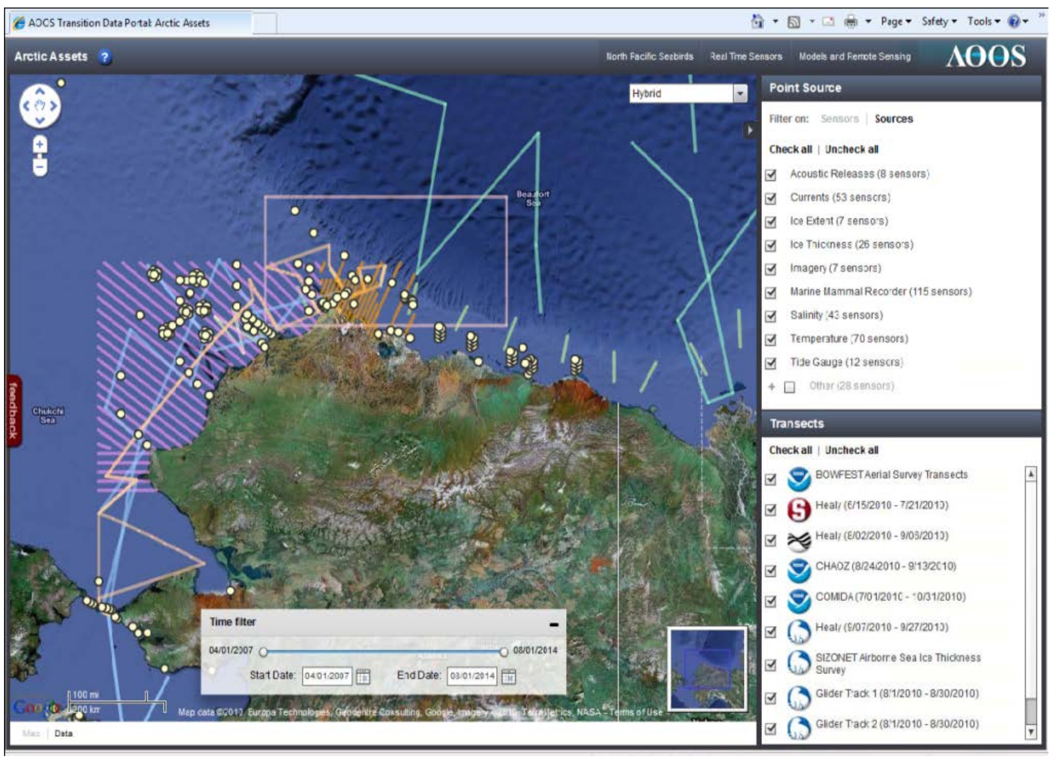

Figure 5. Arctic Research Assets Map (ARAM) Webpage

Conclusion

The vision of an integrated ocean observing system, capable of linking the vast network of disparate, federal and non-federal ocean observing systems to produce a cohesive suite of data and information, is being realized through the efforts of U.S. IOOS. While full implementation is a multi-year effort, initial successes reported herein are laying the foundation for moving ahead with plans outlined in the newly produced *Blueprint*.

Using a logical, structured approach as directed by the *Blueprint*, U.S. IOOS is leading the efforts to build on current observing capabilities with an initial focus on data integration, interoperability issues, and certification guidelines. With oversight from the IOOC, the program is well-positioned to address technical and programmatic challenges as they arise.

Fully implementing U.S. IOOS will take the combined efforts of all of the federal agencies in partnership with the non-federal entities. While the roles vary greatly, each partner shares a piece of the ocean observing community and all are needed to form a cohesive, functional U.S. IOOS. Reaching out to partners, both current and future, remains an essential component of U.S. IOOS execution and will be further advanced with the planned FY2011 comprehensive U.S. partner assessment.

The value of an integrated approach to ocean observing is already evident based on early success stories, with more to come as the program matures. The future of U.S. IOOS lies in the continuing efforts of its partners to collaboratively provide integrated data and information to its users, helping them make more informed decisions that produce economic, societal, and environmental benefits for the Nation.

Appendix A
Acronyms

ACT	Alliance for Coastal Technologies
AOOS	Alaska Ocean Observing System
ARAM	Arctic Research Assets Map
AUV	Autonomous Underwater Vehicle
BOB	Basic Observation Buoy
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CaRA	Caribbean Regional Association for Ocean Observing
CeNCOOS	Central and Northern California Ocean Observing System
C-MAN	Coastal-Marine Automated Network
CDIP	Coastal Data Information Program
CO-OPS	Center for Operational Oceanographic Products and Services
COSEE	Centers for Ocean Sciences Education Excellence
CSREES	Cooperative State Research, Education, and Extension Service
CW	CoastWatch
DAC	Data Assembly Center
DIF	Data Integration Framework
DMAC	Data Management and Communications
DOE	Department of Energy
DOS	Department of State
DOT	Department of Transportation
EOC	Education and Outreach Committee
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FAC	Federal Advisory Committee
FFO	Federal Funding Opportunity
GCOOS	Gulf of Mexico Coastal Ocean Observing System
GCOS	Global Climate Observation System
GEOSS	Global Earth Observation System of Systems

GGOS	Global Geodetic Observing System
GLOS	Great Lakes Observing System
GOOS	Global Ocean Observing System
GSA	General Services Administration
HAB-FS	Harmful Algal Blooms-Forecast System
HFR	High Frequency Radar
ICOOS	Integrated Coastal and Ocean Observing System
IOOC	Interagency Ocean Observation Committee
IOOS®	Integrated Ocean Observing System
IWGOO	Interagency Working Group on Ocean Observations
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
JCS	Joint Chiefs of Staff
JSOST	Joint Subcommittee on Ocean Science and Technology
MACOORA	Mid-Atlantic Coastal Ocean Observing Regional Association
MARCOOS	Mid-Atlantic Regional Coastal Ocean Observing System
MMC	Marine Mammal Commission
MPA	Marine Protected Area
NANOOS	Northwest Association of Networked Ocean Observing Systems
NASA	National Aeronautics and Space Administration
NCDDC	National Coastal Data Development Center
NCEP	National Center for Environmental Prediction
NCOP	National Currents Observation Program
NDBC	National Data Buoy Center
NERACOOS	Northeastern Regional Association of Coastal Ocean Observing Systems
NERRS	National Estuarine Research Reserve System
NFRA	National Federation of Regional Associations
NGO	nongovernmental organization
NGS	National Geodetic Survey
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOPP	National Oceanographic Partnership Program

NORLC	National Ocean Research Leadership Council
NOS	National Ocean Service
NSF	National Science Foundation
NWLON	National Water Level Observation Network
NWLP	National Water Level Program
NWQMN	National Water Quality Monitoring Network
NWS	National Weather Service
O&M	operations and maintenance
ONR	Office of Naval Research
OOI	Ocean Observatories Initiative
PacIOOS	Pacific Islands Ocean Observing System
pCO_2	partial pressure carbon dioxide
PORTS®	Physical Oceanographic Real Time System
R&D	research and development
RA	Regional Association
RCOOS	Regional Coastal Ocean Observing System
RICE	Regional Information Coordination Entity
SAR	Search and Rescue
SAROPS	Search and Rescue Optimal Planning System
SCCOOS	Southern California Coastal Ocean Observing System
SECOORA	Southeast Coastal Ocean Observing Regional Association
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
SOS	Sensor Observation Service
SURA	Southeastern Universities Research Association
USACE	US Army Corps of Engineers
USARC	US Arctic Research Commission
USCG	US Coast Guard
USGS	US Geological Survey

Appendix B
ICOOS Act Implementation Report

The U.S. IOOS Program developed a web-based tool to provide a transparent mechanism for sharing information about how the community is implementing the ICOOS Act of 2009. This online progress report is available to the public on the U.S. IOOS website (www.ioos.gov) and includes a color-coded rating system characterizing the status of the required tasks included in the ICOOS Act. The ICOOS Act assigns these tasks to different entities, including the interagency-led IOOC, NOAA as the lead federal agency, and external partners, including the RAs, identified as RICEs. These groups are identified in the progress report and the tasks that are assigned to them in the ICOOS Act are defined in more detail through indicated web links. The progress report will be updated periodically to ensure the information presented is up to date and a current reflection of efforts made to build a sustainable, robust U.S. IOOS.

ICOOS Act Governance and Required Activities	Council	Committee	Lead Federal Agency	RICEs	Federal Agencies
Establish a National Integrated Coastal and Ocean Observation System	● (gray)				
Develop and publish a Public Private Use policy	● (gray)				
Develop and transmit annual budgets and long term plans (pdf, Nov 2010)	● (gray)	● (green)			
Establish observation data variables (pdf, Nov 2010)		● (green)			
Develop certification standards, compliance procedures and program guidelines (pdf, Mar 2011)		● (green)	● (green)		
Establish process and observation coverage gaps or capital improvement needs (pdf, Nov 2010)		● (green)	● (green)	● (green)	
Obtain independent cost estimate (pdf, Nov 2010)		● (yellow)	● (yellow)		● (yellow)
Establish an IOOS Program Office within NOAA (pdf, Sept 2010)			● (green)		
Review and evaluate non-federal assets(pdf, Mar 2011)			● (green)		
Implement a merit-based competitive funding process to support non-federal assets (pdf, Mar 2011)			✓		
Establish protocols for and develop a data management and communication system (pdf, Mar 2011)		● (green)	● (green)		
Implement a public education and outreach program (pdf, Mar 2011)			● (green)		
Establish a system advisory committee (pdf, Mar 2011)			● (green)		
Respond to reporting requirements (pdf, Mar 2011)			● (green)		
Demonstrate capable organizational structure and operate under a strategic operational plan				● (gray)	
Additional Required Activities (10 items)	Click here for further details				

Online progress report image from the IOOS webpage