The way forward on

IOOS

By Zdenka Willis, Director, NOAA IOOS Program
&
Kim Cohen, Management Analyst, NOAA IOOS Program

The U.S. Integrated Ocean Observing System (IOOS) will be a sustained network of "eyes" on buoys, ships, satellites, underwater vehicles, in-situ sensors and other platforms that routinely supply data and information needed to detect and predict changes in our nation's coasts, oceans, and Great Lakes. IOOS is intended to be a major shift in approach to ocean observing, 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, IOOS is expected to advance beyond its current science and management applications toward an instrument of policy and governance. Current efforts only scratch the surface of what we need to know about our oceans and coasts to fully assess their impact on commerce and transportation, weather and climate, and ecosystems.

Ocean observing data are required to support a wide range of critical decisions, including evacuations, beach and shellfish closures, fisheries catch limits, and the identification of safe and efficient shipping routes to transport the products we rely on each day. The impact of these daily decisions on the U.S. economy is significant, as the coastal state economy is valued at $10.3 trillion . According to the National Ocean Economics Program, the 30 coastal states accounted for 82% of the total U.S. population in 2006 and 81% of jobs. In 2004, the coastal leisure and hospitality sector alone generated $340B and 10M jobs to the U.S. economy. The coastal trade, transportation, and utilities sector generated an additional $950B. In 2005, Hurricanes Wilma, Rita, and Katrina accounted for approximately $157B in damages and 1,987 deaths within coastal communities . Resource and emergency managers must have ready access to the tools and information needed to support informed and effective coastal and ocean decision-making.

U.S. IOOS

At the National level, the U.S. IOOS is a user-driven, coordinated network of people, organizations, and technology that generate and disseminate continuous data about our coastal waters, Great Lakes, and oceans. The power of IOOS is in its partnerships. Seventeen Federal agencies and eleven Regional Coastal Ocean Observing Systems (RCOOSs) share responsibility for the design, implementation, operation, and improvement of the U.S. IOOS over time. By working together to integrate our data and provide a broad, detailed, and synoptic view of our coastal, Great Lakes, and ocean environments, we deliver a coordinated data network that allows resource managers, emergency responders, scientists, policy makers, and many others quick and easy access to a range of information on demand and in formats useful for everyday decisions.

Two interdependent components constitute the IOOS: (1) global ocean component and (2) coastal component. The latter includes the national set of observations for the Great Lakes and the EEZ, as well as the network RCOOSs. Federal agencies are responsible for the design, operation, and improvement of the both the global component and the national network of observations. RCOOSs augment existing federal observing capacity around the nation and expand the number of variables measured according to local priorities within the region. Regional observing systems are designed, operated, and improved by the Regional Associations (RA).

NOAA's Contributions

The National Oceanic and Atmospheric Administration (NOAA) has participated in the development of the U.S. IOOS since its beginnings in the late 1990s. In February 2007, VADM Conrad C. Lautenbacher, Under Secretary of Commerce for Oceans and Atmosphere and Administrator of NOAA, established a new program to serve as the overall coordinator NOAA's IOOS activities and to provide a consistent management function. The program's mission is to "Lead the integration of ocean, coastal, and Great Lakes observing capabilities, in collaboration with Federal and non-Federal partners, to maximize access to data and generation of information products, inform decision making, and promote economic, environmental, and social benefits to our nation and the world."

In support of this mission, the NOAA IOOS program initiated development of a Data Integration Framework (DIF) to improve management and delivery of an initial subset of ocean observations. The DIF will establish the technical infrastructure, standards, and protocols needed to improve delivery of five of 20 IOOS core oceanographic variables, as defined in the First U.S. IOOS Development Plan. Integration efforts will focus on temperature, salinity, sea level, surface currents, and ocean color to improve NOAA's efforts to model and forecast harmful algal blooms, coastal inundation, hurricane intensity, and integrated ecosystem assessments. NOAA's goal in this effort is to test and demonstrate the value of integration. Ultimately, the intent is to extend this capability to include other data, products, and services.

Zdenka Willis, Director, NOAA IOOS Program, addressed IOOS during an "Industry Outlook Session" talk at the recent OceanTech Expo, held September 5-7, in Providence, RI.

IOOS Data Management and Communications

Data will be compiled from a variety of NOAA observing sources, as well as the Regional Coastal Ocean Observing Systems (RCOOSs) and a subset of Federal and other partners, to achieve rapid and routine operational access for NOAA and other end users and to establish a methodology that can be applied to a broader suite of NOAA and non-NOAA data. The DIF will function as a distributed system, meaning that the agency or organization that owns a particular observing platform will con-

Table 1:
Regional Coastal Ocean Observing Systems

RCOOS Name	Geographic Extent
Northeast Regional Association of Coastal Ocean Observing System (NERACOOS)	Maine to Massachusetts, including the Canadian Provinces of New Brunswick and Nova Scotia
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Cape Cod, Massachusetts to Cape Hatteras, North Carolina
Southeast Coastal Ocean Observing Regional Association (SECOORA)	North Carolina to the Atlantic coast of Florida
Caribbean Regional Association (CaRA)	Puerto Rico, the U.S. Virgin Islands, and the island of Navassa
Gulf of Mexico Coastal Ocean Observing System (GCOOS)	Gulf coast of Florida to Texas
Southern California Coastal Ocean Observing System (SCOOS)	Southern California Bight
Central and Northern California Ocean Observing System (CeNCOOS)	Central and Northern California
Northwest Association of Networked Ocean Observing Systems (NANOOS)	Oregon and Washington
Alaska Ocean Observing System (AOOS)	Alaska
Pacific Islands Integrated Ocean Observing System (PacIOOS)	Hawaii and Pacific Islands
Great Lakes Observing System (GLOS)	Great Lakes

tinue to collect, assemble, and manage the data that are produced. The DIF infrastructure provides the necessary connections to and translations among these various, distinct networks of ocean observations to enable increased data compatibility, accessibility, and utility for host of end-user purposes.

Distributed data access will be accomplished using a Service-Oriented Architecture (SOA), Web-services based approach, to ensure consistency with the larger Global Earth Observation System of Systems (GEOSS) and U.S. IOOS Data Management and Communications Plan. Within the context of IOOS, SOA refers to an approach to organizing and utilizing distributed data sources operated by independent organizations.

The establishment of community-wide data standards is an essential, yet challenging, first step in this process to advance interoperability among these distributed sources. For that reason, a national Data Management and Communications (DMAC) team formed and defined a data standards process that was published in 2006. This process has not been exercise due to lack of funding. The NOAA IOOS program has the resources to initiate the DMAC process. On 1 October, 2007, Ocean.US and NOAA issued a joint letter announcing that the DMAC process would begin accepting standards. The initiation of the DMAC Standards process is an exciting and necessary step towards data interoperability.

Regional Capacity

The eleven RCOOSs and corresponding regional management structures (Table 1.) provide a vital and vast network to identify and address regional priorities, augment the geographic coverage of the U.S. IOOS, and ensure strong customer focus and connection. Each RCOOS is

comprised of a series of sub-regional observing systems and as a single, regional management structure that provides operational products to a myriad of users and also be incorporated into the national system.

Regional Success

The federal and regional IOOS partnership has benefits on a local and national scale. The expanded implementation of an observing technology, known as high frequency Radar (HF radar), represents an example of successful and effective partnership among federal and regional IOOS components. HF radar systems collect near-real time currents essential that supports a range of applications including, search and rescue, oil spill response, assessment of beach water quality. Surface current maps generated from HF radar stations along the east coast now deliver up-to-the-minute information on currents to the U.S. Coast Guard's Search and Rescue models, greatly improving their ability to rescue ships in distress. A combination of Federal funds was allocated among the regions to advance this capacity and, as a result, the U.S. is well on its way to demonstrating the benefits of a National HF radar capability.

Regional observing system technologies are used to monitor and assess local water quality impacts. For example, water quality sensors provide information used by California Water Quality Control Boards to monitor the influence of hydrodynamic circulation on water quality, including the identification of illegal dumping activities. Public health agencies use real-time surface current maps to determine if polluted water is likely to affect swimming beaches.

Emergency managers represent another key user community, given their need for timely and accurate data to inform public safety decisions. Tide and water level data and inland stream gauges provide critical information to monitor conditions and predict the expected location and severity of storm and flooding impacts. Regional models provided detailed information during Tropical Storm Ernesto that caused a decision by Delaware River managers to not to open upstream dams, which abated flood damage. Storm surge forecasts and probability maps provide emergency managers in South Carolina and Tampa Bay, Florida with detailed information to support evacuations and other important decisions.

The challenge with all of the RCOOSs is to identify sufficient funding to support the development and sustainment of the end-to-end system. The funding for the RCOOSs is provided through NOAA and we are working hard to keep this capacity from being lost.

Industry Partnerships

Industry has the capacity and expertise contribute to every aspect of IOOS development and operations and is considered critical to the longer-term success of the U.S. IOOS; however, resource constraints currently limit the feasibility of major industry involvement. In addition, U.S. IOOS efforts are still in a process of discovery with regard to the many technical challenges associated with U.S. IOOS development. In 2006, NOAA funded two industry studies by Raytheon and Lockheed to develop conceptual designs that validated the technical feasibility of building an IOOS and provide notional diagrams of what the IOOS should look like.

While not yet involved in a systematic manner, industry has served as an active partner in certain IOOS partnerships and provides value-added products and services. The NOAA Chesapeake Bay Interpretive Buoy System (CBIS) is one example. CBIS is the water counterpart to the United States Appalachian Trail, designed to mark significant points along the Captain John Smith Chesapeake National Historic Trail and to provide timely information about weather, oceanographic, and water quality along the way. This effort is the first of its kind, representing a large partnership among seven federal and non-federal entities and a number of industry representatives. The buoy, purchased from Axys Technologies, Inc., was mounted with a Nortek AS Acoustic Doppler Current Profiler (ADCP). NOAA worked with WET Labs, Inc. to develop an additional water quality instrument. Tellus Applied Sciences provided data management and web design support. Verizon wireless provided the data transmission, and Verizon Business system provides the data to voice conversion — a business application adapted for buoy use.

Conclusion

NOAA is the first Federal agency to establish a formal IOOS program. We strive to ensure that NOAA's IOOS contributions and investments support the U.S. IOOS and set a path for a more comprehensive U.S. IOOS that moves from planning and development to implementation. NOAA understands that a number of challenges ranging from technical and programmatic to budget that must be addressed to advance this effort. The NOAA IOOS program remains committed to moving the current IOOS capability into a National program as the President highlighted in is U.S. Ocean Action Plan, December 2004 - the time is now to build IOOS.