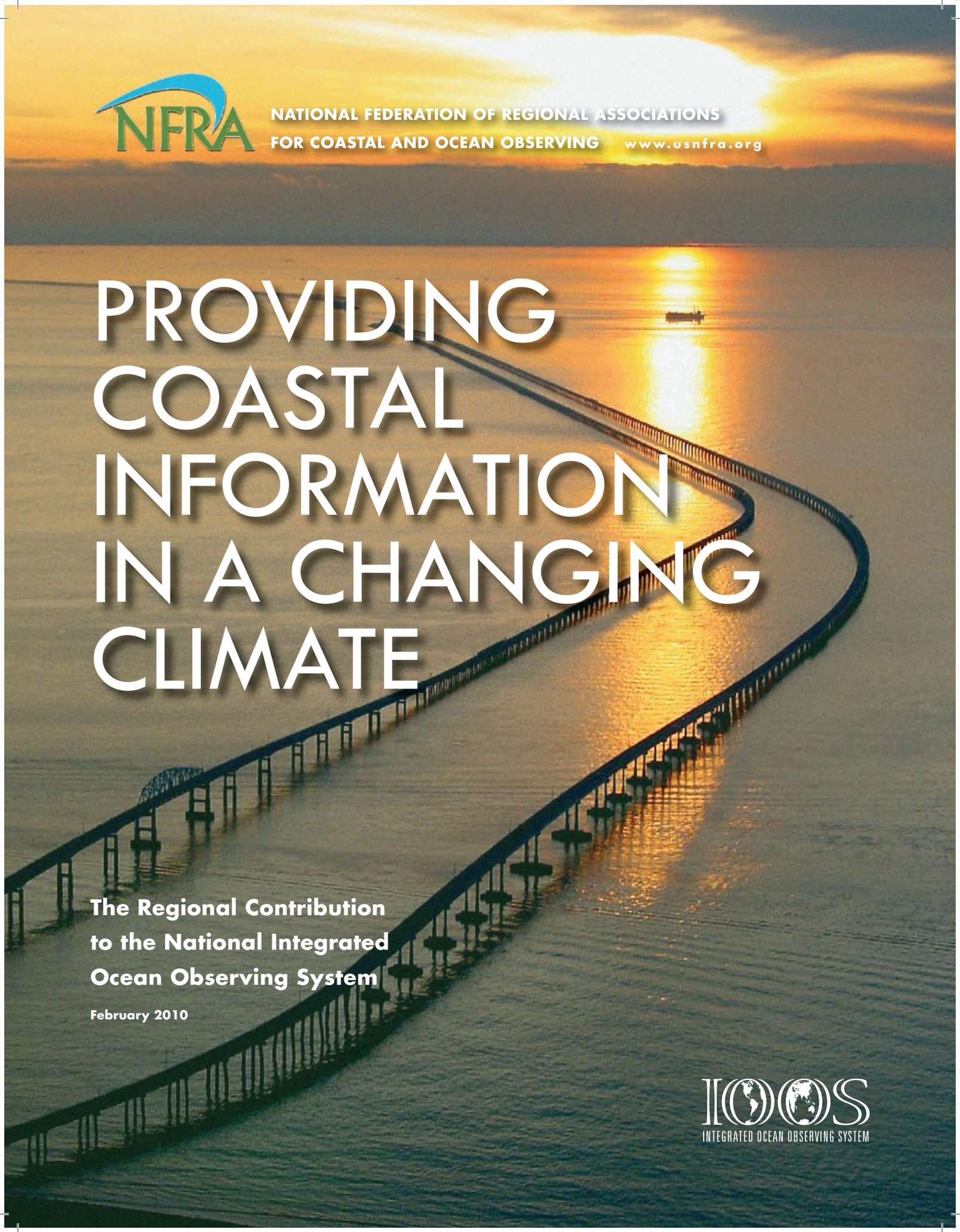

NFRA
NATIONAL FEDERATION OF REGIONAL ASSOCIATIONS
FOR COASTAL AND OCEAN OBSERVING
www.usnfra.org
PROVIDING COASTAL INFORMATION IN A CHANGING CLIMATE
The Regional Contribution to the National Integrated Ocean Observing System
February 2010
IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

As the uses of our coastal and Great Lakes waters increase and become more diverse, and as we face the unknown consequences of a changing climate, so the need for accurate and timely information intensifies.

STAYING CURRENT IN A CHANGING CLIMATE

CONTENTS

On the cover:
Sunset over Chesapeake Bay and the Bay Bridge.

The national Integrated Ocean Observing System (IOOS®) provides us with an "eye on our oceans, coasts and Great Lakes." IOOS® is a federal, regional, and private-sector partnership working to enhance our ability to collect, deliver, and use ocean information. IOOS® delivers the data and information needed to increase understanding of our oceans and coasts, so decision makers can take action to improve safety, enhance the economy, and protect the environment. IOOS® is a partnership between 17 Federal agencies and 11 regional systems.

This document focuses specifically on the contribution of the regional systems to the national program.

The robust national network of regional coastal observing systems is essential to the IOOS®. IOOS® is designed to provide seamless information about our nation's coastal ocean and Great Lakes at a variety of scales. Congress created the regional component of IOOS® to enhance the ability of federal agencies to provide the depth or scale of information needed to solve national issues that manifest themselves at the regional and local levels (Pew Ocean Commission, 2003; U.S. Commission on Ocean Policy, 2004). The complexities of the coastal environment and the inherent variability in regional ecology call for partnerships that not only cut across federal agencies but also reach out to regional managers, academia, industry, non-governmental organizations and the general public. The Regional Associations of IOOS® serve that function.

Full implementation of IOOS® is critically important for economic development, public health and safety, and managing marine ecosystems. Initial observing projects have demonstrated the value of integrating and using locally specific data and nationally relevant information to support policy decisions, maintain safe operations and foster the successful management of healthy coastal ecosystems throughout the country. This ability is only achievable through a coordinated network of regional systems linked with federal agencies, local stakeholders and regional partners. A five-year funding strategy is proposed to transform the initial projects into a sustained program of ocean observations that can routinely, reliably and rapidly supply the integrated information needed to plan, conserve and wisely manage our coastal ocean and Great Lakes ecosystems and resources.

In FY11, $53 million is requested for IOOS®, with $33 million for regional IOOS®.[1] This funding will:

- Establish 11 operational regional data information centers;
- Deliver regional scale observations of essential climate variables to track change over seasonal, annual, and decadal periods;
- Support regional modeling capacity to predict and forecast future conditions, extrapolate point observations into region-wide information, and verify global climate models at finer scales;
- Provide the nation with new observing, modeling, and visualization technologies into operational status; and
- Provide multi-purpose observing platforms (e.g., buoys, moorings, etc.) for deploying sensors and technology to meet the diverse information needs of our nation's ocean user communities.

[1] The FY10 budget included $27 million for regional IOOS®: $20 million for the network of 11 regional systems, $4 million for a modeling testbed and $3 million for a sensor validation program.

INTRODUCTION

The Interim Report of the Interagency Ocean Policy Task Force (September 2009) calls for strengthening the nation's capacity to observe the nation's oceans, coastal waters and Great Lakes. IOOS®, established by law in March of 2009 and referred to in the statute as the Integrated Coastal Ocean Observing System, provides the framework for developing such a system.

The Act establishes a federal-regional partnership for understanding the unique characteristics of the nation's diverse regions, integrating existing information from federal and non-federal sources, and expanding the observation network to fill critical gaps. IOOS® is a partnership of 17 Federal agencies and 11 Regional Associations for Coastal Ocean Observing (RAs).

The need for more comprehensive and higher resolution data and information about our coasts and Great Lakes has never been greater. Climate change, ocean acidification, declining fish stocks, expanding dead zones, and the increasing and sometimes conflicting uses of our coastal waters for food, transportation, energy, mineral resources and recreation require an expanded network of observations, enhanced analyses and understanding, and improved predictive and forecasting capabilities.

THEMES

The 11 RAs that support the advancement of IOOS® provide a nationwide network of coastal observing systems that are uniquely positioned to provide the information needed to address five broad themes that have been 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

These themes are similar to priorities cited in other ocean reports, including the U.S. Ocean Action Plan of 2007.

Dunes overlooking Lake Michigan, Sleeping Bear Dunes National Lakeshore, Glen Arbor, MI. (GLOS)

The Interagency Ocean Policy Task Force has recently identified the need for coastal and marine spatial planning (CMSP) as a tool for ecosystem-based management. CMSP will require integrated, reliable information on regional ecosystems to inform wise decisions. The RAs are poised to provide a neutral, science-based source of information that will be critical to implementation of ecosystem-based management.

This document outlines the products the RAs will provide, organized under five themes. For each theme the value of the products and the ways in which successful implementation will be measured are discussed. The document closes with a brief description of the infrastructure needed to make the products and the funds necessary for implementation.

LEARN MORE ➲

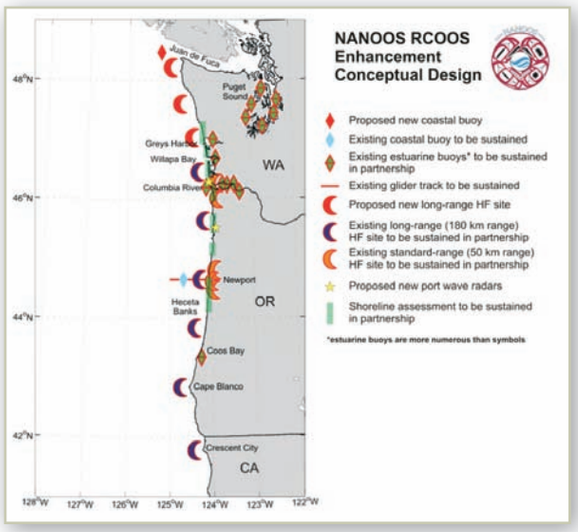
STANDING ON THE SHORE,

Standing on the shore, humans see the oceans and Great Lakes as vast, static, two-dimensional bodies of water. Underneath the surface, however, lies a dynamic world of fluctuating currents, diverse temperature, salinity and density regimes, nutrient upwelling areas, hypoxic zones, and plant and animal communities that can change from month to month, season to season, year to year, and decade to decade. Advances in technology, data transmission and data management now allow us to observe these fluid environments in real-time, yielding improved understanding of these complex ecosystems.

WHY A REGIONAL APPROACH

WHAT IS A COASTAL OBSERVING SYSTEM?

A regional coastal observing system is a comprehensive operation that includes all the components necessary to collect observations and turn them into useful and meaningful information products. The eleven IOOS® RAs design, operate and manage eleven coastal observing systems. Each system includes:



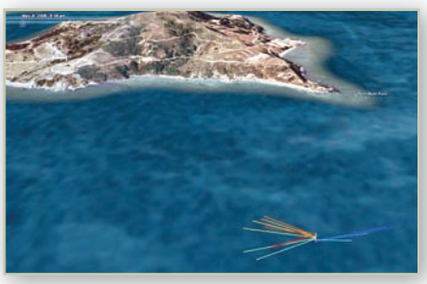
A conceptual design for an observing system for the Pacific Northwest based on user needs and regional and national priorities. The design includes fixed stations, transects, surface current radars and shoreline assessments. The $33 million would support a portion of the full plan for each region. (NANOOS)

OBSERVING CAPACITY FOR EXISTING AND NEW PLATFORMS

- **SENTINEL FIXED PLATFORMS** (such as buoys) that relay data from above and below the water back to shore;
- **TRANSECT LINES** that use autonomous vehicles such as gliders or ships to conduct seasonal monitoring along fixed lines that complement the point measurements; and
- **SATELLITE INFORMATION** that provides synoptic views of surface conditions.

PRODUCT SERVICES

- **DATA MANAGEMENT AND INTEGRATION** that support the development of regional data integration centers for seamless access to existing and new regional data;
- **REGIONAL-SCALE MODELS** that can be nested within basin and global models to provide users with higher resolution forecasts; and
- **PRODUCT DEVELOPMENT** that uses technical expertise to translate raw data into useful and meaningful information products.



Snapshot of currents in Raccoon Strait, San Francisco Bay, CA, as sampled by two Acoustic Doppler Current Profilers. Red arrows are near the surface and blue arrows are towards the bottom. This snapshot was taken during the flood tide. The information is useful for boaters, sediment transport, and constraining an ocean circulation model for the San Francisco Bay. (Google)

EDUCATION AND OUTREACH

- **USERS AND STAKEHOLDERS** help determine priorities for the system and provide input on the design of the observing system, and partnerships with educators help ensure incorporation of high quality data and information into educational tools and curriculum resources.

SYSTEM MANAGEMENT

- **MANAGEMENT TO OVERSEE OPERATIONS,** identify priorities and ensure routine and reliable delivery of information.

A REGIONAL APPROACH

Coastal ecosystems are complex. U.S. territorial waters encompass 11 Large Marine Ecosystems (LMEs), as designated by NOAA, that range from the cold waters of the Chukchi Sea in the Arctic to the warm waters of the tropical Pacific Islands (UNEP Report 182). The Great Lakes, with over 10,000 miles of coastline, are the world's largest system of freshwater lakes. Each region is characterized by unique geological, physical and chemical properties, biological productivity and human uses.

The diversity of these ecosystems, their large geographic extent and the differing needs of users call for a regional approach. The IOOS® RAs provide a forum for convening regional experts, agencies, industry and users to discuss mutual needs, leverage assets and share expert knowledge. The U.S. Commission on Ocean Policy, the Pew Ocean Commission and, most recently, the Interagency Ocean Policy Task Force have endorsed a regional approach to ocean observing and ocean governance.

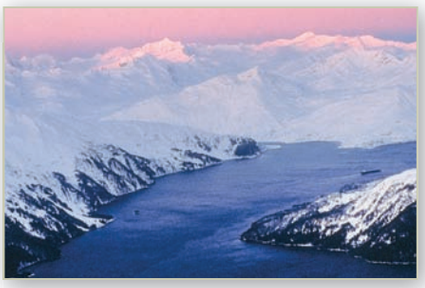
The information needs are diverse because they are derived from a broad range of coastal ocean users. Users include mariners who need access to the latest sea state conditions; fishermen who are planning their days at sea; resource managers who need definitive ecological trends and risk factors; federal agency personnel who need data for modeling and prediction; emergency managers who need forecasts and predictions to protect public health and safety; and the general public who want to plan for coastal activities, recreation and tourism.

The national network of RAs provides services to the entire coastline of the U.S., including the islands and territories and the Great Lakes. Each RA is a non-governmental organization, managed by a board of directors drawn from stakeholders in the region.

THE REGIONAL ASSOCIATIONS PROVIDE:

- **A TRUSTED SOURCE OF SCIENCE-BASED INFORMATION** that is responsive to regional stakeholder needs;
- **REGIONAL FORUMS** for regional experts, data providers, government agencies, industry and users to coordinate efforts, leverage assets and maximize limited resources;
- **TAILORED PRODUCTS** that are specific to the unique characteristics of the region;
- **DATA INTEGRATION CENTERS** that pull together data from multiple sources and make them easily accessible;
- **FEDERAL AGENCIES WITH ACCESS TO DATA** and information from non-federal sources that can enhance their models and forecasts; and
- **TESTBEDS** for developing new technologies or methodologies and partnerships with regional experts.

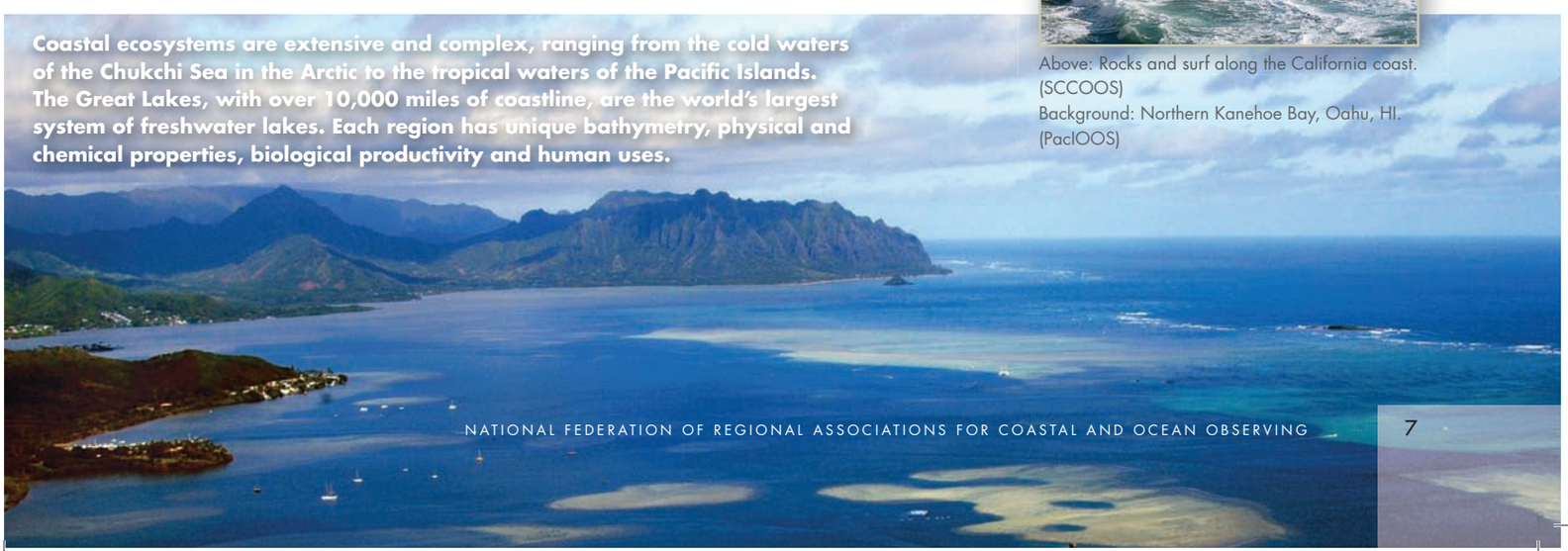
San Francisco Bay and the Golden Gate bridge. (CENCOOS)



Valdez Narrows, Prince William Sound, AK. (AOOS)

Detroit waterway. (GLOS)

Above: Rocks and surf along the California coast. (SCCOOS)



Coastal ecosystems are extensive and complex, ranging from the cold waters of the Chukchi Sea in the Arctic to the tropical waters of the Pacific Islands. The Great Lakes, with over 10,000 miles of coastline, are the world's largest system of freshwater lakes. Each region has unique bathymetry, physical and chemical properties, biological productivity and human uses.

Background: Northern Kanehoe Bay, Oahu, HI. (PacIOOS)

MARINE OPERATIONS

Commercial and recreational boating safety, efficient shipping, safe offshore oil and gas operations, and informed and efficient offshore renewable energy production are aspects of marine operations that impact human health and economic vitality in the US. Each will be significantly improved by enhanced observing capacity.

More than 95 percent of the U.S. overseas trade occurs by ship (USDOT). IOOS® works with programs such as NOAA PORTS to ensure that the maritime industry has ready access to critical information on waves, wind, currents, salinity and water levels. (Port of Norfolk, VA, MACOORA)

Providing real-time and enhanced information to marine operations has been one of the most successful aspects of the early development of IOOS®. Mariners are eager for access to information on sea and weather conditions. RAs have posted real-time conditions on websites or on NOAA weather radio for mariners. Oceanographic models interpolate conditions between observations and have been able to provide mariners with information exactly where they need it. A new, land-based high-frequency radar system (HFR) now provides real-time information on the speed and direction of ocean currents. In 2009, the Coast Guard routinely accessed information from the Mid-Atlantic Coastal Ocean Observing Regional Association for search and rescue purposes. The Coast Guard would like to see this capacity expanded to all regions.

U.S. Coast Guard operations off Alaska. (USCG)

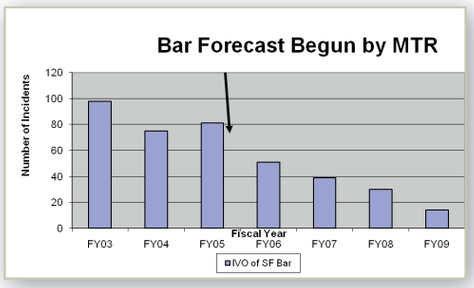
KEY PRODUCTS, SERVICES, AND EXPECTED RESULTS

After a five-year implementation period the regions will deliver the following products and services related to Marine Operations.

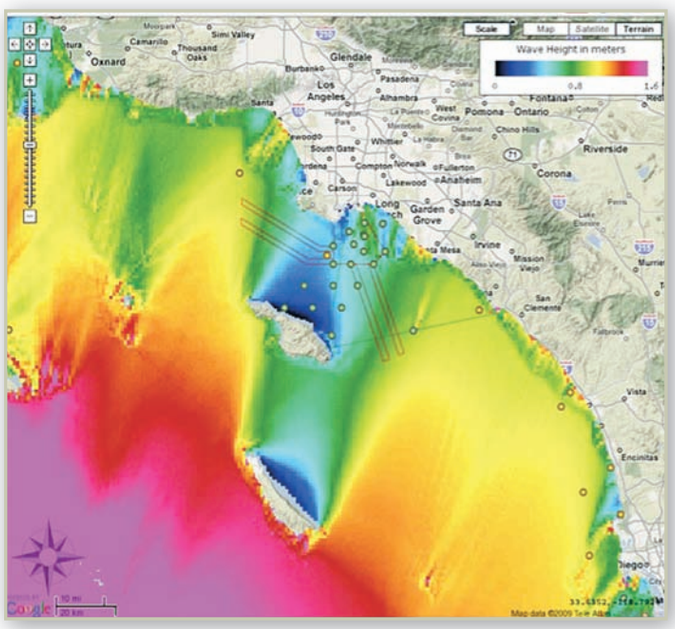
- **PROMOTE SAFE AND EFFICIENT MARINE COMMERCIAL SHIPPING AND RECREATIONAL BOATING** by deploying easy-to-use web displays that package new and existing ocean observations and model output on ocean and lake conditions. Consistent information on nearshore and inshore ocean conditions at key ports will maximize cargo capacity, reduce incidents and shipping costs, and improve recreational boater safety.
- **SUPPORT COAST GUARD SEARCH AND RESCUE AND NOAA SPILL RESPONSE** with real-time nowcasts and forecasts on surface conditions. Search and Rescue (SAR) and Hazardous Material (HAZMAT) operations are critical safety missions that at present suffer from limited information on real-time and forecasted ocean conditions. Real-time surface current information from high-frequency radars is proving to be an invaluable tool. The result of a fully developed surface current network will be more efficient search and rescue operations, fewer lives lost at sea and better containment of hazardous material spills.
- **INFORM OFFSHORE ENERGY PLANNING AND OPERATIONS** through the synthesis of regional-scale baseline environmental data and real-time ocean observations. The synthesis will be used by state and regional ocean alliances for offshore energy planning. Once energy production is operational, accurate regional scale forecasts will ensure efficient energy generation and safe offshore operations. A remarkably diverse set of information is needed to support wise ocean energy development. Recent state and federal efforts in Coastal and Marine Spatial Planning aim to integrate the broad sets of marine geospatial information needed to inform management decisions.

HOW WILL WE MEASURE SUCCESS?

- Shipping incidents and time spent waiting to enter harbors will be reduced through improved shipping environmental support systems. The cost for holding large cargo ships offshore is between $100,000-$200,000/day/ship.
- Integrated observations and models including winds, waves, currents, water level, sea surface temperature, salinity, Automatic Identification System (AIS) ship reports, bathymetry and navigation charts will support commercial shipping interests and recreational boaters and SAR and HAZMAT operations.
- Recreational boaters will have information on local sea conditions needed to plan safe and enjoyable trips.
- Reducing the size of the Coast Guards's search area and the response time for rescues will reduce the number of lives lost at sea.
- The efficiency and accuracy of responding to marine spills will be increased by accessing real-time information on surface currents and other environmental factors.
- The Coastal and Marine Spatial Planning process will use RA integrated information for offshore energy site selection and monitoring.



In 2005, the Coastal Data Information Program (CDIP) deployed a wave buoy at the San Francisco Bar. This chart shows a decline in the number of Coast Guard responses after the National Weather Service started including the wave information in their forecasts.



SCCOOS provides tailored information on waves and sea conditions for commercial mariners for specific locations based on their oceanographic model. Such information can save tankers money by avoiding costly delays due to bad weather. (SCCOOS)

Recreational boaters, surfers and beachgoers are major users of real-time oceanographic data. Information on weather, waves and sea conditions help them plan safe passages. (Michigan Sea Grant)

THE NATIONAL SURFACE CURRENT MONITORING PLAN

Surface current measurements are useful for navigation, search and rescue operations, tracking and responding to spills, monitoring the extent of harmful algal blooms, tracking larval transport and other applications. Over the last 15 years, close to $55 million has been invested in a new technology, high-frequency radar (HFR), that provides real-time information on surface currents. This technology is proving to be a cost-effective approach for building a national system to meet these needs.

In 2009, the federal Interagency Working Group on Ocean Observations released "A Plan to Meet the Nation's Needs for Surface Current Mapping." The Plan calls for the continued operation and maintenance of existing HFR systems and identifies where critical gaps in coverage exist. $10 million is needed to sustain the existing systems and another $10 million is required to fill critical gaps. This money will also support the development of a comparable system that works in the Great Lakes.

Land-based high-frequency radar antenna such as this one on the New Jersey coast provide real-time information on the speed and direction of surface currents. The nation has close to 150 such stations already installed. The National Surface Current Mapping Plan calls for doubling that number in order to fill critical gaps. The Coast Guard uses such information to reduce search and rescue response time. (Rutgers University COOL Room)

The U.S. territorial islands of the Pacific and the Caribbean are known for their unique ecosystems and biodiversity. They are also extremely sensitive to variations in climate. Since the 1990s, coral bleaching associated with long-term warming of surface waters has become widespread in the Pacific and Caribbean. (R. Chaparro, PR Sea Grant)

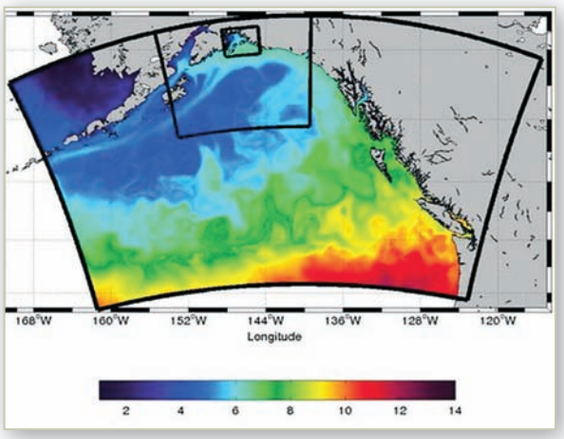
CLIMATE VARIABILITY AND CHANGE

The U.S. Climate Change Program is in critical need of sustained observations and climate indices at regional scales throughout the coastal and nearshore zones, out to the 200-mile exclusive economic zone (EEZ).

According to the U.S. Global Change Research Program's report, Global Climate Impacts in the United States, significant impacts will be experienced by the ocean and coasts due to climate variability and change. In many cases, these will not be new impacts, but rather, an increase in intensity or occurrence of changes and events already experienced by the nation's coasts and oceans.

Specifically, U.S. coasts are expected to see:

- Increased sea level rise and storm surges,
- More spring runoff plus warmer waters resulting in decreased oxygen,
- Higher water temperatures and increased ocean acidification, and
- Changing ocean current patterns.



Nested models, such as ROMS for Prince William Sound, the Gulf of Alaska and the North Pacific, link global phenomena to regional and local phenomena providing the context for understanding how local conditions are influenced by larger scale events. (AOOS)

While most coastal communities expect an increase in sea levels, the levels of the Great Lakes are expected to lower as a result of rising temperatures and less ice. (Traverse City, MI Sea Grant)

KEY PRODUCTS, SERVICES, AND EXPECTED RESULTS

After a five-year implementation period the regions will deliver the following products and services related to Climate Change.

- **SUPPORT REGIONAL CLIMATE STATUS AND TRENDS** by tracking essential climate variables. This monitoring will document effects of regional variability on key short-term climate observations such as water temperature, water levels, ice coverage, currents, waves, winds, storms, ocean acidification and salinity. Future observations will document effects of longer-term climate variability on environmental parameters and coastal communities.
- **PROVIDE NATIONAL CLIMATE EXPERTS WITH REGIONAL MEASUREMENTS** useful for climate indices and models. Scientists use indices to monitor variability and change over time. Higher resolution data on upwellings and other coastal manifestations of large-scale circulation patterns such as El Niño/La Niña, and Atlantic/Pacific/Arctic Oscillations should improve these indices and thereby enhance their usefulness. Regional observations on land-sea interactions provide vital input to hydrological models describing the interaction between freshwater input and coastal ecosystems.
- **PROVIDE COASTAL COMMUNITIES WITH MORE ACCURATE ESTIMATES** of the environmental effects of short-term climate variability. Environmental trends measured at fixed locations and along transects can be used to provide information needed for planning and development as well as mitigation of potential hazards to coastal communities.

HOW WILL WE MEASURE SUCCESS?

- Regional climate forecasts will be improved by accessing information on changes in environmental conditions at the regional scale.
- The accuracy and resolution of the effects of climate variability on regional and local resources will be increased by the inclusion of regional observations into climate indices and models.
- Improved understanding of the links between freshwater inputs (ground water, drought, snow melt, river flow), coastal circulation and ecosystems will improve the ability to effectively manage fragile ecosystems.

Students from the MarineQuest summer camp in North Carolina learn to use a Conductivity, Temperature and Depth (CTD) sensor. CTD sensors provide scientists with information on the distribution and variety of water temperature, salinity concentration and depth that help them understand how the oceans affect life. CDT information will be critical for tracking changes in the ocean due to a changing climate. (Jamie Moncrief/UNCW)

The toxic algae *Karenia brevia* causes red tide in the Gulf of Mexico. (Scanning electron microscope image courtesy of the Fish and Wildlife Research Institute of the Florida Fish and Wildlife Conservation Commission)

ECOSYSTEMS, FISHERIES AND WATER QUALITY

Marine and Great Lake ecosystems are dynamic and complex. These three-dimensional fluid systems function through the complex chemical, geological and biological interactions and processes that change over time and space. Water temperature, salinity, dissolved oxygen content, sea and lake levels, upwellings, storms and drought conditions all affect water quality and ecosystem health.

Hypoxia (areas of low oxygen levels) and outbreaks of harmful algal blooms (HABs) are occurring in more areas, at greater frequencies. Pollutants, pathogens and other contaminants threaten public beaches, shellfish stocks and drinking water supplies. Many fish stocks are in decline due to fishing pressure, loss of spawning and other habitats, and changes in water temperature and chemistry. Climate change will alter how these ecosystems function in ways that are not currently observable or predictable because of the limited availability of long-term environmental data sets.

Observations on oceanic habitats (i.e., benthic and water-column habitats), nutrient fluxes, upwelling areas, freshwater plumes, discharges, runoff, erosion, inundation, contaminants, and plankton are needed for ecosystem-based management.

More than 40 million people depend on the Great Lakes for drinking water. GLOS supports circulation modeling in the Huron-Erie corridor that allows managers to track contaminants. (Michigan Sea Grant)

NOAA's Pacific Marine Environmental Lab (PMEL) works with the regions on their ocean acidification monitoring programs. This buoy in Hawaii is jointly funded by PMEL and IOOS® and includes CO_2 sensors. This is an example of a single observing system serving multiple purposes. (R. David Beales, University of Hawaii Creative Services)

EXISTING CAPACITY

Observations from buoys, ships and satellites have documented hypoxia, algal blooms and the spread of polluted waters. Public health officials have been working with IOOS® scientists to combine the surface currents from high-frequency radars with oceanographic models to better understand when pollutants may be carried near public beaches. In the Great Lakes, oceanographic model output is helping county officials manage drinking water intake systems. In the Mid-Atlantic fisheries, biologists are working with IOOS® oceanographic information to determine spawning and migration patterns.

KEY PRODUCTS, SERVICES, AND EXPECTED RESULTS

After a five-year implementation period the regions will deliver the following products and services related to Ecosystems, Fisheries and Water Quality.

- **MINIMIZE THE POTENTIAL HARM** from harmful algal blooms, hypoxia, and pollution by providing public health officials and others with early warnings of when oceanographic condition are favorable for such events. Early warnings will allow public officials and industry time to take action to minimize harm. For example, NANOOS and the National Estuarine Research Reserve System (NERRS) provide alerts to shellfish growers in the Pacific Northwest and Alaska when water quality may threaten the health and viability of their animals.
- **SUPPORT THE PROTECTION OF DRINKING WATER SUPPLIES** by providing managers with decision-support models that track the movement of drinking water contaminants. This is a particular concern for the Great Lakes, which provide drinking water to 40 million people. Such a tool is currently being tested in the Lake Huron-Erie corridor.
- **PROVIDE ACCESS TO OBSERVING INFRASTRUCTURE** for other monitoring programs. IOOS® is a single system that serves multiple purposes. For example, NOAA's ocean acidification research and monitoring program at the Pacific

Marine Environmental Laboratory (PMEL) is working with the RAs to add their sensors to existing buoy arrays. PMEL needs the data but doesn't want to operate an observing system. This is a win-win for both and saves money by avoiding expensive duplication of infrastructure.

- **SUPPORT ECOSYSTEM-BASED MANAGEMENT** by developing maps of subsurface conditions and regional analyses of changes over time and space. The marine and coastal ecosystems are dynamic systems. Ecosystem-based management depends on understanding the cycles and how the ecosystems change over time. Routine and sustained measurements of water temperatures, currents, salinity and nutrients will provide information on fundamental ecosystem parameters.
- **ASSIST PUBLIC HEALTH OFFICIALS, RESOURCE MANAGERS AND PUBLIC USERS** with easy access to beach and nearshore water quality conditions through regional databases. Information on water quality is collected by local, state and federal agencies. The information can be difficult to access and integrate for analysis with other parameters such as ocean currents. The RAs are establishing regional data centers to provide water quality data from multiple sources for use in forecasting, issuing water quality advisories, managing beach activities, aquaculture and shellfish harvesting, and planning for recreational and commercial activities.

HOW WILL WE MEASURE SUCCESS?

- Reductions in the financial loss to the shellfish industry from HAB outbreaks because early warnings will allow industry to take precautionary actions and managers to narrow the window of harvest closures.
- Fewer illnesses from exposure to contaminants in coastal waters and the Great Lakes.
- Reduced losses for the aquaculture industry from unfavorable conditions (e.g., warm water for shellfish, superchill for salmon).
- Cost savings realized by using regional platforms for other monitoring needs such as the ocean acidification monitoring program.

Real-time current and wave observations along with circulation models provide public health officials with information on when ocean conditions might bring pollution near public beaches. (J. Thomas)

THE NATIONAL WATER QUALITY MONITORING COUNCIL (NWQMC)

The Council was formed in 1997 to provide a consistent and coordinated approach to improving water quality. In 2006, the Council released a Network Design for a national water quality monitoring program that includes specific links to IOOS. RAs were involved in the 3 pilot projects in the Delaware River, Lake Michigan and San Francisco Bay. IOOS® and representatives of the NWQMC work cooperatively on data standards, observations and products.

This satellite image (MODIS true color) reveals high concentrations of river sediments entering the northern Gulf of Mexico through the Mississippi "bird-foot" delta and the Atchafalaya delta. (Earth Scan Laboratory, School of the Coast and Environment, Louisiana State University)

COASTAL HAZARDS

Coastal communities are at risk from inundation and erosion. These hazards result from natural cycles on a monthly or seasonal basis, episodic events such as tsunamis, tropical storms, hurricanes, or other extreme weather events and from changing climatic conditions, such as sea level rise and land subsidence or uplift.

Erosion affects coastlines around the nation. Climate change is expected to increase sea levels in most areas and to change rainfall amounts, both of which will increase erosion. IOOS® works with the National Weather Service and other groups to provide enhanced information for emergency managers and the public so that risks to property and life can be minimized. (SCCOOS)

These events increase the risk of damage and losses to private property, public infrastructure such as airports, port facilities, water systems and roads, and natural ecosystems. The National Science and Technology Council (2005) identified six challenges to disaster reduction. The RAs will contribute to solving three by:

- providing hazard and disaster information where and when it is needed;
- understanding the natural processes that produce hazards; and
- promoting risk-wise behavior.

KEY PRODUCTS, SERVICES, AND EXPECTED RESULTS

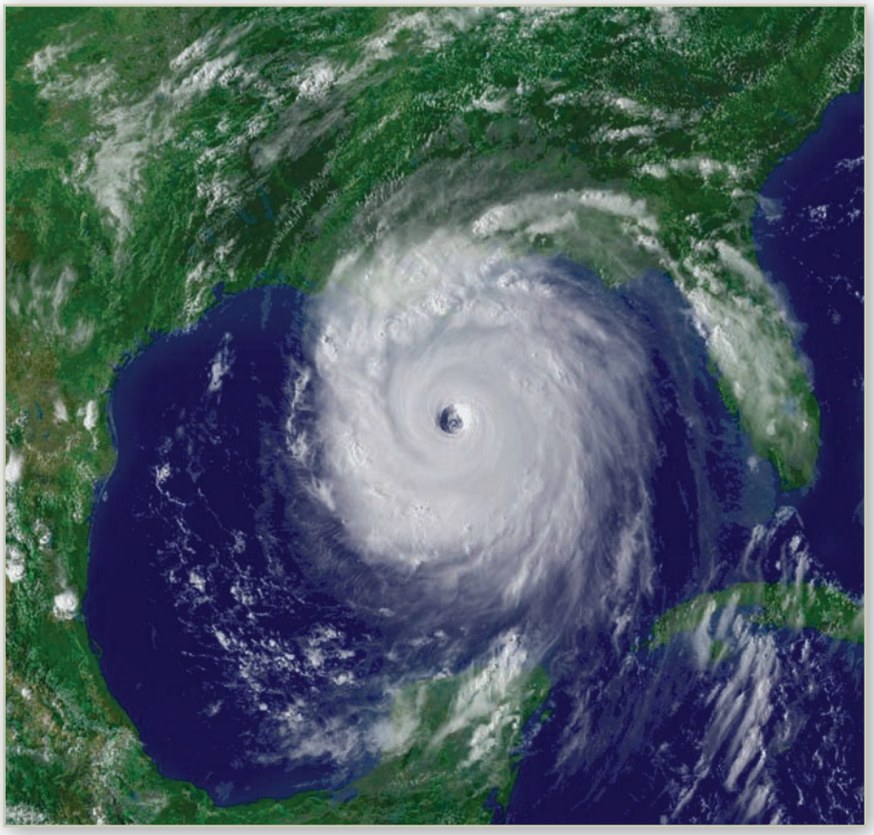
After a five-year implementation period the regions will deliver the following products and services related to Coastal Hazards.

- **PROVIDE ROUTINE REGIONAL OBSERVATIONS** on waves, water levels, precipitation during and after storms, currents and meteorological data. These regional data will improve the accuracy and resolution of regional forecasts for inundation and erosion risks and aid emergency managers by providing information to improve real-time situational awareness.
- **OPERATE REGIONAL MODELS** that indicate the potential risks of inundation and erosion from storm surge and runoff before, during and after an event. Most of the models currently being used are based on storm surge and do not include the risk from intense rainfall that often accompanies large storms.
- **INCREASE THE ACCURACY AND CREDIBILITY OF MODELS** and products by incorporating the most up-to-date technologies and techniques being developed by researchers and industry by serving as regional testbeds. The RAs provide excellent testbeds for testing new techniques and technologies to improve forecasts at the regional scale.

The water level in the Great Lakes is expected to decrease due to warming water temperatures and diminishing ice coverage due to climate change. (GLOS)

HOW WILL WE MEASURE SUCCESS?

- Reductions in the risks to lives and property from extreme coastal storms and long-term water level changes because of improved forecasts and predictions on the regional scale. Increased access to actual observations is key to increasing the accuracy of forecast models.
- The accuracy and scale of forecast models will be increased through the adoption of new technologies and techniques that have been first tested at the regional level.
- Coastal and Great Lakes communities will have the information they need on the scale that they need for preparing and adapting to climate changes.



Satellite image of Hurricane Katrina in the Gulf of Mexico, 2005. Hurricane forecasting is improved with increased numbers of observations. (NOAA)

Satellite image of the Great Lakes. (SEAWIFS)

THE NATION'S INLAND SEAS: THE GREAT LAKES

The Great Lakes—Superior, Michigan, Huron, Erie and Ontario—and their connecting channels form the largest fresh surface water system on Earth. Covering more than 94,000 square miles and draining more than twice as much land, these Freshwater Seas hold one-fifth of the world's fresh surface water supply and nine-tenths of the U.S. supply. The Great Lakes are a vital asset for the nation and continent. The Great Lakes coastline totals nearly 11,000 miles ; more than 44 million people live in the watershed and depend on the lakes for their drinking water.

As the only freshwater region of IOOS, the Great Lakes Observing System (GLOS) is filling a critical gap by gathering and integrating chemical, biologic and hydrologic data, and monitoring lake conditions and trends over time. These observations are being used in a host of programs to monitor water quality for human and ecosystem health, drive ecosystem forecasting models, especially related to climate change, and assess the progress of restoration efforts.

COASTAL AND MARINE SPATIAL PLANNING

Coastal and marine spatial planning (CSMP, but also known as marine spatial planning or MSP) is gaining popularity as a process for achieving ecosystem-based management because it provides a framework for harmonizing the regulations of multiple federal and state agencies and minimizing use conflicts. The Interagency Ocean Policy Task Force is tasked with developing a framework for coastal and marine planning.

With the appropriate resources, human coastal observing systems administered by the 11 RAs can provide ecosystem and use information and analysis that will support both regional and national marine spatial planning. Data provided by the RAs can help with both short-term and long-term decision making, answering such questions as:

- Where is the best place to site an offshore wind farm given the waves, winds, currents, geology, vessel traffic, fishing areas, and bird and marine mammal distributions of the region?
- What are the long-term impacts of designating Marine Protected Areas on the ecosystem?
- Will the proposed uses change the ecosystem over time?
- How might climate change affect the region?

EXISTING CAPACITY: REGIONAL SPATIAL PLANNING

Most of the IOOS® RAs are involved in the regional ocean governance initiatives in their areas. In the Northeast, NERACOOS, the Northeast Regional Association for Coastal Ocean Observing Systems, has signed a formal memorandum of agreement with NROC, the Northeast Regional Ocean Council, to provide regional science and ocean information. Recently, NERACOOS worked with NROC to integrate the spatial plans from Massachusetts and Rhode Island into a regional framework.

The most common definition of marine spatial planning comes from UNESCO:

Marine spatial planning is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process. Characteristics of marine spatial planning include ecosystem-based, area-based, integrated, adaptive, strategic and participatory.

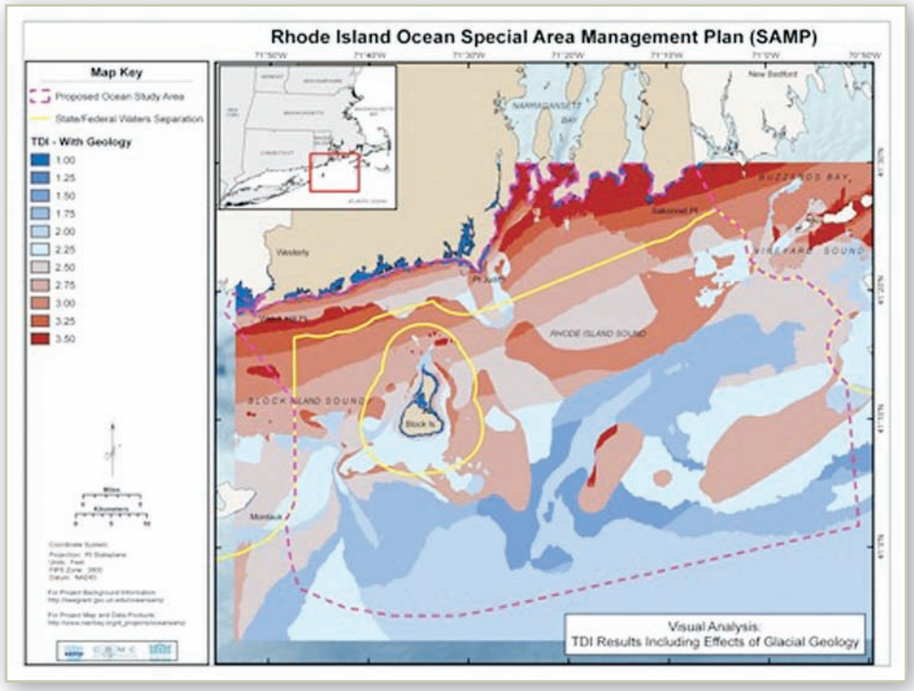
Marine spatial planning is not an end in itself, but a practical way to create and establish a more rational use of marine space and the interactions between its uses, to balance demands for development with the need to protect the environment, and to achieve social and economic objectives in an open and planned way.

One of the goals of coastal and marine spatial planning is to allow for multiple uses of our marine environment while minimizing potential conflicts, such as those between offshore oil and gas development and whale migration routes. (Dr. Christopher Richter, U.S. Minerals Management Service Sperm Whale Seismic Study)

KEY PRODUCTS, SERVICES, AND EXPECTED RESULTS

Within the one- to five-year implementation period the regions will deliver the following products and services related to Marine Spatial Planning. Some will come on line within one year.

- **PROVIDE REGIONAL MARINE SPATIAL PLANNERS WITH A COMPREHENSIVE LOOK AT THE MARINE ECOSYSTEM** by developing maps and other products that integrate surface characteristics with characteristics of the water column and seafloor. IOOS® is one of the only sources of operational information about the dynamic nature of the water column. Regional data management systems with common standards and protocols will allow for the rapid discovery, distribution, integration, and analysis of data from disparate sources.
- **SUPPORT ADAPTIVE MANAGEMENT** through regular synthesis of coastal data. Timely synthesis and analysis of regional ecosystem data will provide managers key information on how environmental conditions are changing and whether new management approaches are warranted.
- **PROVIDE MANAGERS WITH REGIONAL MODEL FORECASTS** that allow for improved understanding of temporally variable spatial patterns in the region.



The above is an example of an analysis based on the integration of several sources of data. This particular visualization was done for the State of RI for wind farms. Areas with a low Technology Development Index (TDI) have high wind resources and low construction challenges, making them preferred sites for wind farms. NERACOOS helps provide regional data for these decisions.

HOW WILL WE MEASURE SUCCESS?

- CMSP will be based on robust information that includes the dynamic nature of coastal and Great Lakes waters.
- The time and effort to identify, collect, harmonize and analyze data from different federal and non-federal sources for spatial planning purposes will be reduced.
- Effectiveness of management measures and environmental compliance procedures can be determined through sustained observations.

A modest investment in additional buoys and transect lines will begin to fill the gaps in the nation's observing system and provide the data necessary for the critical issues outlined here.

INVEST IN OBSERVING

Now is the time to make IOOS® fully operational. A total of $53 million is being requested of Congress for FY11. This includes $33 million for the network of regional systems to provide the products and services described in this document.

An additional $20 million is being requested for the national program: $10 million to ensure seamless integration of data from federal and non-federal sources, coordinate interagency efforts and implement the IOOS® legislation. The remaining $10 million would help sustain the National Surface Current Mapping Program to provide the real-time surface current information to all coasts for U.S. Coast Guard search and rescue operations, better oil spill response, coastal water quality and ecosystem assessments.

Investment in Regional IOOS® covers all aspects of coastal observing necessary to transform raw data into useful and meaningful products:

- **OBSERVING CAPACITY** supports fixed stations (such as buoys) and transects with gliders and/or ships
- **PRODUCT SERVICES**
  - Data integration supports the development of regional data integration centers for seamless access to existing and new regional data.
  - Regional-scale models that can be nested within basin and global models can be used for higher resolution forecasts.
  - Product development support for IT and science experts to translate raw data into useful and meaningful information products.
- **SYSTEM MANAGEMENT** support of the operational experts to coordinate and oversee the system to ensure routine and reliable delivery of information.
- **OUTREACH AND EDUCATION PROGRAMS** so that users and stakeholders can help determine priorities for the system and provide input on observing system design, and educator partners can ensure incorporation of data and information into educational tools and curriculum resources.

The U.S. Commission on Ocean Policy called for an initial investment in ocean observing of $150 million per year, with $50 million for regional observing. Recent funding levels for IOOS® have been at the $26.5 million level, with $20 million for regional observing. The following proposes a five-year ramp-up to bring the regional systems up to operational capacity.

In the first year, the funding for the regional system will be increased from $20 million to $33 million. The following table outlines how the funds will be used to support the system at the individual RA basis. These figures are estimates as the actual funds will be awarded on a competitive basis.

Notional Regional System	*Year 1*	*Description of assets on individual RA basis*
Observations (without radar*)	$1.2m	Support for 1-2 buoys, 1 glider and l ship transect in each region, including supporting personnel
Data Integration	$ .45m	Support for a regional data integration center
Regional modeling	$ .45m	Support for developing regional modeling and forecasting capacity
Product development	$ .30m	Personnel support for analysis, product development and delivery (2 FTEs)
Education and outreach	$ .30m	Outreach to users to identify needs and product satisfaction, support for stakeholder councils to provide input into management decisions; support for education materials (2 FTEs)
System management	$ .30m	Administration, system management, board and committee support, regional and national coordination (2 FTEs)
Total	*$ 3.0m*	

* As noted on page 18, support for the national surface current initiative is considered a critical component of the national IOOS® program and is not included in the request for a regional system.

Cost assumptions: The observations estimate is based on the assumption that an in situ platform (e.g., a buoy) capital cost is $200,000 with $50,000 in annual operation and maintenance (O&M) and that 1 FTE is needed to service every 2 buoys. A glider is estimated to have a $120, 000 capitalization cost and $40,000 annual O&M expense and require 1 FTE for every 2 gliders. A ship transect, consisting of 4 seasonal sampling periods, is estimated at $120,000 in ship time and a personnel cost of 1 FTE for every 2 transect lines.

Five year build-out plan	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*
Observations	$13m	$17.6m	$22m	$30m	$38m
Capital costs	*$6.2m*	*$6.7m*	*$6.2m*	*$7.9m*	*$8.6m*
O&M costs	*$6.8m*	*$10.9m*	*$15.8m*	*$22.1m*	*$29.4m*
Data integration	$5m	$6.6m	$8.25m	$11.25m	$14.25m
Regional modeling	$5m	$6.6m	$8.25m	$11.25m	$14.25m
Product development	$3.4m	$4.4m	$5.5m	$7.5m	$9.5m
Education and outreach	$3.3m	$4.4m	$5.5m	$7.5m	$9.5m
System management	$3.3m	$4.4m	$5.5m	$7.5m	$9.5m
Total	*$33m*	*$44m*	*$55m*	*$75m*	*$95m*

After five years of regional IOOS® build-out, the country will have a dramatically improved coastal ocean observing system, with each region operating roughly a dozen new in-situ platforms, several glider and ship survey transects, and interacting components that synthesize and distribute a variety of products to support health, safety and resource management. These combined components are necessary to provide the scale and accuracy of information required by users.

The same system will keep the public involved in its evolution and informed of what is learned and the services provided. A careful evaluation of the adequacy and accuracy of the information generated should be conducted in the last 1–2 years of the build-out to inform future operation and possible enhancement of the system.

LEVERAGING MULTIPLIES VALUE

Regions use the IOOS® investment to leverage additional resources and thus multiply the value of the original investment. They link existing assets into a connected system, and enhance that system by adding new assets. Since much of the information made available through the IOOS® regions is based on observing assets and data not funded by IOOS®, regions provide access to information that was previously difficult or impossible to find.

NATIONAL FEDERATION OF REGIONAL ASSOCIATIONS FOR COASTAL AND OCEAN OBSERVING

A non-profit representing the interests of the Regional Associations formed in support of the Integrated Ocean Observing System

Josie Quintrell, NFRA Executive Director
205 Oakledge Road, Harpswell, ME 04079
tel 207 725 8143 • usnfra@gmail.com

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Alaska Ocean Observing System
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www.aoos.org

Caribbean Regional Association
Lajas, Puerto Rico
cara.uprm.edu

Central and Northern Coastal Ocean Observing System
Moss Landing, CA
www.cencoos.org

Gulf of Mexico Ocean Observing System
College Station, TX
gcoos.tamu.edu

Great Lakes Observing System
Ann Arbor, MI
www.glos.us

Mid-Atlantic Coastal and Ocean Observing Regional Association
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www.macoora.org

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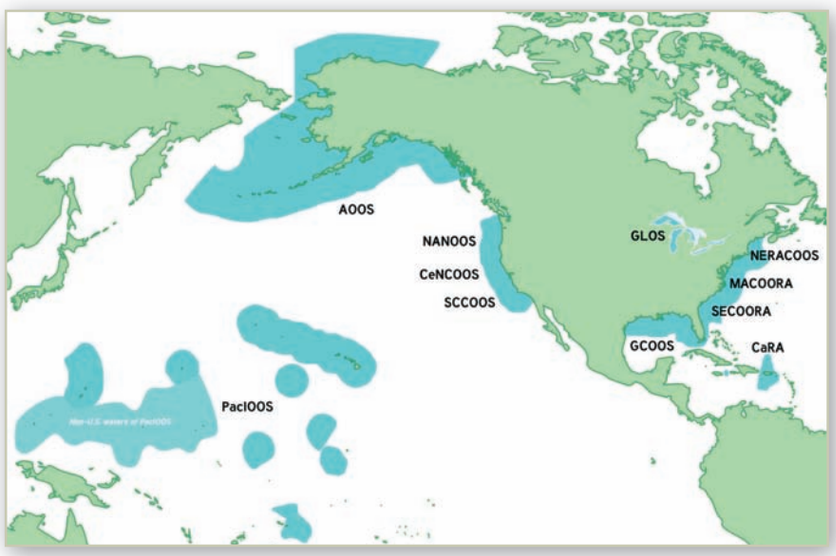

Geographical areas covered by each of the 11 Regional Associations.

This document should be viewed as a work in progress as the Regional Associations continue their planning processes with stakeholders and users.