The Continued Development of the Northeastern Regional Coastal Ocean Observing System

1. Table of Contents

2. TITLE PAGE

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3. PROJECT SUMMARY

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Project Summary:

This project will continue operation and development of the coastal ocean observing system for the coastal waters of the northeastern United States and Canada. In the last year NERACOOS has partnered with regional groups interested in ocean policy, especially the Northeast Regional Ocean Council (NROC), and executed an extensive process of consultation among a wide variety of users and user groups. Participants have included officials of federal, state and local agencies, scientists, private sector businesses and citizens interested in using and protecting the environment. Through this process we have forged new partnerships to develop data-driven ocean information products and distilled the priority needs of the region. This proposal reflects the priorities developed through this strategic planning process. They fall into four main categories: Marine Operations, Ocean and Coastal Ecosystem Health, Ocean Energy Planning and Management, and Coastal Hazards Resiliency. In addition, the New England States have recognized the need for information products that inform Coastal and Marine Spatial Planning (CMSP), and supporting this need is a NERACOOS priority. Enhancing ocean data

management and public understanding of the ocean are national priorities that remain central themes of NERACOOS. Finally, rational decision making and critical review require evaluation of the effectiveness and value of the systems for which we will develop quantitative approaches that can be applied to observing systems.

At the core of NERACOOS are multi-use instrument systems making measurements in the ocean. They support all the NERACOOS goals. This project will sustain the buoy network in the Gulf of Maine, Long Island Sound and Great Bay. Some of these systems have been deployed for nearly a decade and have documented major changes. The network will be expanded to observe harmful algal blooms and CO_2 concentrations, acquire wind and wave statistics off Rhode Island, establish a program of surface current measurement by drifters, support the delivery of water quality data from Narragansett Bay, and reestablish data acquisition from ferries. We will also develop a program of at-sea sampling to monitor the ecosystem at sentinel sites and support delivery of satellite data products.

To make effective use of the observation network we will continue to operate a distributed data system that uses IOOS standards for data transfer, data discovery, and metadata. We will also support continued development of the Northeast ocean data portal for streamlined access to information, in part to enable regional CMSP. Operational models that provide forecasts of hydrographic conditions, sea level, circulation and wave height and allow spatial interpolation and extrapolation of the observations from the instrument array have proven to be high value to regional users. NERACOOS will therefore continue the support of the Northeast Coastal Ocean Forecast System (NECOFS) and WaveWatch3 models, and the Short Term Prediction Systems (STPS) algorithm for forecasting surface currents. We will also expand capacity of NECOFS by linking it to and supporting hydrological and meteorological models. The data distribution system will be employed to archive model simulations and make them available to the data portal and other users. The data and model products will be used in a series of product development tasks to respond to the requests of users.

To inform the public about the coastal ocean and its value, and to expand the audience for NERACOOS products, we will continue to support the education programs operated through the New England Ocean Science Education Collaborative and the COSEE-OS program.

Partners:

Bedford Institute of Oceanography (BIO)
Gulf of Maine Research Institute (GMRI)
New Hampshire Department of Environmental Services (NHDES)
University of Connecticut (UConn)
University of Maine (UMaine)
RMC Research Corp. (RMC)
Applied Science Associates (ASA)
Gulf of Maine Council on the Marine Environment (GOMC)
University of Massachusetts, Dartmouth (UMassD)
University of New Hampshire (UNH)
University of Rhode Island (URI)
Wells National Estuarine Research Reserve (Wells NERR)
Woods Hole Oceanographic Institution (WHOI)
NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center (NOAA/NMFS/NEFSC)

4. PROJECT DESCRIPTION

a. Background

The northeastern region extends from the Canadian Maritimes to Long Island Sound (Appendix Map 1), connected over its coastal shelf and slope by a southwestward-flowing current originating in the Gulf of Saint Lawrence and Labrador Sea. The region is diverse. The watershed of the Gulf of Maine (GoM), one of the most biologically productive of the world's coastal seas, spans 178,000 km^2 and is home for 6 million Americans and 1 million Canadians. More than 8 million people live in the watershed of Long Island Sound (LIS). The region is situated at a bio-geographical boundary sensitive to climate variability and trends, forcing ecosystem shifts and impacts on resource species (e.g. Howell et al. 2005; Greene and Pershing 2007; Fogarty et al. 2008). This region contains one of the highest-value fisheries in the nation, some of the largest coastal human population centers, and significant navigation and trade routes, and it is poised to develop alternative energy resources in coastal waters.

The final recommendations of the Interagency Ocean Policy Task Force (IOPTF, 2010) and the executive order that adopted them provided the Nation's first ever National Policy for the Stewardship of the Oceans, Coasts and Great Lakes. The recommendations also presented an associated governance structure and implementation strategy as well as a framework for Coastal and Marine Spatial Planning (CMSP). The National Priority Objectives identify the need for an integrated observing system to collect and deliver the necessary decision support information. The Integrated Coastal Ocean Observing System (ICOOS) Act of 2009 established the Integrated Ocean Observing System (IOOS) as such an observing system for the United States.

Coordinated Regional Management – NERACOOS was established as an independent, nonprofit organization in the fall of 2008 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 part of the United States IOOS; 2) promote development, assessment, and dissemination of data and data products that meet the needs of end users; and, 3) to advocate through education and outreach for the regional, national, and global ocean observing system and the application of scientific assessments using environmental data that meets societal needs. (For more detailed information on NERACOOS please visit www.neracoos.org).

NERACOOS is located at the Seacoast Science Center (SSC), a science education facility in Rye, NH. As the awardee of an FY2010 IOOS implementation award, NERACOOS has demonstrated the ability to receive, disperse, and administer funds including those from NOAA with bookkeeping supported through our Memorandum of Understanding (MOU) with the SSC. NERACOOS is governed by a Board of Directors with standing Finance and Nominations subcommittees. To ensure a broad and balanced spectrum of members, Directors were originally appointed by three groups, the Northeast Regional Ocean Council (NROC), a consortium of academic institutions engaged in oceanographic research, and the Directors of the region's Sea Grant college programs. These groups now provide nominations to fill vacant positions. Plans and priorities are developed for the Board by a Strategic Planning and Implementation (SPI) team, which has been constituted to reflect the geographic range of the region and the diverse needs for ocean observations. The SPI team includes coastal mangers, as well as scientists and engineers with the expertise necessary to operate observing system infrastructure, model the complex marine environment, and manage and disseminate the resulting information. NERACOOS has no formalized membership apart from members of the board, the SPI team, and the working groups. Additional parties interested in participating in NERACOOS activities are asked to join the Board, SPI Team, or one of the Working Groups as appropriate. An individual may be a member of more than one of these groups. The Board of Directors meet quarterly by video conferencing through sites at Rye, NH, BIO (Halifax, NS), and UConn (Groton, CT), and holds an in-person annual meeting each fall. The SPI team meets more frequently through teleconference and holds quarterly meetings a month before board meetings to develop progress reports. NERACOOS works collaboratively with MACOORA, the IOOS region to the south.

Working groups have been established by the SPI team to facilitate deeper engagement with particular user communities. These working groups mirror the four themes of NROC (Ocean and Coastal Ecosystem Health, OCEH; Coastal Hazards Resilience, CHR; Ocean Energy Planning and Management, OEPM; and Marine

Operations, MO) as well as provide working groups on Data Management and Communications (DMAC), Education and Outreach (E&O), and Performance and Evaluation (P&E). To be efficient, NERACOOS has engaged the Northeast Coastal and Ocean Data Partnership (NeCODP) and the New England Ocean Science Education Collaborative (NEOSEC) to act as SPI team working groups on DMAC and E&O.

NERACOOS has a formal working relationship with NROC via MOU. The MOU's first method of collaborating is "*Regional priorities - On an annual basis the organizations will work together to identify regional coastal and ocean management themes and priorities. The organizations will then use these materials in their work plans and fund development processes."* Together with NROC, NERACOOS led the *2010 New England-Canadian Maritime Collaboration and Regional Planning Initiative* that brought together 13 regional organizations for a series of four theme-based meetings (OCEH, OEPM, CHR, and Ocean Observing). From this regional priority projects were outlined. At a forthcoming summit, representatives of each organization will discuss input on project priorities and develop implementation strategies, and identify and discuss ways to strengthen inter-organizational collaboration. Strengthening this collaboration is essential if the national priority objectives of the final recommendations of the IOPTF are to succeed on a regional scale. '*Coordinate and Support*' is one of the four "*How we do business*" priorities of the IOPTF, and the regional planning initiative provided an initial framework for it. These meetings and subsequent input from the SPI team and working groups formed the basis of the NERACOOS strategic priorities and plan for 2011-2016, that represent the goals and objectives of this proposal.

Observing subsystem – NERACOOS has operated a regional observing, data sharing, modeling, and outreach system since 2007 by building on assets and experience made available by earlier programs. In the GoM, six buoys are currently deployed (Pettigrew et al., 2010). They support the meteorological sensors carried by standard National Data Buoy Center (NDBC) buoys and additional sensors for atmospheric visibility, surface currents, water-column current profiles, temperature and conductivity, fluorescence (for chlorophyll *a* estimation), and backscatter at multiple depths. Additional separately funded sensors, such as fish tracking devices, can be added to most buoys. Two deep buoys are located in the Northeast Channel and Jordan Basin and four coastal buoys are widely spaced down the Maine and Massachusetts coasts. A seventh partner-funded buoy addresses water quality concerns in the densely populated region of the GoM around Boston, MA.

In Long Island Sound (LIS), NERACOOS supports 3 buoys that measure wind speed and direction, circulation, salinity, conductivity, temperature, pressure, currents, and dissolved oxygen near the surface, bottom and mid-depth supporting hypoxia monitoring and research used by both EPA Long Island Sound Study and the CT Department of Environmental Protection (DEP). In the Central Sound, the buoy supports wave observations. NERACOOS also supports a buoy in Great Bay, NH during ice-free months and a shore-based system at the mouth of the estuary to monitor water quality, meteorology, carbon dioxide, and serves as a node for NERACOOS ocean acidification measurements. Such work has advanced knowledge of water clarity and water quality for protecting critical habitats.

As part of the national surface current measurement program, NERACOOS operates an High Frequency (HF) RADAR network in the GoM. These data are shared openly and used in the surface current forecasting system employed by the US Coast Guard (USCG) search and rescue program.

Harmful algal blooms (HABs) in the GoM cause paralytic shellfish poisoning (PSP, e.g., Anderson, 1997; Anderson et al., 2005). State-run shellfish monitoring programs in nearshore waters, and federal efforts to monitor toxins offshore protect public health. To augment these activities, a model of the HAB species, *Alexandrium*, bloom dynamics was developed, and data from NERACOOS buoys are utilized for assessing model accuracy. Steps are underway to transition the model to NOAA, but these forecasts do not yet assimilate cell concentration or toxicity. NERACOOS supports satellite detection and water sampling for *Alexandrium* in the Bay of Fundy, one of the source regions.

Nutrient concentrations are necessary for many management applications, from coastal eutrophication to integrated ecosystem assessments. Offshore, NERACOOS supports the semi-annual sampling of nutrients and hydrographic properties for a section across the Northeast Channel, historically the main GoM nutrient input, as part of the ongoing Atlantic Zone Monitoring Program (AZMP). NERACOOS has also supported an

autonomous, real-time nutrient-sensing center of excellence and deployments of sensors in Narragansett and Great Bays.

Data Management and Communications Subsystem – NERACOOS supports a robust, scalable and cost effective regional DMAC subsystem that is central to the delivery of real-time, delayed-mode, and historical data from observing assets as well as serving model generated forecasts. It also supports integration of data streams into a suite of interoperable decision-support and analytic tools. To date NERACOOS and its partners have implemented various components of a regional DMAC system. Observations are aggregated through sensor observation service (SOS) to a spatially enabled relational database management system designed for long time series and for multiple properties at numerous depths. This system supports a variety of services designed to provide end users with data access and delivers real-time observations to NDBC. Several regional modeling efforts have established thematic realtime environmental distributed data services (THREDDS) data servers to distribute regional gridded data sets such as forecast models and remote observations. Extensive metadata exists for NeCODP members. A robust 24/7 web presence has been developed and leverages the underlying service oriented architecture (SOA) to cost effectively deliver and integrate multiple data sources into user driven products. The NERACOOS DMAC team has participated in national and regional working groups to evaluate, test and enhance SOA standards for ocean observations. The NEARCOOS DMAC team is strongly connected to IOOS and other national data management programs. The DMAC team is participating in the EPA funded Exchange Network, the development of the IOOS catalog as well as the IOOS-funded super-regional modeling testbed.

NERACOOS is collaborating with Massachusetts Ocean Partnership (MOP), ASA, GMRI, The Nature Conservancy (TNC), and NROC to develop a prototype regional atlas/data portal (a map viewer, data warehouse and a collaborative environment) for the initial focus of supporting CMSP. The portal design can support multiple priority areas, e.g. ecosystem based management (EBM), coastal hazards, and climate change and it represents a powerful and flexible "front end" to the NERACOOS DMAC system.

Modeling and Analysis Subsystem – Because inundation and combined tides, storm surge, and wind waves can cause significant coastal damage (Bernier and Thompson, 2006), NERACOOS has supported the development of the inundation forecast system (IFS) of the Northeast Coastal Ocean Forecast System (NECOFS) to provide warning of coastal flooding to facilitate evacuation and other emergency measures and to develop accurate statistics of coastal inundation that enable rational planning for sustainable land-use and potential impacts of climate-related sea level rise. NECOFS features three core components (Figures 1-2 in the Appendix): 1) the NOAA/NCAR Weather Research and Forecast (WRF) mesoscale weather model, (2) an unstructured-grid version of the Simulating WAves Nearshore (SWAN) surface wave model (SWAVE, Qi et al. 2009), and (3) the Finite-Volume Coastal Ocean Model (FVCOM, Chen et al. 2003, 2006). The WRF output is used to drive SWAVE and FVCOM-GOM3, which are both used to drive the higher-resolution domains. Supporting data include NCEP NAM data, ocean tidal and WaveWatch3 wave forcing, satellite SST and radiation data, river discharge, NOAA C-MAN and NDBC buoy data, and NERACOOS buoy data.

NECOFS is strongly connected to IOOS and other NOAA national programs. The NECOFS team is participating in the IOOS-funded super-regional modeling testbed, which has chosen Scituate (MA) as its extratropical storm inundation model testbed site. The core ocean model in NECOFS is FVCOM 3.1, and several groups in the tropical storm testbed are using FVCOM 3.1 in hurricane hindcast. The NOS CSDL is also focusing on FVCOM as a coastal ocean model for future use. Presently the NECOFS team is assisting the NOS CO-OPS in setting up a FVCOM 3.1-based forecast system for the northern Gulf of Mexico and helping GLERL integrate FVCOM 3.1 into their existing Great Lakes forecast system. The NECOFS team hopes to transition NECOFS to NOS CO-OPS by the end of this project.

NERACOOS produces surface wave forecasts for the region in near real-time which are used in operational products such as the splash-over tool used by the National Weather Service (NWS) Weather Forecast Offices (WFOs, Bogden et al., 2008). In support of the National HF RADAR surface current program, NERCOOS operates a computer system to automatically retrieve data from the National HF RADAR database hourly for the national grid, compute the STPS forecasts for 24 hours, and share the results with the USCG's Environmental Data Server (EDS), which is used by the USCG for search and rescue.

Outreach and Education – Engaging users of ocean observing system information is essential for defining the scope of information required and framing its delivery. Through an MOU with NEOSEC, NERACOOS has access to valuable resources to develop, deliver, and share program outcomes through NEOSEC member institutions - 43 science and education-based organizations working toward promoting ocean literacy through the ocean literacy principles (OLP). NERACOOS supports NEOSEC, hosts its website, and is a co-sponsor and participant of its 2010 Ocean Literacy Summit. NERACOOS has successfully partnered with NEOSEC members to produce both informal and formal education materials, for example, the Seasons of the Sea exhibit at the SSC and Earth as a System is Essential: Seasons and the Seas (EaSiE) project of the Maine Mathematics and Science Alliance (MMSA). NERACOOS is hiring an outreach and education specialist in October 2010.

This proposal, therefore, builds upon extensive regional planning infrastructure to produce a stakeholder-driven, regional observing system that expands upon and optimizes previous NOAA and non-NOAA funded efforts for this geographically complex and economically important region. Support is requested for the continued development and operation of the observations and analysis products of NERACOOS, and the continuation of regional leadership in the development of a multi-use and stakeholder driven component of the National Integrated Ocean Observing System in the northeast as envisioned in the ICOOS Act of 2009.

b. Goals and Objectives

The overarching intent of this proposal is to continue operation and further the development of the integrated ocean observing system for the Northeast and to expand the user base through consultation and outreach. In the following summary of the specific goals of the proposed activities, we first list the goals of the four Priority Areas identified in the 2011-2016 Strategic Plan. In section **b.5** we outline the goals of the DMAC system development since it supports all activities. Subsequently, the goals in the crosscutting areas of CMSP and Climate Change, E&O, and P&E are outlined. Timelines for associated activities are provided in the Milestone Schedule section.

b.1 Marine Operations (MO), NERACOOS will: 1) continue delivering Real-time Ocean Conditions and Forecasts to Mariners by maintaining and enhancing observational and modeling capacity; and 2) make the region 'Response Ready' by a) continuing integration of NERACOOS information into response tools, b) developing rapid response observation capability, and c) developing high-resolution models for at-risk locations.

b.2 Ocean and Coastal Ecosystem Health (OCEH), NERACOOS will establish: 1) an Ecosystem Monitoring & Modeling System including a) an Integrated Regional Sentinel Monitoring Program incorporating similar partner programs through data sharing, a range of assets measuring water-column and benthic properties, and an event reporting tool, b) a Regional Model Interoperability System for driving nested physical and ecosystem models, c) an Integrated Water Quality Observing System aligned with the National Water Quality Monitoring Network and including real-time nutrient, ocean acidification, and HAB sensors, and d) a Hydrological River Discharge & Water Quality modeling and forecast system; 2) an Integrated Observation & Forecasting Tool For Beach & Shellfish Water Quality to support healthy beaches and shellfisheries; and 3) a Northeast Atlas / Ocean Data Portal for access to the information.

b.3 Ocean Energy Planning and Management (OEPM), NERACOOS will include: 1) resource information and regional data products in the Northeast Atlas / Ocean Data Portal; and, 2) offshore energy facilities monitoring and platform access in the Ecosystem Monitoring and Modeling System and develop standardized protocols comparing monitoring at facilities with non-impacted sites.

b.4 Coastal Hazards Resiliency (CHR), NERACOOS will: 1) continue development of the Regional Hazards Forecasting & Hindcasting System by a) completing and evaluating regional and sub-regional surge models, b) develop seamless integration between current regional weather models and national hurricane models, c) improve online distribution of forecasts for WFOs, USCG, and the public including model-driven observation stations, d) expanding current inundation forecasting capacity to other locations, and e) supporting Hydrological River Discharge & Water Quality modeling and forecast efforts; 2) Increase Sea Level observations by filling tide gauge gaps with lower-cost technology; and 3) participate in regional efforts to better understand the effects of Climate Change.

b.5 Data Management and Communications (DMAC), NERACOOS will; 1) ensure that all data and associated metadata are delivered using national IOOS standards and services; 2) provide open access to real-time and historical data; 3) ensure that all NERACOOS products are discoverable and accessible; 4) support cost effective and scalable development of products, 5) facilitate the transfer of observations and model products to national data centers; 6) ensure that all NERACOOS data services are registered, cataloged and monitored; 7) develop and implement performance measures and usage statistics; and 8) ensure that all partners and data management activities gain IOOS certification.

b.6 Coastal and Marine Spatial Planning (CMSP) and **Climate Change,** NERACOOS will support NROC's efforts in **CMSP** by continuing development of the Northeast Atlas / Ocean Data Portal that will allow discovery, display, download, and analysis of geospatial and time-series information, and by the development of the Ecosystem Monitoring & Modeling System that will facilitate adaptive management by documenting and interpreting change in biological, physical and biogeochemical environments, including species shifts and ocean acidification. Both this system and the portal will enable the region to understand, mitigate, and adapt to the effects of **Climate Change.** The Regional Hazards Forecasting & Hindcasting System will also provide hazards-focused climate change analyses, and participate in regional efforts to better understand the effects of climate change.

b.7 Education and Outreach (E&O), NERACOOS will develop and implement a Coordinated Outreach and Communication Strategy. NERACOOS staff and scientists will work directly with regional partners such as NEOSEC and national partners such as the NFRA Education and Outreach Committee (EOC) to enhance and implement ocean observing education that will address ocean literacy. Specifically, NERACOOS will increase public understanding of climate change as directed in the ICOOS Act (2009).

b.8 Performance and Evaluation (P&E) NERACOOS will: 1) develop operational metrics for the valuation of observing and modeling assets; 2) develop a comprehensive framework for economic performance evaluation, 3) populate the framework by collecting data to assess the value of NERACOOS products and services, 4) identify a small set of current assets for detailed economic analysis; 5) select one potential investment for OSSE assessment and detailed benefit assessment; and 6) implement metrics distributed by the NOAA IOOS Program Office.

c. Audience and Benefits

Audiences for NERACOOS data products are diverse and represent many sectors. They are engaged in the board, SPI team, and working groups to ensure that products are aligned with needs. NROC is both a strategic partner and a conduit to an important user group - the state and federal agencies of the region. The NERACOOS- and NROC-led Regional Planning Initiative expanded the audience and assisted the strategic planning process. **MO** groups engaged include the USCG, the NOAA NWS, port and harbor operators and organizations of fishermen. Coastal managers, NOAA NMFS and EPA employees, representatives of NGOs and members of the fishing industry, and regional scientists attended the meeting on **OCEH**. Attendees at the **OEPM** meeting included researchers, state and federal regional planners, and engineering companies. The **CHR** included representatives of many of the same constituencies as well as municipal planners and experts on simulation. Reports of these meetings are available at the NERACOOS website. This professionally engaged audience is augmented by the millions of people in the region who rely on ready access to weather and ocean conditions and forecasts each year. Observations from the NERACOOS arrays are routinely used by the NWS to improve forecasts, directly by mariners going to sea, and local TV and radio stations to inform the public. We document the value of NERACOOS products to users in their own words:

Maritime Operations– Testimonials from **mariners** include: *"I trust the weather buoys with my life. Thank you."* - Maine Fisherman; *"Love your service…I believe your service is a lifesaver. Thanks!"* -Dave, Pilot; and *"I would like you to know that information you are providing us not only aids us in our work, it almost certainly has saved lives."* -Roy Atkinson, Fisherman. The **National Weather Service** wrote that they *"routinely integrate NERACOOS data into our forecasts and warning operations on an hourly basis"* and *"Products derived from NERACOOS buoys are critical to protecting the lives and property of mariners and coastal residents alike"*. The **USCG** notes NERACOOS benefit them by *"directly improving our ability to locate*

mariners in distress" and *"would provide the critical data needed to enhance the accuracy and reliability of spill trajectories"*. **NOAA OR&R** wrote *"This information significantly improves our ability to provide timely science-based support for a spill in the northeast US"*.

Ocean and Coastal Ecosystem Health – Regional HAB managers wrote that the proposed effort will *"directly benefit the regional HAB monitoring by continuing to provide the buoy observations … This work directly contributes to protecting the lives of those who enjoy harvesting and consuming the regions shellfish"*. **NOAA/NMFS/NEFSC** wrote *"the NERACOOS buoys are used in Ecosystem Assessment products … HabCam supports the NEFSC habitat mapping and resource survey activities"*.

Coastal Hazards Resiliency – Local town managers from Scituate and Saco wrote that the proposed effort would *"greatly improve the ability of the Town staff to provide timely warnings and plan possible emergency responses as needed"*. **Northeast States Emergency Consortium** wrote NERACOOS will *"directly support the work of emergency managers and first responders throughout the Northeast"*.

Ocean Energy – The **DeepCWind Consortium** wrote *"If the marine environment is not sufficiently characterized, developers will not risk starting offshore wind projects in the Gulf of Maine. These buoys and model information will improve the viability of the Gulf of Maine as a strong candidate for offshore wind farm developments … We look forward to working with NERACOOS on sharing monitoring information"*.

NROC noted a *"seamless transition of policy objectives from NROC to the scientific objectives of NERACOOS. … Water quality managers, fisheries managers, researchers, mariners, emergency responders, coastal land managers, aquaculturists, and many more will benefit from this system"*.

d. <u>Work Plan</u>

The work plan is organized by subsystem, asset class, and general priority at three overall funding scenarios: base or level, capacity maintaining, and enhanced. The overall priorities are to 1) maintain current systems even at reduced capacity with level funding, 2) maintain capacity of these systems with initial incremental funding, and 3) enhance capacity with further increments. The approximate first year costs are included for each system.

i. Coordinated Regional Management

Base Capacity

<u>The NERACOOS office (NERACOOS, $400K-level)</u>

Governance and organization – The Board of Directors will continue to meet quarterly with an annual meeting in the fall. A similar quarterly meeting schedule for the SPI Team will occur a month before Board meetings, allowing feedback on progress to date.

Management Plan –The NERACOOS Executive Director has overall responsibility to oversee the sustained management, development and operation of the regional observing system for the Northeast. He will coordinate and lead the PI Group consisting of the other investigators named in this proposal. This group will meet monthly via tele/video conference and in person once a year in conjunction with the SPI team annual meeting and will report out to the SPI team quarterly. The NERACOOS office will compile and send semi-annual progress reports to NOAA in the specified format, provide performance metrics, and seek certification by IOOS when appropriate.

Identifying Regional Needs and Priorities – Building on the 2010 regional planning initiative, NERACOOS will annually invite the user base to review strategic priorities and identify omissions. A running list of needs and enhancements will be compiled and reviewed quarterly by the SPI team in order to refine and manage priorities. NERACOOS will enhance its requirements process by contacting end users of all products and services to determine how well they meet end-user needs and how products can be improved. In development of new products, NERACOOS will invite users to participate from end to end.

Information, Product and Service Requirements Process – The SPI team and its working groups bring representatives of stakeholders who need the information, products, and services of NERACOOS together with those who have the capability to deliver them. All working groups, based on input from activities such as the regional planning initiative and communications with its membership, suggest strategic priorities. The SPI team then collates the input and develops the full strategic priorities. NERACOOS will be creating a product team in fall of 2010 to be charged with development of products determined for which a clear need is identified. The

process includes initial scoping of requirements, information gap assessments with suggestions for remedying, technical development, and performance evaluation. The product team will be highly flexible and drawn from individuals funded by NERACOOS as well as interested parties and contractors, and overseen by the outreach and communication specialist.

Enhanced Capacity

Performance and Evaluation (WHOI, $25K, and RMC, $50K) – A fundamental measure of performance for an observing system is the economic value it produces. Evaluating the performance of NERACOOS in this way requires information about how sensors, models, and data infrastructure contribute to the information and products delivered to users, and the monetary value of those products. The long-term goal is to develop a comprehensive view of the links between all assets and economic benefits, including the value of the investments from partners and users. This assessment requires information on the costs of all components of subsystems and is already underway. Through May 2011, data flows from NERACOOS sensors to products and users will be mapped, providing estimates of users' benefits and illustrating the relationship between assets and economic value with a simple "OSSE-like" analysis focused on physical parameter products. In subsequent years, the assessment will expand to other product categories and evaluation of future investments in improved products and additional assets. The conceptual P&E model will be populated with data as they are assembled, and will evolve with each iteration.

ii. Observing Subsystem - a system of systems with multiple uses

The NERACOOS observing system supports multiple uses of individual assets and includes additional capacity and leveraged activities to provide an integrated regional monitoring program. The initial priorities are to fund the current systems either at existing funding levels (with the resulting loss of capacity over time), or at anticipated levels necessary to maintain the current capacity now and in future years. Subsequent increases in funds will add additional elements detailed below as Enhanced Capacity. All data will be quality controlled, and with nationally recognized standards (e.g., Quartod developed protocols) when applicable.

Planning for future enhancement – Observing systems are designed to measure inherent variability of environmental systems at sufficient temporal and spatial resolution to enhance understanding and remove gaps in knowledge. Future build-out plans for the observing system will first define the knowledge gaps and the measurements needed to address them. The final design will then optimize asset deployment to maximize knowledge return to multiple sectors based in-part on economic return. Balance between financial constraints and optimal design is not trivial and the former are the major obstacles to meeting stakeholder requirements. Technological challenges exist, too, such as sensor availability and adaptability to environmental conditions. An updated conceptual design developed in the next year by the SPI Team will refine gap analysis in the current system and provide a basis for system enhancement. Annual updates of the gap analysis are an integral part of the strategic operating plan (SOP) mandated by the ICOOS Act of 2009.

Base Capacity – Level and capacity maintaining funding of current systems

The Gulf of Maine Buoy Array (UMaine, $705K-level $810K- maintain capacity) – UMaine Physical Oceanography Group (PhOG) will continue to operate data buoys in the GoM for 2011-2016. PhOG has designed, built and operated the IOOS buoy system in the GoM since 2001. Operations include calibration and sensor preparation, system testing, and mooring operations as well as all data processing and distribution, in IOOS-compatible formats for posting on the NERACOOS website. Deployment and servicing are on a 12-month rotation. Unscheduled servicing will be performed only to deal with failures related to marine safety (wind, waves) or malfunctions that could risk buoy loss.

Level funding allows only four buoys to be operated. Incremental funding up to the capacity-maintaining level will continue the current six-buoy array. Costs of a seventh buoy (Boston, MA) have been leveraged with contributions from an LNG settlement fund and the Massachusetts Water Resources Authority (MWRA, total $600K) that will continue to support it through the first 3-4 project years. Exact locations of the buoys will be determined by NERACOOS based on the level of funding as part of the SOP.

The Long Island Sound Buoy Array (UConn, $280K-level /$390K- maintain capacity) – UConn will maintain, operate and distribute data from 3 buoys that measure wind speed and direction, currents, salinity,

conductivity, temperature, pressure, currents, and dissolved oxygen near the surface, bottom and mid-depth supporting hypoxia research whose results are used by both EPA Long Island Sound Study and NY and CT to set nutrient reduction goals. Two buoys will be located in western LIS and the third will be in the Central Sound. All data will be telemetered to shore, and UConn will maintain and operate a data archive and Mapserver-based distribution system that shares the near-real-time observations with the NDBC and the NERACOOS data system. UConn will also continue to acquire monthly water quality survey data from the CTDEP and include it in the freely accessible archive. With level funding only two buoys can be supported.

The Great Bay Coastal Buoy (UNH, $115K-level, $124K-maintain capacity) – UNH will continue operation of the Great Bay Coastal Buoy (initiated in 2005) during ice-free months and the Coastal Marine Lab (CML) will also monitor oxygen and carbon dioxide, and serve as a node for NERACOOS ocean acidification data. With level funding the number of sensors supported will be decreased.

Gulf of Maine HFR array (UMaine, included in buoy budget) – The UMaine PhOG will continue its CODAR operations at three locations (two at level) in the northeastern GoM, process the data, post them online, and make them available to the national HF RADAR Network Gateway for use by the USCG, and provide them to the Canadian Coast Guard for integration with Canadian Search and Rescue operations. Although PhOG will continue to visit the island installations for servicing, most of the routine operations will be performed via subcontract with CODAR Ocean Systems (the manufacturer) to ensure consistently high data quality.

HAB monitoring (BIO, $20K) – BIO will continue detecting *Alexandrium* using remote sensing data in the pilot area of the outer Bay of Fundy. BIO will perform weekly shipboard sampling over a fixed array of five stations from May to October, and collect, analyze and validate high-resolution ocean color imagery (MERIS) through direct measurements of optical properties in the surface layer. The diatom algorithm of Sathyendranath et al. (2004) will form the basis of a "HABs warning" product that will be validated for the Bay of Fundy before expansion to the rest of the region.

Nutrient work (URI, $60K-level, $150K-obtain capacity, BIO, $5K) –URI will facilitate continuous, in-situ, spatial and time-series measurements of nutrient concentration by deploying commercially available sensors at key regional locations and time periods. URI has a long-term goal of obtaining and analyzing in situ, time-series measurements of nutrient concentrations by deploying commercially available sensors. The URI nutrient sensing team will oversee analytical calibration, operation, deployment and data processing and products for in situ nutrient sensors deployed on moorings and other regional observation platforms. Five different types of commercial nutrient sensors are presently available (11 units total) for the project. The nutrient sensing facility team will co-deploy nutrient sensors along with other water quality sensors on multiple sampling platforms and locations determined by the SPI team within the NERACOOS region. With level funds sensors will be deployed off the URI dock; additional funds will allow buoy integration.

The ongoing AZMP regular, semi-annual sampling of nutrients and hydrographic properties will be continued for a section across the Northeast Channel. Processing of data will take place at BIO, and results will be made available online through the BIO hydrographic database.

Enhanced Capacity

RI buoy (URI, $175K) – With funding from the RI Ocean Special Area Management Plan (SAMP) program and under contract with URI, UMaine deployed two buoys in RI coastal waters in October 2009; current funding will keep them operating until September 2010. The buoys are similar to the GoM array and operated by UMaine PhOG with data accessible via the PhoG's and the NERACOOS' websites and are used for wind resource assessments and to understand circulation dynamics. The proposed effort will continue operations of one of these buoys.

Jeffreys Ledge wave buoy (UNH, $21K) – Since 2008, UNH has operated a buoy in the GoM on Jeffrey's Ledge supplying near-real-time ocean wave and sea surface temperature data every 30 minutes for 23 of the last 24 months. The buoy is integrated into the Scripps CDIP, NOAA NDBC, and NERACOOS web-based data servers and is used by the Gray, ME, WFO for setting the SST boundary condition at the southern end of their region. The data are regularly accessed by NWS forecasters, recreational and commercial fishermen and whale-watch vessels. This effort complements the other CDIP buoy operated by the US Army Corps of

Engineers (USACE) off Block Island that is also already integrated into NERACOOS and contributes to the National Wave Plan.

CO2 buoy (UNH, $64K) – A secular increase in ocean acidification (OA) is occurring in New England waters just as for the global oceans, as more than a third of the increasing atmospheric CO_2 is continually dissolving into the surface ocean. A multi-phase approach will bring OA observations into NERACOOS coordinated with regional efforts planned by the NOAA OA implementation team and the North Atlantic Regional Team. Existing CO_2 measurement infrastructure established with NOAA IOOS funds will be maintained and operated to deliver three ocean acidification monitoring time series, two offshore (climate impact) and one nearshore (watershed impact). Observations have revealed natural seasonal variability as well as the yearly increases driving ocean acidification. Each site delivers sampling of pCO2 and derived pH including QA/QC and delivery to the DOE-CDIAC data center. Water samples needed to validate and QA sensor observations will also be collected. OA work is a collaboration with the NOAA Pacific Environmental Marine Laboratory,

HAB buoy (WHOI, $125K) – The Environmental Sample Processor (ESP, Scholin et al. 2009) can detect and enumerate toxic cells and radio the information to shore. Through a $2M NSF award to WHOI and additional support from the EPA and the IOOS Program Office, six ESPs and three moorings are available for activities in the GoM. The proposed effort would support deployment, operation, and validation of ESPs for HAB monitoring. In initial years, one instrument will be deployed during the bloom season. In subsequent years, instruments will be deployed at other key locations in the HAB pathway. Data will be assimilated into the *Alexandrium* model and independently funded OSSEs run to optimize locations for future deployments. Data collection and distribution policies and procedures as well as outreach strategies will be developed with NERACOOS.

Drifter systems (NOAA, $50K) – Ongoing description of the circulation of the northeast region will be provided using low-cost drifters. These student-built, ship-of-opportunity-deployed, satellite-tracked drifters are used around the country in various applications (Manning et al, 2009). A primary objective is to provide data to support the prediction and diagnosis of HAB events. We will conduct routine drifter deployments at selected locations around the GoM and Southern New England Shelf. Monthly deployments can be made from assorted ships of opportunity (ferries, lobster boats, etc). In addition to regular deployments, drifters can be deployed in a fast-response mode for particular cases as needed. The primary motivation behind these deployments is to provide data for validation of the NECOFS forecasts. Hundreds of school children will be engaged in making and tracking these drifters.

Narragansett Bay real-time telemetry (URI, $50K) – The Narragansett Bay fixed-site water quality monitoring network (NB-FSMN) presently consists of 13 estuarine locations capable of continuously monitoring water quality conditions with respect to hypoxia. RI Department of Environmental Management (RI DEM) coordinates the network and uses the data to support the assessment water quality conditions. Recent assessments (Codiga et al. 2009) indicate about one-third of the Bay waters (RI only) experience periodic hypoxia associated with excessive nutrient loadings. To address it, wastewater treatment facilities discharging to the upper Bay and its tributaries are in varying stages of implementing upgrades. Monitoring the bay over the next five to seven years is critical to measuring the responses of the bay ecosystem. The project will provide real-time transmission from 3 sites a year via the NERACOOS website through IOOS standards and expand the distribution of data by linking quality-assured data to NERACOOS annually.

Ferry-based observation products (URI, $50K) – URI will develop a region-wide network of cost-effective, ferry-based sampling to complement buoy observations. Ferries generate sustained, high-frequency time series of lateral structure across critical passageways. Existing programs (WHOI, URI, and StonyBrook) will be leveraged to create real-time observation products for (a) near-surface water quality parameters including nutrients from one ferry (Eastern LIS) as a prototype, and (b) vertical profiles of subsurface water currents from three ferries (Nantucket Sound, Eastern LIS, Central LIS). Contingent on funds, plans exist to expand meteorological sampling and equip additional ferries; these observations support all NERACOOS priority areas, from mariner needs to improving the skill of model products.

Integrated Regional Sentinel Ecosystem Monitoring

There is critical need to develop high resolution seafloor and water column mapping products at sentinel locations throughout the northeast to support CMSP and EBM. Data requirements for effective CMSP and EBM are immense and diverse, requiring integration of multiple data sets and data types across a broad range of spatial and temporal scales.

Satellite remote sensing (UMaine, $30K) – The UMaine Satellite Oceanography Data Laboratory (SODL) will build on currently funded activities to operate near-real time receiving, processing, archiving, product creation and delivery streams for satellite chlorophyll (CHL) and sea surface temperature (SST) fields for the region. Near-real-time products will be supported by updated climatology and anomaly fields at a series of temporal resolutions. Data will be made available using IOOS data standards suitable for interoperable delivery.

Water-column properties (UMaine $44K, UNH $72K) – UMaine and UNH will collaborate to institute sentinel monitoring of water-column properties in the western GoM. Two stations, representing the coastal nearshore and deep offshore, will be sampled to capture seasonal and interannual variability in water-column properties such as salinity, temperature and scalar irradiance, dissolved inorganic carbon (DIC), total alkalinity (TA) and pH, chlorophyll *a* and nutrients at multiple depths, zooplankton biomass, species composition and abundance of sentinel species. A laser optical plankton counter (LOPC) will also be deployed, providing data on vertical distribution of zooplankton needed for implementation of coupled physical biological models for this system. To develop an integrated regional sentinel ecosystem monitoring of water column properties, NERACOOS will work with federal and state agencies in the region to coordinate the intercomparability of data, identification of key variables to satisfy modeling needs for each subsystem, and coordination of data distribution through the ocean data portal.

Benthic properties (WHOI $150K) – The benthic component of this project will integrate the existing IOOS-funded project NEBO (Northeast Bentho-Pelagic Observatory) into the NERACOOS framework by continuing a three-year-long time series established at six sentinel sites along the northeast Continental shelf from Hudson Canyon, Georges Bank and the Stellwagen Bank National Marine Sanctuary, to the northern GoM (see Map 1 of the study sites). Repeated visits to each site will continue a unique view of how benthic communities change seasonally and interannually by using a towed camera system (HabCam) to image the seafloor across 100 km scales but with millimeter resolution. The images provide taxonomic information, often to species level, on community structure and diversity along with substrate composition. Multi-beam and side-scan acoustic systems capture backscattered energy as a proxy for water-column particulates, substrate hardness and geological zones. Habitat maps will be developed illustrating species-specific habitat associations in relation to substrate and water-column processes. Projects associated with this study, including NOAA-sponsored work to develop the science workflow environment for HabCam data and a project recently funded by the Gordon and Betty Moore Foundation to develop image informatics tools for automated image processing, apply strong leveraging for the NEBO program.

Integrating regional partner capacity and leveraged activities – NERACOOS is working to integrate partner efforts including but not limited to: the NSF-funded Ocean Observatories Initiative (OOI) pioneer array to be located in the southern extent of the region; the Right Whale Detection Network in the Boston shipping lanes; NMFS; the region's four NERRs whose data are currently available at the NERACOOS website; the Massachusetts Water Resources Authority (MWRA) which supports an extensive monitoring program in Mass Bay; the LIS Study; and the monitoring efforts of member states represented on the Board. Coordinated monitoring with offshore installations – NERACOOS collaborates with a number of ocean energy developers to access their monitoring data and installations for potential deployment platforms. The DeepCwind Consortium (ME) and Deepwater Wind (RI) monitoring data are already on the NERACOOS website; CapeWind (MA) and the tidal power company Ocean Renewable Power (ME) are also interested.

Operational Contingency Funds ($299K) – Recent events in the Gulf of Mexico demonstrated the importance of ocean observing as well as the need for rapidly creating an infrastructure to fill information gaps. Observing systems need to adapt to meet new challenges as regional priorities and understanding of the ocean environment shift over time. For this reason, funds have been allocated to an operational contingency fund to allow rapid deployment of assets, deployment of new assets and new product development over time to meet evolving stakeholder needs. Examples include rapid deployment of buoys to determine subsurface currents in

the case of an oil spill, deployment of leveraged assets such as gliders or AUVs (see Appendix) to constrain spatial variability, or build out to support national plans such as the ones for waves and surface currents.

iii. Data Management and Communications Subsystem

Base Capacity – Level and capacity maintaining funding of current systems

DMAC coordination (GMRI, $90K-base, $250K-maintain capacity) –Previously NERACOOS and its partners have implemented various components of a regional DMAC system; now we will leverage those past components and existing capacity and upgrade the existing DMAC system to bring it into full compliance IOOS for certification.

At base funding, the GMRI will continue to operate and maintain the core NERACOOS DMAC capacity, which includes maintenance and operations of a secure, robust, 24/7 web presence (www.neracos.org) and data management infrastructure, integration of data from regional providers, coordination and support of regional DMAC efforts and participation in national IOOS DMAC activities. Base funding will only support an incremental adoption of IOOS recommended DMAC guidance as described below.

There is a critical need to better integrate, coordinate, and modernize the entire NERACOOS DMAC system. At the maintenance funding level the DMAC lead will initiate a planning process to develop a long term DMAC implementation plan that will be developed in years 1-2 and implemented in years 2-5. The implementation plan will describe how NERACOOS will deploy the information system components (including infrastructure and relevant personnel) for full life-cycle management of observations from collection to product creation to public delivery, system documentation, and archiving. Maintenance funding will also support the full and timely adoption and maintenance of standards and services described below.

Observations **–**The NEARCOOS DMAC team will ensure that all NERACOOS partner observations are delivered through an OGC compliant SOS service including to NDBC and will provide support to implement and improve these services. The DMAC team will develop monitoring and notification tools for the observing data streams that will allow NERACOOS to monitor and document observing system performance.

Gridded Data –The DMAC team will continue implementation of CF compliant OpenDAP and THREDDS data servers. They will support regional modelers and product developers by providing a standards based, interoperable framework to develop model comparison and validation products, comparison toolkits, and model nesting providing a Regional Model Interoperability System. It will also support delivery and integration of new models as they become available.

Archival – Ensuring archival of NERACOOS data in perpetuity is a critical aspect of the DMAC system. The NERACOOS observations database and web servers are hosted at a managed hosting service. The database is backed up daily. Regional providers perform local archival. To ensure true long term archival, the DMAC team will work with NOAA's NODC to identify and implement a process for delivering NERACOOS information to the NODC archive. THREDDS and other DMAC data servers will facilitate this effort and allow automated archiving of historical data.

Metadata –The IOOS Catalog effort has been focused on harvesting necessary metadata directly from TDS, WMS, WCS and SOS services. Therefore, the NERACOOS DMAC team will ensure that sufficient metadata are returned by the standard service responses in order to generate ISO 19115-2/19 records for all NERACOOS services. The ISO records will be available to web search engines that will facilitate more effective discovery and use of NERACOOS data. Extensive Global Change Master Directory (GCMD) metadata records already exist for the NeCODP members so tools will be developed to convert these existing records to be ISO19115 compliant.

Standards definition – Significant progress has been made by the National IOOS DMAC effort on identifying and recommending standards to support data interoperability. However, some standards are still in development. NERACOOS will continue to actively participate in national and regional working groups to evaluate, test and enhance the existing standards. Additionally, we will continue to participate in efforts to advance DMAC efforts.

DMAC team – NERACOOS DMAC efforts will be led by the ocean data products program at GMRI. All NERACOOS observing and modeling partners will participate to ensure regional integration. The NERACOOS

DMAC work has recently integrated with the work of NeCODP, which led a regional approach to improve the discoverability, accessibility and interoperability of ocean and coastal data sets that reside in various state and federal agencies, academic institutions and nonprofit organizations. This collaboration will provide a wide range of non-IOOS funded routine observations collected in the region, providing a broad spatial and temporal context for interpreting data and feeding assimilative models.

Enhanced Capacity

Ocean Data Portal (GMRI, $100K) – This proposal requests funding to migrate the prototype portal to operational status, enhance it with new data products and decision-support tools and provide maintenance over the 5 year funding period. In collaboration with regional partners, the team will first address data that support priority areas, (e.g. CMSP, climate change) with a particular eye to NERACOOS observational data. Regional CMSP practitioners will be engaged to understand their decision-support needs and develop tools (e.g. cumulative impacts assessment) to be delivered through the portal and supported by regional data products.

iv. Modeling and Analysis Subsystem

Base Capacity – Level and capacity maintaining funding of current systems

The Northeast Coastal Ocean Forecast System (NECOFS, UMassD, $90K-level) – UMassD will maintain and operate NECOFS during the five year period. After the Scituate IFS is tested and operational, it will be used to build the Saco IFS. The IFS will then be expanded for the northeast regional domain. Desired outcomes include 1) 3-day prediction of water surface elevation, temperature, salinity, currents and surface waves, 2) warning of coastal flooding and 3) accurate coastal inundation statistics to enable rationale planning. The current NECOFS hindcast archive 1995-2010 will also be extended to 2016 for use in scientific studies, engineering applications, and federal and state planning efforts (CMSP).

WaveWatch3 (WW3, BIO, $10K) – The BIO wave model will be supported for delivery of surface wave forecasts to the region in near-real-time, and to contribute to operational products such as the spill-over algorithm used by the NWS. There are two primary tasks involved in this work: 1) continuous error-checking and resolution of operational difficulties in maintaining smooth and consistent operation, and 2) implementation of a new version of the operational model, WaveWatch, featuring flexible, two-way nesting of the computational grid providing reduced computation time is and enhanced accuracy.

Operation of the surface current forecasting algorithm for the national grid (UConn, $49K) –UCONN will continue to operate a computer system to automatically retrieve data from the National HF RADAR database hourly for the national grid, compute the STPS forecasts for 24 hours and share the results with the USCG's EDS. To make the system more resilient, in the first year we will purchase and install backup computers at an offsite location to allow the forecasting calculations for the National Grid to be completed when there is a power or data flow disruption at the Avery Point Campus. A review of the errors in forecasts for a 30 day period will be conducted for each area in which the STPS is implemented to ensure that forecasts are consistent with observations.

Enhanced Capacity

NECOFS (UMassD, $111K) UMassD will improve NECOFS by 1) refining the grids in the coastal region, 2) upgrade NECOFS to a 3-way, fully coupled WRF/FVCOM/SWAVE system and place it into forecast operation, 3) improve the estimate of upstream boundary transport by nesting NECOFS with global ocean models, 4) implement hurricane-prediction-capable WRF to improve surface forcing forecasts for extratropical storms and hurricanes to improve NECOFS forecast ability, and 5) integrate NECOFS with the hydrological river discharge and water quality model (below), thereby improving forecasting of freshwater entering the ocean, particularly during snow and ice melt in spring.

Hydrological model (UNH, $72K**)** – Hydrological modeling efforts will build off a northeast regional scale discharge model that was funded under the NOAA-UNH Joint Center for Ocean Observing Technology (see http://www.jcoot.unh.edu/discharge/discharge.html). The model is linked to the UNH WRF model and provides 3-day discharge forecasts. Separate modules capable of estimating water temperature, total nitrogen and dissolved organic carbon have been developed and will soon be integrated into the model. Although useful, it is inadequate for providing robust hydrological and biogeochemical forecasts for the region as it does not account

for routing through the river network, effects of impervious surfaces, or reservoir/lake storage. Moreover, current resolution (9 x 9km) is too coarse for many applications. With requested funding we intend to address these deficiencies and apply the constituent modules.

Product development –As detailed in the Regional Management section, product development is an iterative process starting with requirements scoping and ending with product rollout. To allow flexibility in the three out years, part of the Operational Contingency Fund will be used for development of further products. The product team will oversee this process and in the first two years selected four products for development:

Coastal flooding and erosion tool augmentation (GMRI, $40K) – The coastal flooding and erosion forecast nomogram has been proven effective by NWS during major northeast storms and is an important predecessor to more robust models for the northeast. The current product incorporates water-level and wave-height forecasts from NERACOOS data providers, coupled with empirical storm datum compiled by the NWS. The tool will be extended by adding forecasts for new vulnerable areas and will be improved by adding real-time data, a beach erosion forecast and additional models for fail-over and comparison, and by improving animations.

Regional indicators (GOMC, $40K) – Current regional indicator programs, lead by the GOMC's Ecosystem Indicator Partnership, will work collaboratively to migrate selected NERACOOS information into customized, value-added environmental and economic indicators (documents, graphs, synthesis reports, and online tools) for use by decision-makers. The project will also develop a user's guide and implement both a communications strategy and evaluation methods to assess user satisfaction and the relevance of NERACOOS data. This task builds on the Ecosystem Indicator Partnership formed by the GOMC in 2006 and charged with determining and reporting on priority indicators that track ecosystem health in six focus areas: coastal development, climate change, contaminants, eutrophication, fisheries/aquaculture, and aquatic habitats.

Environmental event reporting tool (GMRI, $30K) – NROC has an online environmental event reporting tool and database as a high priority need. NERACOOS has the technical capacity to effectively implement this product for the region. NERACOOS will work with end users to determine requirements and which events (e.g., harmful algal blooms, fish kills, environmental concerns, nor'easters, hurricanes, flooding) should be included. The product would display real-time warnings, allow users to access and view a history of warnings, and sign up for alerts. The warning/alert page will also promote the NERACOOS assets that are used in the various warnings and forecasts.

Beach water quality tool (ASA, $65K) – Water quality at beaches and shellfishing areas is critical for health and safety of users. ASA will integrate information from multiple sources (including NEXRAD rainfall) to drive a water quality model. A tool will be developed to estimate pathogen levels at Scituate, MA, and Saco, ME (selected because they both have multiple beaches and shellfish areas, the availability of sufficient publically-available data and the high resolution NECOFS sub-models). A web-based user interface will display model output. It will build off a multi-regional collaboration of the three east coast RAs in Jan 2010. Discussions with SECOORA and GLOS have indicated willingness to continue this collaboration. US EPA Region 1(Boston) also is interested to support this type of effort within their BEACH program.

v. Outreach and Education

NERACOOS office ($70K) – One of the recommendations from the regional planning initiative was a regional Coordinated Outreach and Communication Strategy that could leverage partner's strengths and increase impact with common messaging. The NERACOOS outreach and communication specialist will work with the 13 regional partner organizations on developing this strategy.

NERACOOS will continue to work together with NEOSEC in promoting ocean literacy through collaboration, implementation of ocean observing educational capacity, continued co-sponsorship of the Ocean Literacy Summits, and create joint communication and outreach strategies in 2012. NERACOOS and NEOSEC partners will continue to submit applications for mutually beneficial funding opportunities. The EO section of the NERACOOS website will host resources for ocean observing, aligned with ocean literacy principles, and include key data sets, links, and lesson plans. Further, NERACOOS will work with COSEE-Ocean Systems (OS) to connect observing system science with educators. COSEE-OS will employ its proven communication techniques and online tools, to help NERACOOS work effectively with educators in NEOSEC. Through

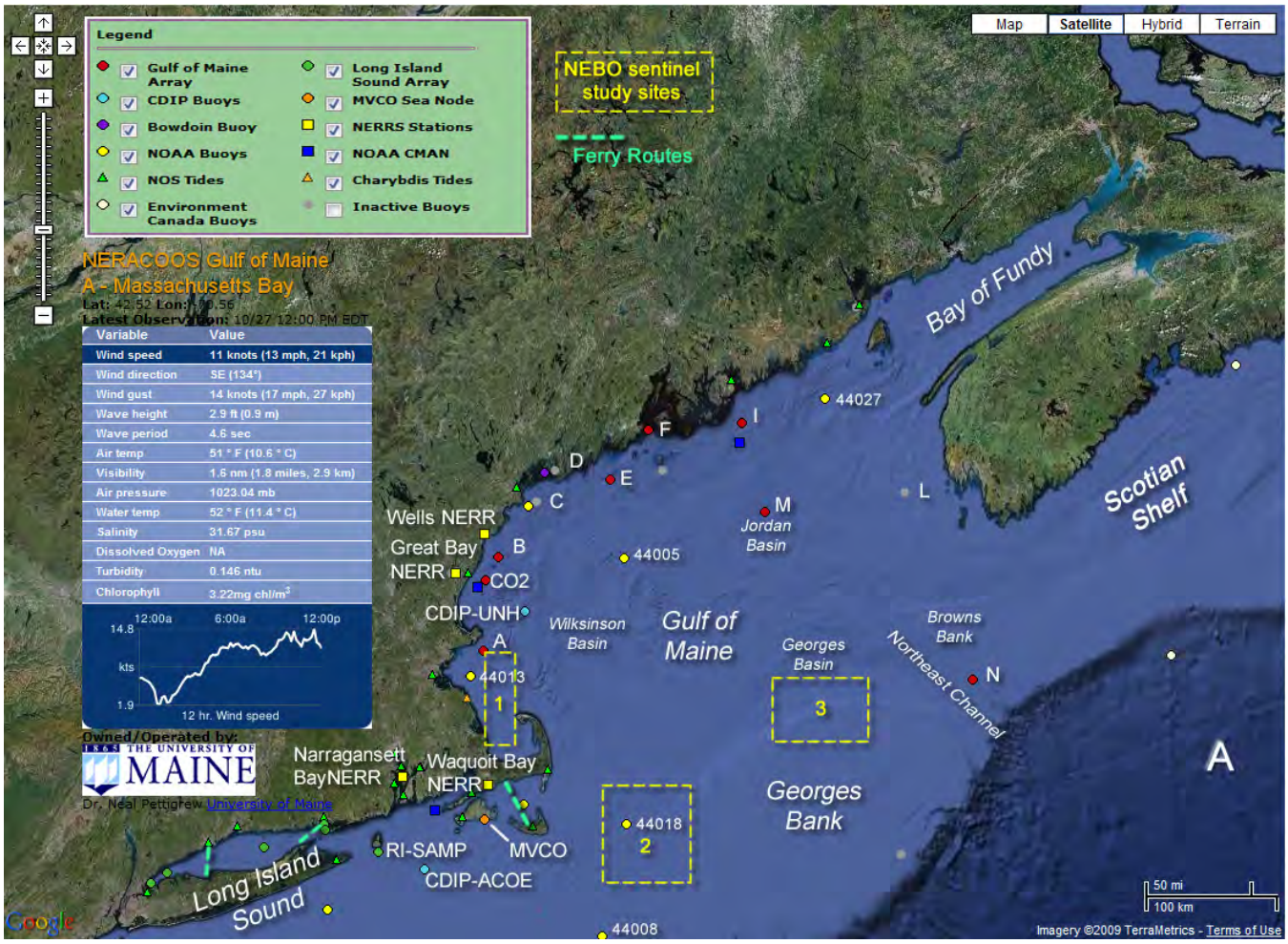
workshops tailored specifically to the needs of NERACOOS scientists and NEOSEC educators, COSEE-OS will help ensure that scientific data and content can reach broad audiences in an efficient manner. An annual environmental assessment will also provide a regional synopsis for managers, educators, and the public.

NERACOOS will continue coordinating with national efforts by continuing its participation with the NFRA Education and Outreach Committee (EOC) which includes representatives from all 11 RAs, IOOS, COSEE NOW, and ACT through regular conference calls and in-person meetings. NERACOOS will continue to participate in mutual projects with the EOC, including developing common products and services utilizing COSEE NOW online infrastructure; developing and implementing a standardized evaluation process; and creating a plan to communicate information about technologies and data being used during oil spills.

e. Milestone Schedule

Major Milestones by Subsystem Goal (on-going activities are shaded, letters represent specific activity in a quarter.)	**Year 1**				**Year 2**				**Year 3**				**Year 4**				**Year 5**			
	Q 1	**Q 2**	**Q 3**	**Q 4**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 1**	**Q 2**	**Q 3**	**Q 4**
i. Coordinated Regional Management																				
Directors and SPI team meet (A - Annual, Q - Quarterly)	Q	A	Q	Q	Q	A	Q	Q	Q	A	Q	Q	Q	A	Q	Q	Q	A	Q	Q
Update strategic priorities and products				X				X				X				X				X
Attend regional coordination meeting		X				X				X				X				X		
Progress reports to NOAA			X		X		X		X		X		X		X		X		X	
ii. Observing Subsystem																				
GoM array deployment & turnaround	X		X		X		X		X		X		X		X		X		X	
LIS array deployment & turnaround	X		X		X		X		X		X		X		X		X		X	
Great Bay Coastal Buoy deployment																				
GoM HFR operations																				
Nutrient center and NEC sampling	N		N		N		N		N		N		N		N		N		N	
HAB sampling																				
Inventory of regional assets and Gap analysis	I		I	G	I		I	G	I		I	G	I		I	G	I		I	G
iii. DMAC Subsystem																				
DMAC Implementation plan				X																
Obs and gridded data surveys			X																	
New SOS and TDS implementation																				
NODC archival implementation																				
DMAC system maintenance																				
iv. Modeling and Analysis Subsystem																				
NECOFS–maintain/improvement																				
Finish Scituate inundation mode																				
Setup Saco inundation model																				
Develop regional inundation model system																				
3-way WRF/SWAVE/FVCOM																				
Add annual hindcast to archive				X				X				X				X				X
Hurricane WRF/coupling wetland runoff model																				
New Products (Scope/Implement/Feedback/Rollout)	S	S	I	I	I	F	F	R	N	e	w		P	r	o	d	u	c	t	s
v. Outreach and Education																				
Annual regional environmental assessment			X				X				X				X				X	
COSEE-OS NERACOOS workshop					X				X											
Co-host NEOSEC summit						X								X						

5. APPENDICES



a. Maps and Figures.

Map 1 A) Map of the spatial extent of NERACOOS from the Canadian Maritimes to the waters off Connecticut, and B) detail of the Long Island Sound. These images were derived from those on the interactive NERACOOS website (www.neracoos.org) from which real-time and 12 hour historical data can be obtained. This is shown in the blue insert over the land to the left of A. The website integrates a wide range of information from federal and non-federal sources as indicated by the key in the green square in A. The NECOFS model produces three-day meteorological and oceanographic forecasts for the whole region each day. Yellow dashed boxes show the locations of three of the NEBO sentinel benthic study sites (1 – Cape Cod Bay/Stellwagen Bank/Jeffreys Ledge, 2 – Great South Channel, 3 – Northeast Peak of George's Bank).

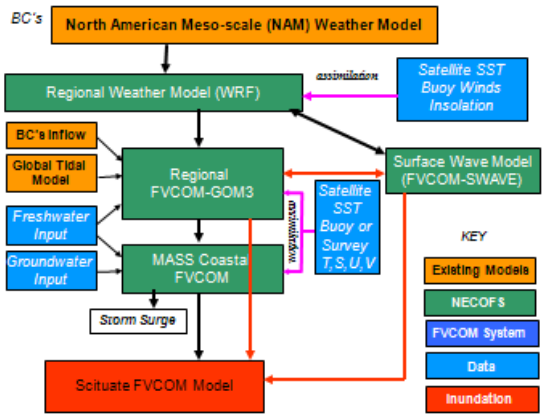


Figure 1 Schematic of NECOFS, showing the three core models (WRF, FVCOM 3.1, SWAVE). Note that the Scituate FVCOM inundation forecast model system can be driven by either FVCOM-GOM3 or MASS Coastal FVCOM.

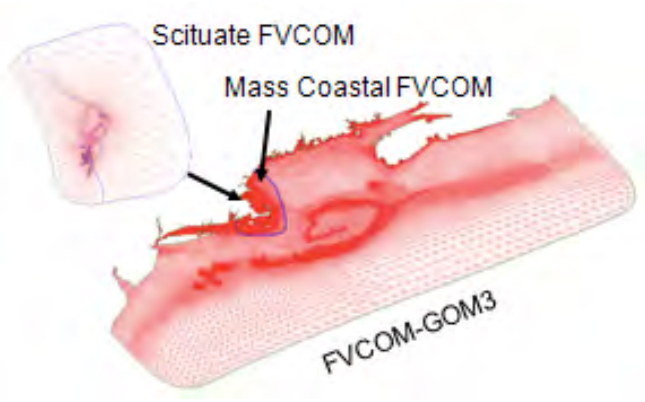


Figure 2 The three grids presently in NECOFS. The regional FVCOM-GOM3, Mass Coastal FVCOM, and the Scituate FVCOM grid for the local inundation forecasting**.**

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