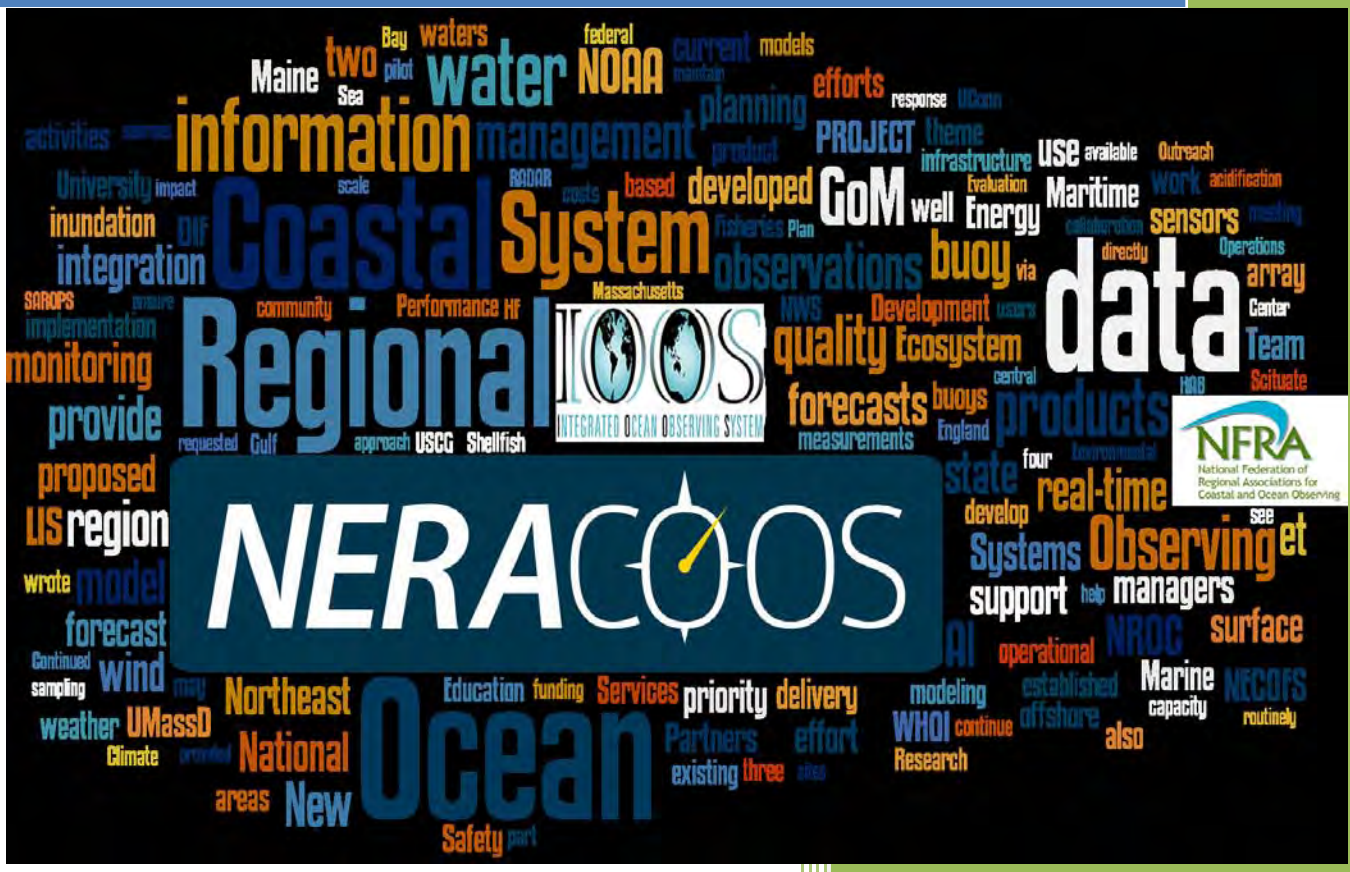
2009-2010

NERACOOS Strategic Plan



NERACOOS Strategic Planning and Implementation Team

NERACOOS Strategic Plan V1 - draft

2009-2010

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I. Executive Summary

The mission of the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS) is to:

1. Lead the development, implementation, operation, and evaluation of a sustained, regional coastal ocean observing system for the northeast United States and Canadian Maritime provinces, as a component of the United States Integrated Ocean Observing System (IOOS),
2. Promote the development, assessment, and dissemination of data, and data based products, that meets the needs of end users,
3. Advocate through education and outreach for the regional, national, and global ocean observing system and the application of scientific assessments using environmental data to meet societal needs.

This document is the first draft of the Strategic Plan for the development of a comprehensive multi-use integrated observation and information system for the coastal and ocean waters from the Canadian Maritime Provinces to the New York Bight. The southern extent of this region overlaps with that of the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA), the neighboring IOOS region. Since there are a wide array of needs and users in the Northeast region (which encompasses the five New England states and three Maritime Provinces), this plan will be periodically revised in the next few years as the vision and budgets for IOOS become more firmly established. The Northeast Regional Ocean Council (NROC) was formed by the New England Governors to coordinate coastal ocean activities and foster the identification and pursuit of region-wide issues and priorities. The NERACOOS Strategic Plan presented here has been developed to support the NROC agenda and the needs of a wide array of users. It will be reviewed and revised through a consultative process that will include NROC and other users beginning in February 2010.

This document has been prepared by the NERACOOS Strategic Planning and Implementation (SPI) Team appointed by its Board of Directors with the support of the Executive Director and staff. The SPI Team formed into seven Working Groups. The four priority areas (Coastal and Ocean Ecosystem Health, Ocean Energy, Coastal Hazard Resiliency, and Maritime Safety and Security) were identified to synchronize NERACOOS priorities with those of NROC in the implementation of the New England Governors' 2007 Coast and Ocean Action Plan. Three additional Working Groups (Data Integration Framework, Education and Outreach, and Performance and Evaluation) were established to develop plans for organizational activities that support all science- and technology-based themes. The Working Groups were responsible for developing components of the strategic plan in consultation with representatives of user constituencies. The chairs of the Working Groups formed the SPI team Executive Committee and the Executive Director participated ex-officio. The reports of the Working Groups identified a broad array of opportunities for NERACOOS based upon users needs identified through a variety of surveys and recommended near term (1-2 year) goals and longer term priorities. The Working Groups will continue to monitor user needs, the effectiveness of the NERACOOS programs and operations, as well as recommend revision to the NERACOOS Strategic Plan on an on-going basis.

Coastal and Ocean Ecosystem Health – The near-term goals in the Coastal and Ocean Ecosystems Health theme are to (1) provide observations and forecast tools for the onset and distribution of Harmful Algal Blooms (HAB), and (2) provide observations and a data sharing infrastructure to support the assessment and management of coastal water quality. In the longer term, the NERACOOS priorities are to: (3) develop survey tools and data systems to support an improved understanding of the variability of fisheries resources and the development of ecosystems based management, (4) establish a networked array of near-shore water quality monitoring buoys in coastal bays and harbors to support coastal zone management needs to monitor highly impacted water bodies, especially estuaries and embayments where cultural eutrophication occurs, and (5) enhance collection of benthic and coastal habitat data, especially high resolution bathymetry, marine geology, and sediment type mapping.

Coastal Hazard Resiliency – In the Coastal Hazard Resiliency theme area, the short-range goal is to complete the development and assessment of the coastal inundation model system using Scituate, MA, and Saco, ME, as pilot sites. This system relies upon NERACOOS observational assets and modeling infrastructure. Additional demonstration sites may be incorporated where partnerships can be established. In the next 3 to 5 years, NERACOOS will create an information system with key hazard datasets (historic inundation levels, shoreline vulnerability metrics, topography/bathymetry, etc.) that can support the development of a regional hazard management system and coastal sediment erosion monitoring system.

Ocean Energy Planning and Management – The Ocean Energy Planning and Management (OEPM) Standing Committee of NROC has begun discussions with regards to needs for ocean energy planning, and hosted a two-day workshop in October 2009 to focus on the role of Coastal & Marine Spatial Planning to advance the goals of the New England Governor's Coast and Ocean Action Plan. It is a priority of NERACOOS to identify observations and services that can support NROC's energy initiative through coordination with the OEPM Standing Committee, potentially supporting workshops to facilitate discussion amongst the key end users and undertake pilot projects that would augment data acquisition to support the high priority areas for mapping identified by the New England states in spring 2009 and the on-going Coastal & Marine Spatial Planning activities underway in the New England states. NERACOOS will seek to establish cooperative agreements with states and developers to acquire and share data at prospective wind and tidal power sites.

Maritime Safety and Security – The National Weather Service (NWS) depends on NERACOOS buoy arrays in the Gulf of Maine and Long Island Sound to routinely produce and share observations with the NWS to improve marine weather and wave forecasts which are frequently consulted by all mariners in the region. The observations themselves are also routinely reviewed by mariners. The NWS also depends on the NERACOOS Northeast Coastal Ocean Forecast System (NECOFS) forecasts of surface icing potential and other parameters to improve their marine weather advisories in coastal areas. Supporting this infrastructure and improving search and rescue in the Gulf of Maine lead to three near-term goals in the NERACOOS Maritime Safety and Security theme: (1) the restoration of the wind and wave monitoring infrastructure to the 2006 level; (2) augmentation of the US Coast Guard surface current forecasting capability by integration of the HF RADAR data-based forecasting tools and the NECOFS model predictions into the US Coast Guard environmental data system; and (3) assessing the skill of these surface current forecasts products in the NERACOOS region. In the longer term, the goals are to augment the buoy network for wind and wave observations to the level envisioned in the 2007 NERACOOS

conceptual design, implement the HF RADAR surface current monitoring plan, and continue to enhance forecast products for regional users.

Data Integration Framework –The NERACOOS Data Integration Framework (DIF) will support the observations and products in all thematic areas. It will enable the interoperable sharing of model results and data and be compliant with national standards adopted by the IOOS office. The two near-term goals of the DIF development theme are to: (1) complete the implementation of Sensor Observation Service (SOS)", Web Map Service (WMS), and Thematic Real-time Environmental Distributed Data Services/Open-source project for a network Data Access Protocol (TDS) for all seven IOOS core variables for all components of the NERACOOS infrastructure; and (2) develop software to facilitate the support of DIF SOS and conversion of existing users of SOS in the region. In the long-term, the DIF Working Group will ensure that all products and data systems will be completely compliant with IOOS DIF standards for SOS, WMS, Telephone and Data Services and Web Coverage Service and Climate and Forecasting OpenDAP. It is the intent of NERACOOS to be a national leader in demonstrating the use of interoperable standards for the development and distribution of ocean observations and products.

Education and Outreach – The three largest audiences identified in the Education and Outreach Working Group (EOWG) survey as Accountability Seekers were: Government, Media and Public. NERACOOS will develop separate approaches for each of the groups. Models have been identified and will be assessed. The EOWG survey found that the education audience (K-12, college and informal programs) for Ocean Literacy (OL) was not a high priority. NERACOOS will, therefore, partner with entities whose highest priority and expertise are to advance OL. These groups will include Sea Grant Educators and Extension staff, New England Ocean Sciences Education Collaborative, local chapters of the National Marine Educators Association, and the Centers for Ocean Sciences Educational Excellence. The near-term goal of NERACOOS in this area is to craft Public Relations messages to raise awareness that "We're all connected to the ocean" and that "Ocean and coastal change has relevant - and sometimes dramatic - impact on people." These messages should be disseminated on web sites and all communications. In addition, NERACOOS will develop and sustain a dynamic and interactive website with specific web pages targeted at the three audiences with assets dedicated to continually updating the content. In the longer term, the EOWG will assess the value of cultivating a community of engaged participants by using "new media" such as e-newsletters, listservs, blogs, and other virtual networking tools.

NERACOOS will continue to partner with the National IOOS office in the development and evaluation of quantitative performance metrics for all aspects of its operations. In the near-term, all NERACOOS data systems will develop and publish statistics characterizing operations (availability, accuracy, etc.) and products will be monitored to track frequency and character of user access. In addition, NERACOOS will develop more sophisticated approaches to the valuation of products by users through web-based (pop-ups) user surveys and more in-depth assessment of the use of products by major users.

The demands on the **NERACOOS coordination office**, currently at the Sea Coast Science Center, Rye, NH, are expected to expand. The office will need to select and monitor the performance of contractors, support the SPI Team and the Working Groups, interact with user constituencies and federal agencies, raise the public profile of NERACOOS, and raise funds to support the operations of the organization. The short term goals administrative goals can be supported by the existing Regional Association grant and include the coordination of workshops to further help in the identification of products and engage managers in discussions of ocean observing systems. These activities will inform the

Working Group deliberations to refine the Strategic Plan and develop implantation strategies. In the longer term, the Executive Director and the Board will develop a public and government relations plan and a funding stream that will support the staff to inform local, state and federal legislators about the operations and needs of the organization.

II. Introduction

A. Background

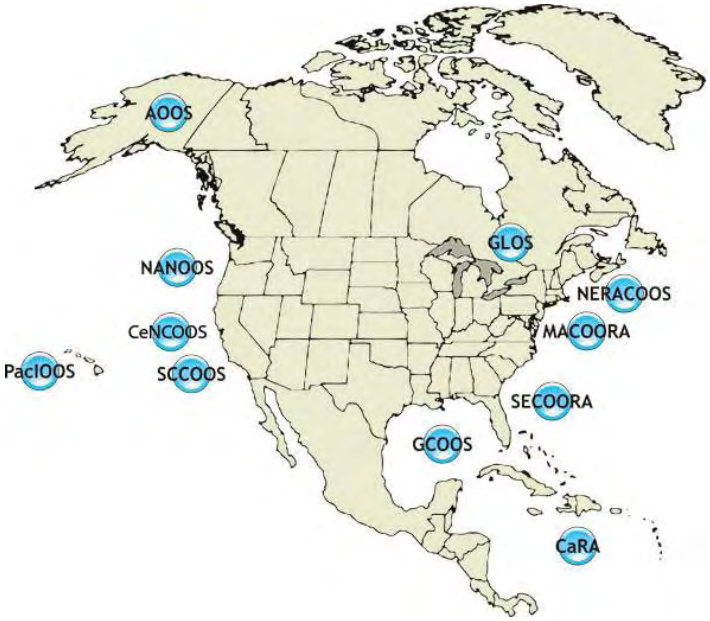

Figure 1. National IOOS map showing the regional associations.

The U.S. Integrated Ocean Observing Systems (IOOS) is a coordinated network of people and technology to generate, archive and distribute observation data about the coasts, oceans and Great Lakes. The U.S. IOOS is a network of Federal and regional contributions to ocean observations, products and services with a program office within NOAA. Ocean.US led the planning for the national (IOOS) from 2000 to 2008. President Obama signed the Omnibus Public Lands Management Act into law in March of 2009 which included the authorization for U.S. IOOS. Ocean.US is maintained as a legacy site.

IOOS has two interdependent components:

1. global component: IOOS is the U.S. contribution to the Global Ocean Observing System (GOOS) which in turn is the ocean component of Global Earth Observation System of System. GOOS[1] is designed to:
   - Monitor, understand and predict weather and climate
   - Describe and forecast the state of the ocean, including living resources
   - Improve management of marine and coastal ecosystems and resources
   - Mitigate damage from natural hazards and pollution
   - Protect life and property on coasts and at sea
   - Enable scientific research

2. national coastal component: Includes 17 federal agencies and a network of 11 Regional Association observations, products, and services.

[1] Source: http://www.ioc-goos.org/content/view/12/26/

IOOS ELEMENTS

According to the (Ocean U.S., 2006), the process of linking observations to the development of useful, environmental information requires "a managed, efficient, two-way flow of data and information among three essential sub-systems. These sub-systems include:

- Measurements: Ocean observations collected from systems in the water, as well as land-based, airborne, or satellite platforms;
- Data Management and Communications (DMAC): The primary mechanism to integrate collected IOOS data so that they are compatible with one another and accessible to users; and
- Modeling and Analysis: Products and services delivered to users, including related socio-economic research, outreach, training, and education"

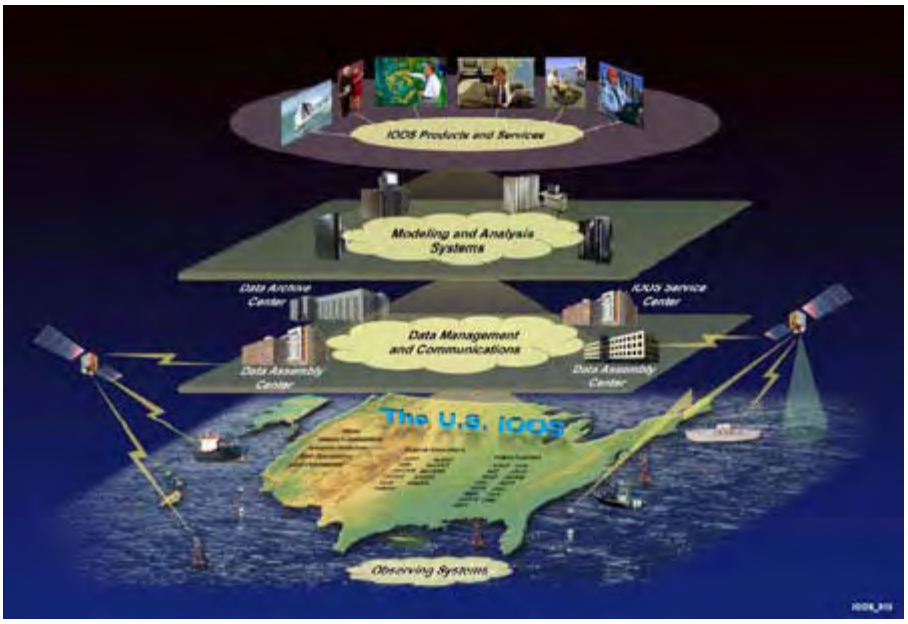

Figure 2. Graphical depiction of the observations, data management and communications, and modeling and analysis subsystems, developed by Lockeed Martin as part of a conceptual design study for IOOS. This is meant for illustration purposes only- NOAA does not endorse this conceptual design study over another. (Source: U.S. IOOS; http://ioos.gov/about/adv_infor.html)

This linkage was initially intended to improve the nation's ability to achieve seven societal goals:

- Improve predictions of climate change and weather and their effects on coastal communities and the nation;
- Improve the safety and efficiency of maritime operations;
- Allow more effective mitigation of the effects of natural hazards;
- Improve national and homeland security;
- Reduce public health risks;
- Allow more effective protection and restoration of healthy coastal ecosystems; and
- Enable the sustained use of ocean and coastal resources.

B. The Northeast Ocean and Coastal Environment

The Northeast is comprised of two large marine ecosystems (LME) namely the Northeast Continental Shelf and the Scotian Shelf by the Regional Seas Program of the United Nations Environmental Programme. (Cook & Auster, 2007) recognize 5 distinct biogeographic regions at these two LME. The geographic area for NERACOOS extends from Nova Scotia to New York City, and includes the Western Scotian Shelf, the Gulf of Maine, Georges Bank, and the Southern New England Regions.

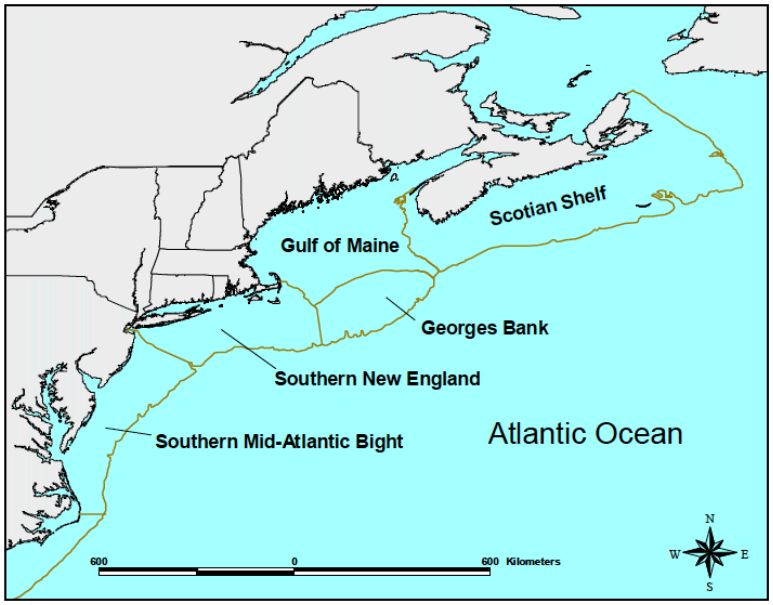

Figure 3. Northeast biogeographic regions (Cooke and Auster).

The Scotian Shelf LME is bordered by Nova Scotia and extends offshore 200 nautical miles to the shelf break and embraces an area of approximately 283,000 $km^{2.}$ This shelf is considered a Class II or moderately high productivity ecosystem (150-300 $gC/m^2/yr$) (Aquarone & Adams, 2009). The Saint Lawrence is the one major estuary. Landscape of the shelf is complex consisting of many offshore banks and deep-mid-shelf basins. Commercial fisheries focus on haddock, silver hake, pollock, halibut, white hake, turbot, Atlantic Herring, Atlantic mackerel, snow crab, northern shrimp, and short fin squid.

The Northeastern LME system is bounded to the east by the Gulf Stream, the complex circulation and rings greatly influence the LME. This shelf is considered a category I (>300 $gC/m^2/yr$) or highly productive ecosystem based upon Sea-viewing Wide Field-of-view Sensor global primary productivity estimates. The fish populations of this LME contribute to about 25% of the value of the U.S. commercial fisheries (Sherman (editor), Jaworski (editor), & Smayda (editor), 1996).

Figure 4. Major features and currents of the Northeast.

The Gulf of Maine is a prominent feature in the north, a semi-enclosed shelf sea separated from the Atlantic Ocean by Georges and Browns Banks (http://www.gulfofmaine.org/council/internal/documents/gomcactionplan_1991-2000_final_optimized.pdf). Fed by numerous rivers and forced by strong tides, particularly in the Gulf of Maine, and it is connected via a region-wide southwestward-flowing current over the shelf and slope, which originates in the Gulf of Saint Lawrence and Labrador Sea. The Gulf of Maine and Georges Bank support highly productive ecosystems, are among the richest fishing regions in the world, and are near a bio-geographical boundary, so that species composition is sensitive to climate variability. The Gulf of Maine experiences Harmful Algae Blooms (HAB) outbreaks, which affect human health and commercially important fisheries.

Figure 5. The moraines deposited at the southern edge of the Laurentian Ice Sheet separate the high energy Atlantic Ocean environment from the low energy ecosystem complex of an interconnected series of six Sounds.

Southern New England has a distinct low-energy nearshore zone that is a series of six interconnected sounds and separated from the ocean environment by the end moraine deposited by the last glaciers. The sounds and bays in the Southern New England Bight support variable and productive ecosystems, and thus economically important recreational and commercial fisheries. Fisheries production has been negatively impacted by viruses, elevated water temperature from climate change and HAB especially brown tide (Gobler, et al., 2008). Coincident with the red tide blooms of the Gulf of Maine, there has been an increased occurrence of small red tide blooms. With more than eight million people living in its watershed, Long Island Sound is one of the nation's principal urban estuaries; its concentrated urban development contributes large nutrient loadings resulting from non-point-source pollution and wastewater discharge. The resulting low concentrations of dissolved oxygen have led to a mandate for improved water quality and costly upgrades of wastewater treatment plants. Narragansett Bay and Buzzards Bay face similar challenges. Maritime safety, specifically including search and rescue operations, is of primary importance in the region because of the density of

marine operations, the severity of wind, wave, and current conditions, and frigid water temperatures throughout much of the year.

Common estuarine and coastal issues for the New England states have been losses of tidal wetlands, decreases in submerged aquatic vegetation notably *Zostera marina* in polyhaline waters. The great diversity of estuaries is described by (Roman, Jaworski, Short, Findlay, & Warren, 2000). The northeast is a popular tourist destination in the summer but all states report beach closures throughout the summer and various sources contribute to closures (EPA Beaches).

C. NERACOOS Missions, Goals and Vision

The ultimate goal of NERACOOS is to establish and maintain, in the Northeastern Region, a comprehensive system that achieves the mission established for the Integrated Ocean Observing System. NERACOOS will provide the primary framework to coordinate ocean observing activities and is responsible for the design and coordinated operation of sub-regional coastal ocean observing systems within their respective geographies. Members of NERACOOS work with user communities at the state and local levels to ensure that the regional system is designed to be as useful as possible.

The challenge facing the Northeast region is to integrate the elements of the existing regional coastal ocean observing system (RCOOS) into a coherent system at all levels:

- at the data acquisition level (what products do users most need, what are their data requirements, and in what platforms and technologies should we be investing to obtain the data?);
- at the data and information sharing level (how can data from diverse, distributed sources be shared to enable the creation of products users need?);
- at the research and-operations level (how should the fruits of research, including both technology and predictive capacity, be integrated into 24/7 operations?); and
- at the institutional level (how are priorities for coastal ocean observations set, and how should investments to meet those priorities be directed?).

Meeting the challenge also includes integrating data acquisition, modeling, and data communications with other regional associations, especially MACOORA, with which the Northeast shares a large-scale ecosystem.

Objectives leading to this goal include:

1. respond to and, in the governance of the Regional Association, provide a voice to users;
2. secure the participation of the producers and providers of data and data products through the existing, distributed regional system of ocean observing and predictions;
3. develop synergies between the national backbone of the RCOOS and the regional enhancements, with strong connections to the Mid-Atlantic region, as well;
4. assure that the “conveyor belt” is in place, by which research in ocean observing technologies and modeling feed ocean observing operations, and operations, in turn, inform the need for research; and
5. build on recent breakthroughs in dynamic data sharing, both technically and institutionally, and involving oceanographic, biologic, and geologic providers, to create an effective, standards-based data management and communications subsystem.

D. Governance

In 2008, NERACOOS was established as a public benefit nonprofit corporation and aligned its geographic region to match that of the nascent Northeast Regional Ocean Council (NROC). NROC is federal-state partnership consisting of twelve state council members appointed by the New England Governors and six federal agency partners. NERACOOS considered a number of governance models but adopted a Board of Directors inviting nominations from NROC, the New England Sea Grant offices and the Northeast Academic Consortium. The Executive Committee of the Board (President, Vice-President, Secretary, and Treasurer) addresses issues that arise between regularly scheduled Board meetings or when it is not practical or feasible for the Board to meet. The NERACOOS bylaws are found at: http://www.neracoos.org/documents/neracoos-bylaws/bylaws/view

A single Strategic Planning and Implementation (SPI) Team replaced the multiple teams that had existed during the planning phase. The SPI Team includes coastal mangers, scientists, and engineers with the expertise necessary to operate observing system infrastructure, model the complex marine environment, and manage the resulting information. Seven working groups have been created and the four shown in light blue below correspond to the four priority theme areas in NROC's 2007 Action Plan[2].

NERACOOS currently has two full time employees, an Executive Director and an Administrative Assistant. The Executive Director (J. Ru Morrison, Ru.Morrison@neracoos .org) leads the organization under the guidance of the President and NERACOOS Board of Directors. Functions include serving as principal spokesperson for NERACOOS, providing leadership and guidance in the development and implementation of programs (scientific, operational, and business), oversight of grants and contracts, coordinating proposal and fundraising activities, leading outreach and public relations, and serving as a primary liaison to the Board of Directors. A Memorandum of Understanding has been established with the Seacoast Science Center (SSC) in Rye, NH to provide office space as well as financial and administrative support for NERACOOS.

[2] See the NROC Coast and Ocean Action Plan 2008 at http://community.csc.noaa.gov/nroc/

Figure 6. NERACOOS organization chart. The light blue boxes correspond to the work groups developing observations and products for the four theme areas of the Northeast Regional Ocean Council.

III. NERACOOS Priorities

This section describes the priorities of NERACOOS including the four primary ocean observing project areas and three cross-cutting areas (data management and communication, education and outreach, and performance). The four priority areas outlined in the New England Governors' Ocean and Coastal Action Plan of 2007 were embraced by NERACOOS as the initial priority focus areas for the Northeast. The priority areas were developed by the Northeast Regional Ocean Council (NROC) members based upon council deliberations and an NROC sponsored Ocean Congress which was a forum to receive input from regional entities regarding ocean priorities. The priority focus areas[3] are:

- Ocean and Coastal Ecosystem Health
- Coastal Hazards Resiliency
- Ocean Energy (Planning & Management)
- Maritime Safety and Security

It is the goal of NERACOOS to provide observation products and services that support the goals and priorities of NROC identified in the New England Governors' Coast and Ocean Action Plan (2007; or future revisions) as refined in the annual work plans of the NROC Standing Committees. Furthermore these products and services support the seven societal goals of US. IOOS listed above.

The NERACOOS SPI Team was charged with developing a Strategic and Implementation Plan at its first meeting in February, 2009. Delivering priority products and services to stakeholders and users followed by designing the appropriate observing system was central to the process in developing this plan. To achieve this, seven Working Groups were established, four to develop products and services supporting the priority areas of NROC and 3 workgroups for data integration framework (DIF), education and outreach, and performance and evaluation. Working Group membership, like that of the SPI Team comprised representatives from state and federal agencies as well as non-governmental organizations and research scientists. At a meeting in May, 2009 members of the priority theme Working Groups were charged to identify key products and services that NERACOOS could deliver building on previous prioritizing efforts such as NROC work plans. Further refinement and prioritizing continued throughout the summer months with an extensive search of previous regional planning efforts and user surveys by a contractor and weekly teleconferences. A final set of prioritized products and the infrastructure needed to support them was produced by consensus of the entire SPI Team at a meeting on September 16 and three subsequent teleconferences and was later ratified by the Board of Directors. In addition, NERACOOS and NROC have recently established a Memorandum of Understanding to further an ongoing coordinated approach to the identification and implementation of regional management priorities.

A directory of potential products and services has been compiled from various regional surveys and is available for review at (NERACOOS URL to be created). Many of these surveys are dated and predate discussion on emerging issues such as Coastal & Marine

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[3] While climate change and Coastal & Marine Spatial Planning (MSP) are emerging state, regional and national issues, they are components of the above four theme areas.

Spatial Planning. NERACOOS plans for convene a series of regional workshops in the spring 2010 to invite users to confirm and/or review this list and make recommendations regarding the completeness of the directory and to advise on product priorities. NERACOOS is proposing to share the results of these workshops by convening workshops in each of the northeast states as an education and outreach opportunity and invite refinements as to product and service priorities. The SPI workgroups will then select priorities that will form the basis on a 5-year strategic plan to be released in fall 2010.

A. Ocean Observation Priority Focus Areas

The following identifies priorities for the next year. Within each theme area, the priority to retain the accomplishments of the past by means of continued operation of selected elements of the existing regional observing system, chosen for best service to end users and continued regional development. This assumes that in the next grant award, the NOAA funding is commensurate with the level requisite to support but not diminish the existing products and services. A list of enhancement are listed which will be developed from existing year-3 funds from a previous RCOOS award. Finally a list of potential products and services are listed which are contingent upon increased funding in 2010. Over the next year, NERACOOS will review with regional leaders and end users needs identified in previous surveys, identify key priorities in New England and revise this plan to a five-year plan that includes more diversified funding sources.

With regard to the NERACOOS RCOOS project funds, the objectives are divided into three groups: objectives specific to the Gulf of Maine sub-region, an objective specific to the Southern New England sub-region, and region-wide objectives.

The objectives that are specific to the Gulf of Maine support the operation, maintenance, and modest enhancement of selected elements of the legacy observing system that has been established in this sub-region by previous funding. These objectives are:

1. to produce continuous time-series measurements of atmospheric and water-column conditions by maintaining five Gulf of Maine buoys and one estuarine buoy;
2. to produce continuous time-series maps of the spatial distribution of surface currents by maintaining three high-frequency radar (CODAR) sites;
3. to determine HAB abundance in the Bay of Fundy and quantify nutrient inflows to the Gulf of Maine through the Northeast Channel by means of quarterly shipboard surveys; and
4. to produce continuous operational nowcasts of waves by means of numerical simulations.

The objective that is specific to Southern New England supports the operation and maintenance of selected elements of the legacy observing system that has been established in Long Island Sound by previous funding. This objective is to produce continuous time-series measurements of atmospheric and water-column oceanographic conditions by maintaining three buoys in Long Island Sound.

The region-wide objectives are:

1. to advance and demonstrate a region-wide capability for time-series measurement of nutrient concentrations;

2. to advance and demonstrate a region-wide capability for simulation and prediction of coastal inundation (NECOFS, the Northeast Coastal Forecast System); and
3. to disseminate data and information to end users in a timely, accurate and useful manner.

1) Ocean and Coastal Ecosystem Health

Nitrogen enrichment from runoff, groundwater, point sources and atmospheric deposition has created a range of health issues from loss of *Zostera* communities, alteration of phytoplankton blooms in the case of Long Island bays and Narragansett Bay, increases in undesirable macrophytes, and hypoxia in Long Island Sound and Narragansett Bay. Warming of coastal waters due to climate change have contributed to lobster declines, shifts in cold to warm water fish populations, alteration of plankton blooms in Narragansett Bay, and increasing fish kills in coastal embayments. Climate change may be altering wind patterns which in the case of Long Island Sound may be offsetting the gains in reducing hypoxia via nitrogen reduction from sewage treatment plants. In the last several years there have been extensive outbreaks of red tide (*Alexandrium fundyense*) in the Gulf of Maine and ocean currents help to transport these blooms into the easternmost southern New England Sounds. Since 1985, brown tides (*Aureococcus anophagefferens*) have impacted the bays of eastern and southern Long Island impairing *Zostera* beds and devastating hard clam and scallop production. Important shellfish diseases include Dermo (*Perkinsus marinus*), MSX (*Haplosporidium nelsoni*), paramoeba, shell disease, Vibrio, Bumper car disease (*Anophrhyoides haemophilia*), and Gaffkemia (*Gaffkya homari*). All of the states are restoring degraded tidal wetlands and some states have monitoring programs to evaluate the health of wetlands. Common wetlands concerns include invasive species, wetland loss due to accelerated sea level rise, sudden vegetation dieback and unique to western Long Island Sound is long-term submergence (i.e., conversion of low marsh to intertidal flat). The oceans absorb about 25% of the CO^2 emitted to the atmosphere. CO^2 dissolves in seawater to form carbonic acid which causes seawater to become corrosive to shells and skeletons. The monitoring and effects of this phenomenon called ocean acidification is a national priority.

All of the northeast region states coastal management programs are making inroads in Ocean Management and Ecosystem Based Management; the leading states are Massachusetts, Rhode Island and New York. Regardless of the status of these planning initiatives, all of the states need spatial data and environmental monitoring of ecosystem status and health. A regional workshop was held in May 2009 to discuss the role of and need for Coastal & Marine Spatial Planning (CMSP) in the northeast. NROC is sponsoring a second workshop in the fall of 2009 to further identify the MSP needs and potential partnerships. "Implement comprehensive, integrated, ecosystem-based coastal and Coastal & Marine Spatial Planning and management in the United States" is one of the nine priority objectives in Interim Report of the Interagency Task Force (Interim Report of The Interagency Ocean Policy Task Force, 2009).

a) Product Areas

Maintaining the existing core observational and modeling capacities is that support coastal hazards planning and response is a priority. This includes but is not limited to:

- buoys that collect data (e.g., temperature, salinity, currents, wind, light, nutrients, dissolved oxygen)
- HF radar collecting surface current data

NERACOOS will maintain, operate and distribute data from three existing buoys that measure wind speed and direction, circulation, salinity, temperature and dissolved oxygen. Two buoys will be located in western Long Island Sound (LIS) for the entire year. Both buoys will be equipped with three YSI sensors to measure conductivity, temperature, pressure and dissolved oxygen concentration. All will be also be equipped with acoustic Doppler current profilers. A third buoy will be located in Block Island-Eastern LIS station and will be equipped with nutrient sensors. All LIS buoys will be partnered with current meters mounted on bed frames and data will be delivered to shore by acoustic modems and satellite telemetry.

NERACOOS will operate and maintain five real-time buoys (B, E, I, M, and N, see Figure 6) as the main part of the Gulf of Maine buoy array. An additional buoy (A, in Massachusetts Bay) will be operated under separate funding and integrated into the NERACOOS system. As in previous years, UMaine will seek additional funds to support Buoy F in Penobscot Bay.

NERACOOS will also maintain continuity of the data record from a mooring in the Great Bay Estuary that has been deployed during ice-free conditions (April to early December) since 2005. This work will also include wintertime operation of a water sampling station at the UNH Coastal Marine Laboratory while the Great Bay mooring is out of the water for icing protection (December to April).

The priority areas for enhancements include:

1. observations and forecast tools for the onset and distribution of Harmful Algal Blooms (HAB),
2. evaluation and demonstration of nutrient sensor deployments,
3. deploying two buoys in Rhode Island waters to collect weather, water quality and wave data as part of their ocean planning initiative, and
4. deploying two sensors to measure ocean acidification.

The Bedford Institute of Oceanography (BIO) will analyze in situ phytoplankton samples in the Gulf of Maine sub-region and compare these to contemporaneous remote sensing (ocean color) data. The Atlantic Zone Monitoring Program (AZMP) spring and fall missions will be extended to sample ten stations across the Northeast Channel (Figure). A subset of the AZMP variables, including nutrients, will be sampled, and nutrient fluxes will be calculated.

The University of Rhode Island (URI) has a long-term goal of obtaining and analyzing in-situ, time-series measurements of nutrient concentrations by deploying commercially available sensors at key NERACOOS locations and time periods. To accomplish this, URI has established a nutrient sensing facility in the Center for Marine and Atmospheric Chemistry, located on the campus of the URI Graduate School of Oceanography. The plan is that the URI nutrient sensing facility would ultimately oversee the care-taking, analytical calibration, operation, deployment and data processing for in situ nutrient sensors deployed on

moorings, and other observation platforms. This nutrient monitoring effort will begin in Long Island Sound and ultimately extend to other locations in the NERACOOS region, as sufficient funds from NOAA and other agencies become available. Four commercial nutrient sensors have been acquired and are being evaluated:

1. Submersible Ultraviolet Nitrate Analyzer (SUNA - Satlantic, Inc.)
2. CYCLE-P phosphate analyzer (WET Labs, Inc.)
3. ChemFIN nitrate/nitrite analyzer, (SubChem Systems, Inc.)
4. Autonomous Profiling Nutrient Analyzer (APNA – SubChem Systems, Inc.)

In addition, four Envirotech Ecolabs and a Satlantic ISUS nitrate sensors have been loaned by EPA to The University of Connecticut through a cooperative agreement with NERACOOS for deployment in Long Island Sound and the URI group will support this activity.

These nutrient sensors will be deployed on four platforms in the NERACOOS region including a LISICOS buoy, Great Bay buoy, Martha's Vineyard Coastal Observatory and URI Bay Campus pier. The laboratory autoanalyzer will be used for verification analyses on collected water samples. The URI nutrient sensing facility also has a bench-top laboratory autoanalyzer system, on loan from Astoria-Pacific, Inc., for conducting nutrient validation measurements on water samples that have been collected. Technical support for the utilization and deployment of the ChemFIN and Cycle-P sensors is partially leveraged by two FY'08 NOPP projects that were awarded to SubChem Systems and WET Labs.

Two buoys will be deployed in the waters of Rhode Island to support the new Ocean Special Area Management Planning initiative of the Coastal Resources Management Council. These buoys will collect weather (air temperature, air pressure, wind speed, wind direction), water quality (water temperature, salinity, dissolved oxygen), light and wave data. The buoys will be deployed and maintained by the University of Connecticut.

Products contingent upon 2010 funding:

- A pilot project is proposed to demonstrate standards-compliant real-time delivery of water quality indices and velocity profiles from existing ferry-based sampling systems in LIS and GoM. URI will deliver velocity profile product to NERACOOS. The ferry traveling from Boston to Provincetown will be instrumented by WHOI with a basic senor and real-time telemetry package.
- A national priority for NOAA is the study of ocean acidification and the Pacific Marine Environmental Laboratory will provide the pCO^2 sensors for a regional deployment in the northeast. The sensors will be deployed at Buoy N (NE channel) and the UNH Coastal Marine Laboratory.
- In support of Ecosystem Approaches to Management, WHOI will extend NEBO to test sites containing epi-benthic communities critical to commercial fisheries.
- The University of New Hampshire will implement the NH Coastal Model in a watershed to include modeling stream flow and developing river discharge and nutrient forecasts (identified as a priority by NECOFS group).
- The Satellite Oceanography Data Lab of the University of Maine will continue to provide sea surface temperature, chlorophyll concentration, sea wind and true color products derived from satellite imagery. The geographic area will be expanded to include southern New England to the New York Bight.
- Deploy 4 Envirotech Instruments Ecolab sensors in LIS to study mixing and nitrate variability. Construct and deploy two buoys to record water quality data including dissolved oxygen and nutrients at shallow water locations. These buoys would be deployed seasonally in southern New England.

- Restore two buoys to the GOM array and support for the central LIS buoy
- The existing UNH wave observation buoy at Jeffery's Ledge would be supported.
- Construct and deploy drifters from ship-of-opportunity to evaluate model predictions.
- Support will be provided to continue the HAB ship surveys and an Environmental Sampling Processor (purchased for NERACOOS by EPA through WHOI) will be configured for red tide cell and toxin detection and deployed on a new specialized mooring in spring 2011 near GoM Buoy B. The Boston ferry will also collect water samples that will be examined, as needed, for the presence of red tide organism *Alexandrium*. In order to further assist in the prediction and diagnosis of HAB events, routine drifter deployments will be conducted at select locations around the GoM coordinated by NOAA NMFS. BIO will perform weekly shipboard sampling at five fixed stations from May to October and validate high resolution ocean color imagery (MERIS) through direct measurements of surface water optical properties.

2) Ocean Energy

The last decade has brought an ever increasing number of energy transmission and telecommunications proposals in the coastal and ocean environments of New England. The ocean equivalent of the key spatial planning datasets that support land planning and development are topography, bedrock geology, and surficial materials; unfortunately these maps do not exist, provide spotty coverage, or are not of sufficient vintage or scale to be useful. Ocean energy planners and regulators cannot make informed decisions regarding energy proposals absent high resolution bathymetry, marine geology, sedimentary environment and seascape maps. This need was identified the NROC at its first council meeting related to traditional energy proposals such as cables and pipelines. The 2007 New England Governors' Coast and Ocean Action Plan identified alternative energy as an emerging focus for energy planning. "In addition to details on the short and long-term effects of energy (alternative) technologies based upon wind, wave, and current, there is a critical need for baseline information on the coastal and ocean environment for which they are proposed, or may be proposed. Core data on bathymetry, seafloor geology and biota, current and hydrodynamics, wind patterns, distribution of natural resources, and current and future uses will fuel the strategic thinking on the siting of facilities where the renewable sources have the greatest potential and so that adverse effects can be minimized or eliminated." (NROC, 2007). It has been noted that some of the nation's best wind fields for turbines is the northeast ocean.

Together with NROC and MOP, we have begun integrating the required information with a proof of concept on our website (www.neracoos.org/products/wms) which includes the WMS output from individual state planning efforts, relevant NECOFS modeled information, bathymetry, etc. Additionally, NERACOOS has the ability to provide baseline observations, to play a unique role in placing observation instruments on wind farm structures and to recommend monitoring protocols to be implemented on offshore platforms, as well as to develop modeling studies to develop an understanding of cumulative impact.

At the present time, two NERACOOS buoys are operating in Block Island Sound funded by the RI wind power initiative. In addition to the standard measurement suite, passive acoustics for monitoring marine mammals and bats were added to help evaluate the impact wind farms would have on these protected species. UMaine has recently received a major DOE grant ($8M) for the establishment of a center for offshore wind technology testing and development. The suitability of Maine state waters for this center was established using wind, wave, and current climatologies constructed from the eight-plus years of operational

IOOS data from the GoM array. As part of this project, a NERACOOS GoM-style monitoring buoy will be deployed in the test site for two years, and the standard data will be supplied in real-time to the public via the NERACOOS website. The ability to establish a “calibrated” test site was crucial to the success of the offshore wind technology center.

a) Product Areas

Sustaining the existing core observational and modeling capacities that support ocean energy planning and response is a priority. This includes but is not limited to:

- buoys that collect wind data
- buoys that collect ecosystem data and thus support CMSP

NERACOOS staff will actively participate in regional planning meetings, with regulators, developers and other stakeholders, to provide guidance and establish partnerships to enhance observations and data sharing. The Ocean Energy Planning and Management (OEPM) Standing Committee of NROC will be hosting a two-day workshop in October 2009 to focus on Coastal & Marine Spatial Planning (CMSP) needs to support ocean energy planning for alternative energy and to minimize impacts from the siting of cables and pipelines. NERACOOS will participate in this workshop and discuss with NROC potential partnerships such as in sponsoring additional workshops or conducting user needs survey related to ocean observations.

3) Coastal Hazards Resiliency

A goal of NROC is to "…Render New England a ‘Coastal Hazards Ready’ region by providing existing federal, state, and municipal programs with state-of-the-art data and tools to advance planning and response to storms, shoreline erosion, and coastal inundation due to projected sea-level rise from global warming." (NROC 2007). Coastal hazards are a subset of other natural hazards such as wind, flood, erosion and seismic as the related to a specific coastal geography. These hazards can occur individually or simultaneously via storms such as nor'easters and hurricanes. This priority area addresses three of seven IOOS societal goals. .

An emerging issue for the region is the recognition that the impacts of climate change will likely exacerbate the effects of coastal hazards which threaten many coastal communities, recreational areas and infrastructure. These coastal areas are important revenue generators for the region as they are popular tourism areas and recreation areas such as beaches. The Union of Concerned Scientists note that hurricane intensity is forecast to increase with the warming of the oceans and that nor'easters have shifted northward since the 1970's striking New England with great frequency and intensity (Frumhoff, McCarthy, Moser, & Wuebbles). A recent bout of nor'easters in Long Island Sound caused considerable loss of public beach at CT's most popular and primary park revenue generator Hammonasset Beach State Park. The 2007 Patriot's Day Storm caused extensive shoreline erosion and flooding to the Gulf of Maine states. Despites these events, coastal and ocean observations can play a critical role in mitigating adverse impacts. For example, GoMOOS used the Coastal Flooding and Erosion Forecast model which predicted days in advance that there was a likelihood of shoreline damage. In addition, the Mid-Atlantic Region demonstrated accurate storm forecasting for tropical depression Ernesto by combining sea surface temperatures with a high resolution atmospheric model. As a result, the regional New Jersey utility company could pre-deploy equipment and man-power to reduce cleanup time saving cost for the utility and providing rapid power restoration for its customers.

IN short, the National Weather Service, Coastal Managers, Hazards Mitigation officers and Utility companies rely upon regional and national observation assets such as stream gages, tide gages, wave buoys to predict the severity of approaching storms, anticipate storm damage and pre-deploy equipment and staff for post disaster cleanup.

a) Product Areas

Maintaining the existing core observational, data delivery, and modeling capacities that support coastal hazards planning and response is a priority. This includes but is not limited to:

- buoys that provide providing weather and wave data and HF Radar providing real-time surface current data
- maintaining forecast capacities such as the Northeast Coastal Ocean Forecast System (NECOFS), surface wave forecasts and nowcast, and the Coastal Flooding and Erosion Forecast tool.

BIO will maintain its operational regional wave model system for the Gulf of Maine sub-region. This activity includes (1) continuous error-checking throughout the model system, implementing patches and bug-fixes as reported by the model-user community, as they become available; (2) resolution of mix-ups in winds from the Fleet Numerical Meteorology and Oceanography Center (FNMOC); and (3) computer maintenance to ensure continuous operation of the operational wave forecasts.

The priority enhancement includes improvements to NECOFS, adding the high-resolution subdomain finite-volume coastal ocean model (FVCOM) to provide 3-day forecasting to the waters of Massachusetts, adding the new unstructured-grid surface wave model (FVCOM_SWAVE) forecast, and configure a subdomain model for Scituate. A thorough analysis of the field network systems requirements and providing the design of an operable NERACOOS test bed that can be used not only to enable the operational inundation forecast application, but to advance our understanding of the emerging science of observing system design and architecture.

The desired outcomes of the forecast system include (1) warning of coastal flooding on an event timescale in order to facilitate evacuation and other emergency measures to protect human life and property in the coastal zone and (2) accurate estimation of the statistics of coastal inundation in order to enable rationale planning regarding sustainable land-use practices in the coastal zone. End users include weather forecasters, emergency management planners and managers, policymakers and land-use planners in federal, state, and local government agencies and private industry.

Products contingent upon 2010 funding:

- Coastal inundation predication will be added for two new sites (to be determined, but ideally sited to provide balance throughout the region.)
- UMass will hold a workshop regarding the inundation model.
- The NECOFS inundation tool will be extended for street-level inundation.

4) Maritime Safety and Security

This theme is directed towards the support of products for enhancing safety and security in the coastal ocean adjacent to New England. Mariners routinely consult data from buoys in the region and National Weather Service Forecasts before leaving land. While recognizing that the National Weather Service carries the primary responsibility for forecasting weather conditions, there is a long tradition of cooperation between forecasters and observers. The Report of the May 2009 NERACOOS Strategic Planning Team recognized that sustaining and expanding the regional data sources that are integral to forecasting as part of any multi-use array was of high priority to the Maritime Safety and Security mission. When accidents do occur, the U.S. Coast Guard is the agency that coordinates Search and Rescue (SAR) operations for ships and sailors at sea. Search planning is supported by an information management system called Search and Rescue Optimal Planning System (SAROPS) that uses measurements of ocean and atmosphere conditions to optimize the probability of successful rescues. Though the last known position and physical characteristics of the search target are crucial, SAR success is improved by knowledge of the wind and surface current velocities. The water temperature influences the survival duration of a person in the water and the sea state and visibility control the effectiveness with which targets can be located so these are also important variables in SAR. The availability of surface current measurements in by HF RADAR systems has recently been demonstrated to enhance search planning and the U.S. Coast Guard has incorporated both observations and short term forecasts into SAROPS. However, the system is limited by the availability of instrument systems. The NERACOOS HF RADAR Gap Analysis outlines the regional infrastructure required to provide surface current observations and predictions throughout the region.

a) Product Areas

Maintaining the existing core observational and modeling capacities that support maritime safety and security is a priority. This includes but is not limited to:

- buoys that provide providing weather, wave, current, visibility and water temperature data,
- HF Radar providing real-time surface current data,
- forecast capacities such as the Northeast Coastal Ocean Forecast System (NECOFS), surface wave forecasts and nowcast.

Planned enhancements include (1) the restoration of the wind, and wave monitoring infrastructure to the 2006 level; (2) augmentation of the US Coast Guards surface current forecasting Short Term Prediction System (STPS) capability by integration of the HF RADAR data based forecasting tools and the North East Coastal Ocean Forecast System model predictions to the US Coast Guards environmental data system; and (3) assessing the skill of these surface current forecasts products in the NERACOOS region.

UMaine will operate a high-frequency radar (CODAR) array in the eastern Gulf of Maine. Three long-range CODAR units will be operated on Greens Island (off Vinal Haven ME), Grand Manan Island (New Brunswick, Canada) and Cape St. Mary (Nova Scotia, Canada). These three units will be integrated with the several units owned and operated by the Canadian Coast Guard in southeastern Nova Scotia as part of a SAR Array. The combined array will cover the eastern Gulf of Maine from Penobscot Bay to southeastern Nova Scotia (Figure XX). A trial will be run at the Cape St. Mary site to test the effectiveness of running a long-range unit with dual transmitters. This arrangement should allow the two transmitters to operate like a mini phased array and could increase substantially the

effective range of the system. Increased range at this central site should greatly improve the modest coverage that has been achieved to date.

The high-resolution subdomain FVCOM will be added into NECOFS for Massachusetts waters and this will provide the 3-day forecast with a horizontal resolution of 20-25m spatially detailed output (described under Coastal Hazards Resiliency section above) requested by The US Coast Guard 1st District (Boston) for Search and Rescue planning.

NERACOOS will provide support in the form of buoy, drifter, HF radar and modeling for the Spill of National Significance scheduled for March 2010.

Products contingent upon 2010 funding:

- Develop short term prediction system for surface currents in the Gulf of Maine and integrate into SAROPS.
- Initiate of the operational CODAR-based forecast tool for the GOM to enhance USCG SAROPS.
- UMassD will add surface visibility and ceiling forecasts for NWS Gray and Taunton WFO's and 1st District USCG.

B. Data Integration Framework

A robust, scalable and cost effective regional Data Management and Communications (DMAC) infrastructure is a critical component of NERACOOS, enabling and supporting efficient development and delivery of a suite of sophisticated and interoperable decision support and analysis tools. Implementing and sustaining a successful DMAC system depends on the robustness of its components and the effective implementation of them throughout the region. NERACOOS DMAC efforts will be led by the NERACOOS DIF team and all NERACOOS observing and modeling partners will provide information via IOOS DIF compliant protocols. The NERACOOS DIF work will be integrated with the Northeast Coastal and Ocean Data Partnership (NeCODP). The NERACOOS/NeCODP collaboration will bring into NERACOOS the wide range of non-IOOS funded routine observations collected in the region, providing a broad spatial and temporal context for interpreting data and model assimilation.

The near-term goal for the DMAC system is to achieve 100% compliance in the implementation of IOOS-recommended DIF standards. The NERACOOS DIF team will provide assistance to partners to ensure we reach this goal. We propose to expand DIF-compliant data access across the region to diverse datasets by the continued development and deployment of easy-to-use software toolkits in a variety of implementation languages. These software toolkits will also help other regions and international partners deliver data via standards-based services, thus enabling integration on a national and international scale.

NERACOOS has demonstrated success in implementing a regional DIF Sensor Observation Service (SOS) observation capability. Regional modelers and the DIF team will continue their implementation of CF compliant OpenDAP and Thematic Realtime Environmental Distributed Data Services (THREDDS) DIF standards. This will allow NERACOOS to efficiently develop model comparison products and support the efficient delivery of model output and integration of new models as they become available. NERACOOS will continue to actively participate in the national and regional DIF implementation team working groups to evaluate, test and enhance the existing standards. Additionally, we'll continue to participate

in community efforts designed to advance DMAC efforts of the IOOS such as the Open Geospatial Interoperability Experiment II.

Regional scale integration of the many diverse data sources and modeling efforts has also been highlighted by the water quality management community both nationally and regionally. NERACOOS has supported the continuing partnership between the State of Connecticut DEP and UConn to provide access to the database of water quality measurements acquired in LIS in the last 20 years. The EPA has also funded the NeCODP Exchange Network program (ODPX) through NHDES to implement data sharing by multiple partners. To expand these capabilities and provide access to water quality data in all the states, NERACOOS partners will contribute to a proof-of-concept project for utilizing web services to access and integrate watershed and coastal ocean data with common standards (WQX, ODPX, and IOOS DIF) using Open-Geospatial Consortium compliant tools to serve analysis results. For this project, to be coordinated for NERACOOS by GoMOOS, data and model results will be integrated from USGS, EPA, National Estuaries Programs (NEPs), states, provinces, NERRS, DFO, Environment Canada, and academia to provide a single point of access for regional nutrient information for water quality managers and researchers. This effort will help integrate IOOS and the National Water Quality Monitoring Network which, it is anticipated, will also provide funds for this. The integration effort will result in a region-wide indicator/estimator of land-based nutrient loads to coastal estuaries and embayments, and a simple estimator of median nitrogen concentrations for basins which have no data or sparse data.

NERACOOS Website

In the summer of 2009, the NERACOOS SPI and DIF teams developed a set of requirements for a new NERACOOS web presence that would achieve the following goals: demonstrate the leading edge capabilities of the region, inform the public about NERACOOS, and display and consolidate and deliver regional model and observation data to stakeholders.

The resulting NERACOOS website consists of several key cutting-edge products that integrate various data streams and models in an effort to bring a more complete view of observations and forecasts to regional stakeholders in an easy to use website. The website also includes key project information, data and web services, focus areas, education and outreach, calendar of events, general NERACOOS information and contact lists for staff and teams.

The anticipated audience for the NERACOOS.org website includes a variety of users with different needs, therefore the messaging focuses on ease of use and ability to access desired information, regardless of the user. This was achieved through user-friendly menus, search functionality and content organization.

The real-time data map integrates real-time observations made available via web services from a multitude of partners throughout the NERACOOS region. These partners include UMaine, UConn, UNH, MVCO, URI/SAMP, Bowdoin College, Environment Canada and NOAA (NDBC, CMAN, NERRS and NOS stations). The product utilizes Google Maps technology and provides real-time data from all available platforms as well as 12-hour trend charts for each parameter.

The Map and Model Viewer is a web-mapping interface that integrates and displays WMS (web mapping service) layers available in the region. The available layers include model output of hindcast/nowcast/forecasts for parameters such as wind, currents, temperature,

salinity and tides. Additionally, geospatial map layers (such as shipping lanes, protected areas, pipelines) are available and are useful for marine spatial planning.

C. Education and Outreach

The Education and Outreach (EO) Working Group conducted a poll of the members of the seven working groups to identify the key audiences. The three largest audiences identified as Accountability Seekers (AS) are Government, Media and Public. Each has very different needs, and therefore requires unique strategies and messages for successful EO efforts. Specific sectors should be handled differently. Some of the sub-groups require specific contact - media, for example managers, industry and government need to be met on their own turf such as at conferences, conventions and meetings. Lobbyists are best approached individually. There are several ways that others have successfully worked with the AS audience and NERACOOS should consider these models for its own communication strategy: Mass Ocean Partnership, Mass Ocean Plan, COMPASS, San Diego Coastkeeper Wiki, and One NOAA Science Seminars. Specific talking points need to be developed for NERACOOS representatives for use when meeting face-to-face with AS audiences.

Survey takers recognized that the "Ocean Literacy" (OL) audience is very different than the others in terms of who they are, what messages are appropriate for them, and their relative importance. Based on survey results, the OL audience is dominated by informal and formal education. Formal education included K-12 and college level audiences. The survey takers' relatively low prioritization of OL audiences indicates that it is in NERACOOS's best interest to partner with entities whose highest priority and expertise are improving OL. Examples include Sea Grant Educators and Extension staff, New England Ocean Sciences Education Collaborative (NEOSEC), local chapters of the National Marine Educators Association, and the Centers for Ocean Sciences Educational Excellence. One of the first priorities for NERACOOS is to craft its own set of public relations messages and post these on their website and in other outreach materials that will distributed to the public. The true OL content is contained in the following two messages synthesized from survey responses: "*We're all connected to the ocean*" and "*Ocean and coastal change has relevant - and sometimes dramatic - impact on people.*" NERACOOS needs to take on the challenging task of crafting messages that spark interest to leave the audience "wanting more" but are not so generic that they apply to any entity doing ocean research and education

A dynamic and interactive website would be helpful in many aspects of NERACOOS EO. NERACOOS look to effective models of website designs that deliver science data and other content (e.g., GoMOOS, National Weather Service). The website would be a good location for "streaming" messages such as the synthesized messages identified by the EO team from the "Audience Identification, Prioritization & Quantification" survey. NERACOOS might consider cultivating a community of engaged participants by using "new media" such as e-newsletters, listservs, blogs, and other virtual networking tools. However, it is critically important to make sure that whichever of these tools is used includes a plan for sustainability. NERACOOS should consider dedicating specific web pages to important OL audiences (e.g., below a navigation button entitled "Ocean Literacy"). Alternatively or perhaps, in addition, pages content could be designed to mirror the OL messages. NERACOOS should adopt specific OL "messages" and repeat these on various pages with links back to the "OL message" pages.

D. Performance and Evaluation and Societal Benefits

Performance measures are required to ensure adherence to IOOS design principles (see section 2.2 (Ocean U.S., 2006). Measures fall into two categories names systems performances and user satisfaction. For the later, considerations include but are not limited to quantity and quality of data received from observation stations, importance of date to the end user and societal values. The new NERACOOS website was launched in August 2009 and website activity is a primary means of delivering data to end users and a primary means to track value to end users. A feedback form will be added to the website to solicit user's opinions about how the website can be improved.

System performance includes measures such as data quality, continuity of data streams, data flow to models. NERACOOS has much experience with a WHOI led project to integrate the recommendations of Quality Assurance of Real-Time Oceanographic Data for waves and current observations. This project is developing tools and guidance for data providers to integrate QA/QC data and process descriptions into a SWE compliant SOS. Eventually this guidance will be implemented by the IOOS DIF but the many NERACOOS SOS's will serve as a testbed for the initial implementation and eventual use by client applications of these data.

IV. The Northeast IOOS

An integrated ocean and coastal observing contains three major subsystems namely observations, models, and data management and communication. Many of the core capacities are multi-use, cross cutting several if not all theme areas, and as such are critical components. The existing capacity of NERACOOS for these subsystems is described below.

A. Observations

NERACOOS delivers and integrates real-time coastal and ocean observations from various partners, academic institutions and federal agencies via their website (www.neracoos.org). Real-time data are provided by:

- NERACOOS Gulf of Maine Array (previously supported by GoMOOS) and operated by the University of Maine. This includes buoys funded by NERACOOS as well as Buoy A supported by the LNG mitigation funds from Massachusetts and Buoy F supported directly by the University of Maine.
- NERACOOS Long Island Sound Array operated by the University of Connecticut includes four buoys and four fixed pilings.
- NERACOOS Great Bay Coastal Buoy operated by the University of New Hampshire and three additonal buoys in the Gulf of Maine.
- Martha's Vineyard Coastal Observatory (MVCO) operated by Woods Hole Oceanographic Institute.
- Coastal Data Information Program (CDIP) of Scripps Institute of Oceanography wave buoys, one off Block Island supported by the Army Corps of Engineers and another on Jeffrey's Ledge supported by the University of New Hampshire (UNH).
- CO^2 buoy off the Isles of Shoals operated by UNH in conjunction with the NOAA Pacific Marine Environmental Laboratory.
- National Estuarine Research Reserves support water quality monitoring under the System-wide Monitoring Program at four locations.
- Bowdoin College operates a single buoy in Harpswell Sound
- National Data Buoy Center (NDBC) of NOAA operates twelve buoys and three observation stations at lighthouses.
- Environment Canada (EC) operates three buoys on the Scotian shelf.
- Tide gauge information delivered in real-time are provided by the NOAA Center for Operational Ocean Products and Services (23), United States Geological Survey (11), and U.S. Army Corps of Engineers (4).
- NOAA Center for Operational Ocean Products and Services also supports two Physical Oceanographic Real-Time System (PORTS).

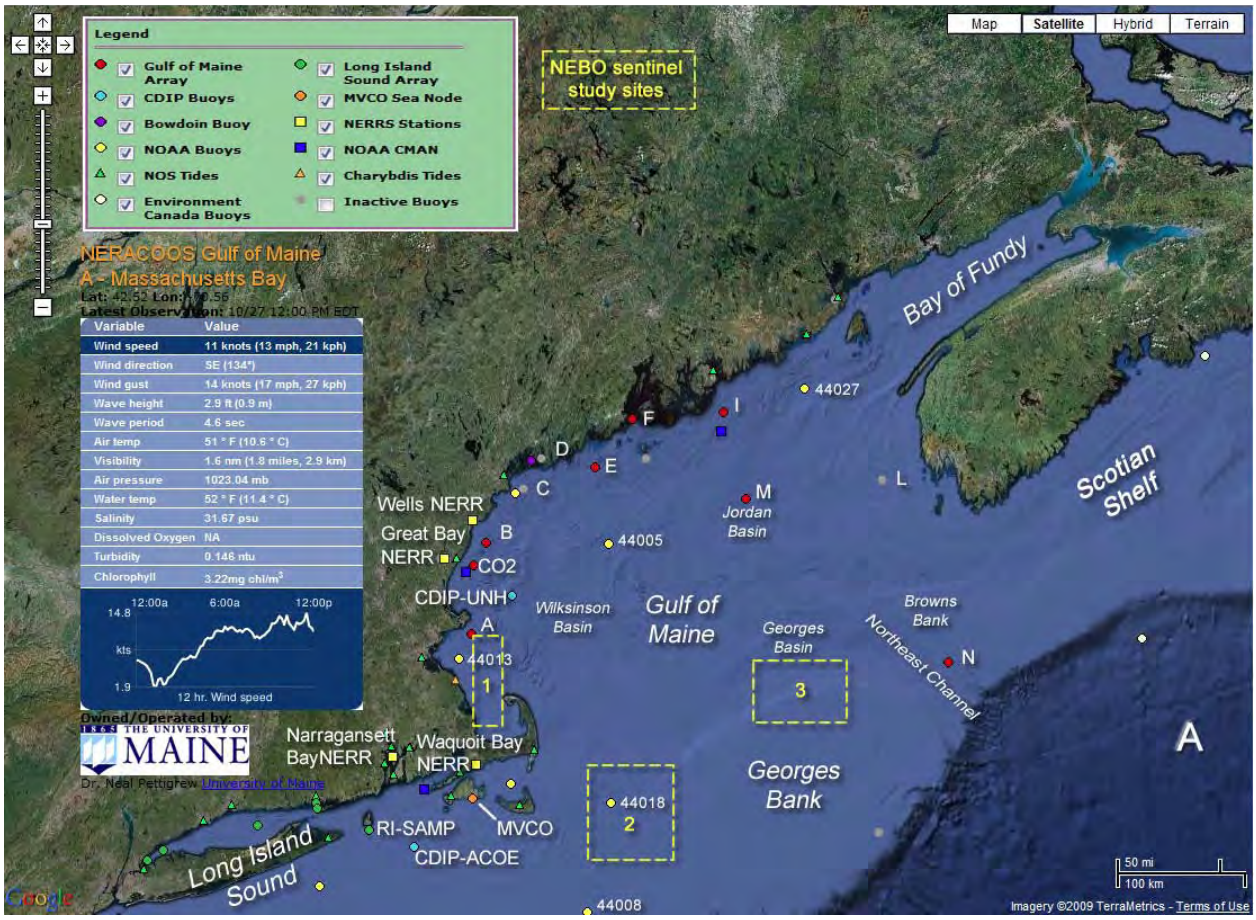

Figure 7. Map of the Northeastern Region with selected observing assets.

The observations (not including tide gauges) provided by the regional and integrated into the NERACOOS website are summarized in table I.

OBSERVATIONS	LISICOS	MVCO	GoMOOS	UNH	Bowdoin	NOAA	NERRS	CDIP	EC
dissolved oxygen	R			R	R		R		
water temperature	R		R	R	R	R	R	R	R
salinity	R	R		R	R		R		
wave	R	R	R	R	R	R		R	R
wind	R		R	R	R	R	R		R
air temperature	R		R	R	R	R	R		R
barometer	R		R	R		R	R		
light	R			R	R				
Infrared radiation	R								
sonic wind	R								
current profile	R								
visibility			R						
HF Radar (surface currents)	R		R						

Table 1. Observations integrated into the NERACOOS website

A variety of shipboard surveys in the region compliments the buoy data and includes the following:

- the Bedford Institute of Oceanography (BIO) in the Gulf of Maine conducts shipboard surveys in the GOM to provide information on harmful algae blooms and oceanographic surveys to monitor oceanic inputs to GOM,
- the Canadian Department of Fisheries and Oceans implements the Atlantic Zone Monitoring Program which includes seasonal and opportunistic shipboard surveys along eleven stations recording biological, physical and chemical properties,
- the Northeast Fisheries Science Center conducts bottom trawl surveys of Northwest Atlantic marine organisms to delineate the species composition, geographic distribution, and abundance of living resources,
- the UNH Coastal Ocean Observation Center Wilkinson Basin and Coastal transect surveys collecting a comprehensive suite of discrete and profiling data at sixteen stations between 2005 and July 2009. This was discontinued due to insufficient funding.
- the National Undersea Research Center at the University of Connecticut has been using remotely operated vehicles equipped with camera and most recently high definition video to record the spread of invasive species, documenting habitat types in Long Island Sound and maritime heritage at Stellwagen Bank,
- the Department of Environmental Protection conducts water quality surveys at 17 stations once a month, except during the summer hypoxia period, when biweekly surveys are conducted, and
- the ferries in Long Island Sound at Brideport/Port Jefferson and New London/Orient Point have been equipped with GPS and instruments to record weather, water quality and current information.

Historically, satellite remote sensing has been directly supported as a regional IOOS activity but there are currently insufficient funds to maintain this effort.

- BIO obtains MERIS imagery to coincide with regular shipboard surveys in the northern Gulf of Maine. These data, commencing 25 May 2008, are served internally at BIO for scrutiny and analysis.
- UMaine processes and distributes satellite SST, ocean color, true color and QuickScat winds through the UMaine website.
- UNH processes and serves MODIS chlorophyll-a and sea surface temperature (SST) imagery to provide the daily satellite data source for the ECOHAB red tide monitoring forecast system as part of NOAA-funded GOMTOX program.

B. Model capacity and analysis

The operational model and satellite products are important and visible aspects of NERACOOS. The hindcast/forecast models incorporate the real-time weather and ocean data being collected by the NERACOOS and other platforms in the region to improve their model accuracy. The output products of these components have a wide variety of applications, ranging from providing a spatial/temporal synthesis of in-situ data collected by fixed (moorings) and/or moving (shipboard, gliders) platforms, to providing forecasts of hazardous conditions (severe weather, waves and seas, HAB).

The Northeast Coastal Ocean Forecast System (NECOFS) of the University of Massachusetts at Dartmouth is a full marine environmental hindcast/forecast model for the Scotian Shelf/Gulf of Maine/Georges Bank/New England shelf region. It contains three core model components the NOAA National Center for Atmospheric Research Weather Research and Forecast (WRF) mesoscale weather model, the Finite-Volume Community Ocean Model (FVCOM) – SWAVE incorporates the Simulating Waves and Nearshore (SWAN) and FVCOM. Outputs from this model include air temperature, sea level pressure, relative humidity, surface heat flux, precipitation, salinity, water temperature, density, sea surface and icing.

Wind and wave forecasts are provided by the Bedford Institute of Oceanography using the Wave Watch III model of NOAA National Weather Service (http://polar.ncep.noaa.gov/waves/wavewatch/). This provides the most probable wave height and direction of the largest wind driven waves and sea state (choppy, swells) for the next 48 hours in Gulf of Maine and is updated twice daily. Additionally, researchers at Texas A & M University at Galveston produce Gulf of Maine wave predictions (http://www.tamug.edu/mase/Wave_file/wave%20simulations.htm). These forecasts are for the following areas: Penobscot Bay, Machias Bay, Saco Bay, Massachusetts Bay, Portsmouth, Muscongus Bay, and Pleasant Bay. NERACOOS has recently implemented a new wind and wave forecast for 24 buoys in the Gulf of Maine and Scotian Shelf.

The ADvanced CIRCulation (ADCIRC) for oceanic, coastal and estuarine waters is a daily surge hindcast forecast run forced by NAM and is provided by the University of North Carolina (http://www.openioos.org/realtime/index.html?map_type=water). "ADCIRC is a system of computer programs for solving time dependent, free surface circulation and transport problems in two and three dimensions. These programs utilize the finite element method in space allowing the use of highly flexible, unstructured grids. Typical ADCIRC applications have included: (i) modeling tides and wind driven circulation, (ii) analysis of hurricane storm surge and flooding, (iii) dredging feasibility and material disposal studies, (iv) larval transport studies, (v) near shore marine operations."

Gulf of Maine Ocean Circulation Model (GoMPOM) is provided by the University of Maine and serves a real-time nowcast/forecast circulation model that is based on the Princeton Ocean Model (POM). Outputs from this model include sea level, water temperature and velocity, and salinity and velocity (http://rocky.umeoce.maine.edu/GoMPOM/). This circulation model is combined with a biological model to provide seasonal summaries regarding phytoplankton, nitrates and silicates.

C. Data Management and Communication

The third subsystem of an IOOS is the Data Management and Communication (DMAC) component. An efficient and effective DMAC subsystem '*… provide the services and infrastructure required to link observational data to the modeling, analysis, and decision-support services that will use the data to provide products to support national needs*' (NOAA IOOS Program, 2009). The DMAC subsystem enables the following functions:

- Data transport
- Data assembly and quality control
- Data access including data discovery, metadata management, data extraction tools, online browsing, and modeling
- Data storage
- Data archiving and
- Information assurance

The NOAA IOOS Program Office has initiated an initiative, the Data Integration Framework (DIF), to test NOAA's ability to integrate data in the current environment and to validate that the integration provides measurable benefit for seven variables (temperature, salinity, sea level, surface currents, ocean color and waves) (NOAA IOOS Program, 2009). NOAA's goal is to get the Regional Ocean Observing Associations to become DIF compliant for these variables. These data must be delivered via Sensor Observation Service (SOS) for in-situ and historical observations, Web Coverage Service (WCS) for gridded data, climate and forecast compliant Data Access Protocol (DAP) for model output and observations and Web Mapping Service (WMS) for data images.

All four of NERACOOS' priority areas will be impacted by the state of the region's DIF infrastructure for data and model sharing and inoperability. A modern and scalable infrastructure built on open standards will enable the cost effective development of cutting edge scientific applications and end user products. A rich history exists among NERACOOS members in promoting, developing and implementing national DIF/DMAC and Open Geospatial Consortium (OGS) standards in the community and this leading experience should be leveraged going forward.

SOS is the recommended standard for sharing real-time ocean observations. A number of NERA observatories have implemented SOS including UMaine/GoMOOS, MVCO, UNH, and Bowdoin. LISICOS implementation of SOS is under development. Other regional observations assets are accessible via SOS either through the NDBC, NOS SOS's or via the Southeast Coastal Ocean Observing Regional Association SOS for the system wide monitoring program water quality data at each National Estuarine Research Reserve site. One outstanding issue which must be addressed is that there is a split in the GetObservation response between the IOOS DIF 0.6 response and the Sensor Web Enablement (SWE) 1.0 response. Work is underway to update the toolkits that NERA observatories used to set up SOS to make them support both output formats. NERACOOS can provide useful guidance for the eventual merger of these two flavors of SOS and to provide an easy path for data providers to get SOS up and running through reference implementations and toolkits.

Some of the NERACOOS SOS's are unique in that they serve a broad range of observations well beyond the 7 DMAC variables including but not limited to chlorophyll, deep water temperature and currents, optics, visibility, dissolved oxygen, and turbidity.

Real-time and historic observations are also served via DAP, GoMOOS, NEFSC, and LISICOS.

A DIF workgroup priority for 2008 was to provide funding to GOMOOS to convert the NERACOOS planning website to an operational from one that focused on planning to a site that provides access to regional data observations, models and services and begins the process of integration of the RCOOS.

Strategic Plan Process

In 2010, NERACOOS will identify products and services to deliver over the next 5-years and modify this plan to become a 5-year Strategic Plan. This will synchronize NERACOOS with the national IOOS schedule to prepare a 5-year strategic plan in 2010. NERACOOS has compiled a list of user needs from various northeast surveys and is proposing a series of workshops in spring 2010 to confirm the completeness and accuracy of this list and seek input as to priorities. The results of this workshops will be used for a meeting in each New England state to educated end users about NERACOOS and solicit input on the priorities.

NERACOOS has a Memorandum of Understanding with NROC to further cooperation between these two regional entities. This will likely include joint meetings of the NROC and NERACOOS workgroups.

NERACOOS will create a dialogue with MACOORA to address the geographic overlap of these two associations to identify which association will be the lead on ocean observations. While New York State is not part of the Northeast Regional Ocean Council, New York does work closely with CT in the management of Long Island Sound. So, at a minimum, NERACOOS needs to develop a mechanism to engage New York with regards to observations made in Long Island Sound. One vehicle for that is the bi-state Long Island Sound Study.

APPENDIX A - Workgroup Membership

NERACOOS 2008-2010 teams and working groups are presented below in table format.

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Appendix B - Bibliography

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Appendix C - Glossary

Cases

AZMP - Atlantic Zone Monitoring Program 18

BIO - Bedford Institute of Oceanography 29

BIO - Bedford Institute of Oceanography 18

CODAR - a patented high frequency radar product 23

DAP - Data Access Protocol 31

DIF - Data Integration Framework 4

DMAC - Data Management and Communications 7

EC - Environment Canada 27

EOWG - Education and Outreach Working Group 5

EPA - Environmental Protection Agency 19

FVCOM - finite-volume coastal ocean model 21

GOM - Gulf of Maine 19

GoMOOS - Gulf of Maine Ocean Observation System 26

GoMPOM - Gulf of Maine Princeton Ocean Model 30

GOOS - Global Ocean Observing System 6

HAB - harmful algae blooms often called red or brown tides 10

IOOS - United States Integrated Ocean Observing System 3

LIS - Long Island Sound 17

LME - large marine ecosystems 8

MACOORA - Mid-Atlantic Coastal Ocean Observing Regional Association 3

MERIS – Medium-spectral resolution, imaging spectrometer 19

MSP – Coastal & Marine Spatial Planning 17

MVCO - Martha's Vineyard Coastal Observatory 27

NDBC - National Data Buoy Center 27

NECOFS - Northeast Coastal Ocean Forecast System 4

NOAA - National Oceanic and Atmospheric Administration 15

Northeastern Regional Association of Coastal Ocean Observing Systems 3

NROC - Northeast Regional Ocean Council 3

NWS - National Weather Service of NOAA 4

OEPM - Energy Planning and Management Standing Committee of the Northeast Regional Ocean Council 4

OL - Ocean Literacy 5

POM - Princeton Ocean Model 30

SAR - search and rescue 22

SAROPS - Search and Rescue Optimal Planning System 22

SOS - Sensor Observation Service 31

SOS - sensor observation service 5

SPI - Strategic Planning and Implementation Team 3

URI - University of Rhode Island 18

WCS - Web Coverage Service 31

WHOI - Woods Hole Oceanographic Institution 19

WMS - Web Mapping Service 31

WRF - Weather Research and Forecasting (Model) 30