The Continued Development of the Northeastern Regional Coastal Ocean Observing System

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LONG-TERM GOALS

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.

OBJECTIVES

NERACOOS will achieve the following objectives detailed in the original work plan of the proposal submitted in the fall of 2010.

1. Coordinated Regional Management
   1.1. NERACOOS office at base capacity.
2. Observing Subsystem
   2.1. Planning for future enhancement and National Synthesis of Regional Build Out Plans
   2.2. The Gulf of Maine buoy array will be maintained at current capacity (6 buoys – UMaine).
   2.3. The Long Island Sound buoy array will be maintained at current capacity (3 buoys – UConn).
   2.4. The Great Bay Coastal Buoy and Coastal Marine Lab will be maintained at current capacity (UNH).
   2.5. The Gulf of Maine HFR array will be maintained at current capacity (3 locations – UMaine).
   2.6. HAB monitoring in the Bay of Fundy and MERIS satellite work will be maintained at current capacity (BIO).
   2.7. Nutrient work will obtain additional capacity to allow buoy integration at URI and maintain capacity of the AZMP program (URI and BIO).
   2.8. Enhanced observing capacity will be achieved with continuing the deployment of Jeffreys Ledge CDIP wave buoy (UNH).
   2.9. Enhanced observing capacity will also be obtained with the real-time telemetry Narragansett Bay Fixed-Site Water Quality Monitoring Network (NBFSMN, URI).

3. Data Management and Communications Subsystem
   3.1. DMAC coordination will be maintained at current capacity and augmented to include work on the IOOS Data Portal (GMRI)
4. Modeling and Analysis Subsystem
   4.1. The Northeast Coastal Ocean Forecast System will be maintained at current capacity (UMassD).
   4.2. The WaveWatch III wave model will be maintained at current capacity (BIO).
   4.3. National SAROPS- STPS effort will be maintained (UConn)
5. Outreach and Education
   5.1. Current capacity at the NERACOOS office will be maintained.

APPROACH AND WORK PLAN

The work plan is organized by subsystem, asset class, and general priority.

1) Coordinated Regional Management

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.

2) 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 Regional Build Out Plan (RBOP) or 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. NERACOOS working with the National Federation of Regional Associations for Coastal and Ocean Observing (NFRA) will also fund development of a national synthesis of the RBOPs developed by all eleven IOOS regions.

The Gulf of Maine Buoy Array– 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.

The Long Island Sound Buoy Array – 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.

The Great Bay Coastal Buoy – 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 – 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 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 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.

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.

Jeffreys Ledge wave buoy – 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.

Narragansett Bay real-time telemetry – 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. 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 via the NERACOOS website through IOOS standards and expand the distribution of data by linking quality-assured data to NERACOOS annually.

3) Data Management and Communications Subsystem

DMAC coordination –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.

4) Modeling and Analysis Subsystem

The Northeast Coastal Ocean Forecast System – UMassD will maintain and operate NECOFS during the five year period. The Scituate IFS will become operational, and used to build a Hampton and Seabrook, NH 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 – 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 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.

5) Outreach and Education

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.

WORK COMPLETED

Objective 1 – Coordinated Regional Management

The NERACOOS Board of Directors continues to meet four times a year and held their Annual Meeting on November 29, 2011. The SPI Team continues to hold monthly conference calls and held their Annual Meeting on September 25. NERACOOS continues to partner with regional organizations on the *New England – Canadian Maritime Collaboration and Planning Initiative* where procedures to update these projects and continue collaboration were discussed on a teleconference of partners in May and an update period of three years was agreed to. Plans are being developed for the next update in 2013.

Objective 2 – Observing Subsystem

National Synthesis of Regional Build Out Plans- Drs. Holly Price and Leslie Rosenfeld completed their support as the contractors for the national synthesis of the regional build out plans.

The Gulf of Maine Buoy Array– The UMaine Physical Oceanography Group continued to operate 6 data buoys in the GoM (B01, E01, I01, M01, N01, and F01). Data from the active buoys were then archived, processed, quality-controlled, and made available in real-time. Buoy M01 broke free from its mooring in November 2011 and was recovered on December 5 by the R/V Delaware on a NOAA/NMFS cruise. Some of the instruments were damaged. New buoy M0119 was successfully deployed on 4 Feb 2012. Data from other UMaine moorings, including A01 (GMRI/LNG and MWRA) and D02 Bowdoin mooring (NASA) are being sent to GMRI for dissemination to NERACOOS. DeepCwind buoy F02 was recovered in June, and may be redeployed in Feb 2013. Bat detection sensors supplied by Stantec have been added to the buoys at A01, B01, E01 and F01. All UMaine NERACOOS buoys continue to have fish tag telemetry receivers for NOAA/NMFS. The UMaine buoy group also assisted in the staging and logistics for the deployment of the Wave glider and Fetch instruments by Liquid Robotics and Sonardyne personnel. The UMaine group continues working with the NERACOOS Products Team to develop climatologies.

The Long Island Sound Buoy Array – UConn continued to maintain, operate and distribute data from 4 axial buoys including Eastern Long Island Sound, Central Long Island Sound, Western Long Island Sound, and Execution Rocks and two stationary sites. All data were telemetered to shore and UConn maintained and operated a data archive and Mapserver-based distribution system that shares the near-real-time observations with the NDBC and the NERACOOS data system. UConn continued to acquire monthly water quality survey data from the CTDEP and include it in the freely accessible archive. An extensive red planktonic bloom was noted while servicing the buoys in September. Analysis by Dr. Senjie Lin at UConn, Marine Sciences revealed that the bloom was caused by the red ciliate *Mesodinium rubrum*, and it was hypothesized that the unusually warm temperatures may have contributed to the large-scale nature of the bloom. UCONN deployed an AUV in July. The UCONN group continues working with the NERACOOS Products Team to develop climatologies.

The Great Bay Coastal Buoy – UNH continued to operate the Great Bay Coastal Buoy for its eighth season of biogeochemical monitoring in the first half of June. UNH also continued the operation of the Coastal Marine Lab (CML)- SSS, SST, O_2, PAR and met variables remain active while the CO_2 sensor and ac-9 have been removed for NOAA and NASA sponsored cruises.

Gulf of Maine HFR array – All intended work was completed at each of the three sites and good data coverage was seen. All data were sent to the national CODAR backbone site in California.

HAB monitoring – BIO continued its work detecting *Alexandrium* using remote sensing data in the pilot area of the outer Bay of Fundy. 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. The 2011 results of the new prototype HABs warning product, based on the inverse correlation between diatom and dinoflagellate (Alexandrium) concentrations, have been sent SABS for comparison with the field counts data, and independent radiation and SST measurements are being compared to those from remote sensing. The overall success rate for the 2011 field season will be assessed and discrepancies used to improve the algorithm. Results of the (potentially) revised algorithm will be compared to the 2010 field data, which await analysis. In addition, broad biweekly surveys of the Bay of Fundy were initiated in early June to determine spatial and temporal distributions of *A. fundyense*.

The MERIS satellite-based detection algorithm was tested and refined using additional data from 2011 and 2012 and some promising results were indicated. A manuscript describing the method and results is being prepared for publication. Unfortunately communication with the ENVISAT satellite which houses MERIS was lost in April, and while waiting for the launch and data availability of OLCI on Sentinel-3, the suitability of MODIS Aqua data as a replacement for MERIS will be investigated. This requires considerable additional work to transport the algorithms to MODIS data, adapt it to the waveband specifications of MODIS, which are different from MERIS, and additional tests are required to establish the validity of the algorithm as implemented for MODIS data.

Nutrient work with integration (URI) and AZMP program (BIO) – The multi-sensor testing was continued off the URI-GSO Pier with the two nutrient sensor test arrays developed with NOPP Funding. The sensor arrays have undergone maintenance and incremental upgrades including to the ChemFIN Nitrate sensor. The latter is being integrated into one of the buoys of the Narragansett Bay Fixed Site Monitoring Network.

The ongoing AZMP regular, semi-annual sampling of nutrients and hydrographic properties continued. Processing of data will take place at BIO, and results will be made available online through the BIO hydrographic database. Nutrient sections continue to be used in conjunction with current data to estimate nutrient fluxes into the Gulf of Maine.

Jeffreys Ledge wave buoy –UNH continued operation of the buoy on Jeffrey's Ledge Datawell waverider buoy. 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.

Narragansett Bay real-time telemetry – All of the Sensor Arrays from the URI-GSO Pier remained out of the water being serviced and repaired for redeployment. Engineering work is in progress by

SubChem, URI and RI-DEM to develop and demonstrate the capability to have nutrient sensors coupled to some of the NBSFMN stations, and will report nutrient data to the NBSFMN and NERACOOS in real-time.

Objective 3 – Data Management and Communications Subsystem

DMAC coordination –GMRI continued work on the ongoing web maintenance and operations which includes web and aggregation database maintenance, daily checks, trouble shooting, bug fixes. GMRI aided UConn with finalizing the implementation of SOS feed for the Long Island Sound buoy array and ingested the data feed into the NERACOOS database. Work is also underway to integrate URI efforts including the in-situ nutrient measurements and the Narragansett Bay Fixed Site Monitoring Network. Migration of the GoMOOS products to the new NERACOOS Drupal content management website was completed and involved product testing with NERACOOS staff and last minute alterations. In April the GoMOOS website was retired and appropriate web pages with messaging were developed. In May, website and data management activates allowed inclusion of the Liquid Robotics Waveglider and Sonardyne Fetch node deployments onto the NERACOOS website. Cloud server work included migration of the dependent buoy database as well as solving FTP and backup issues. USGS tide stations were also included into the NERACOOS data stream and available through the real-time portal. Routine activities included web and aggregation database maintenance, daily checks, trouble shooting, and bug fixes. GMRI also participated in bi-weekly Regional DMAC Conference calls and SOS reference team bi-weekly calls. GMRI leads the Product Team with creating and implementing products like climatologies (to be completed in December 2012), bringing Drifter data into NERACOOS, and a regional portal to improve data access that is currently being scoped. GMRI also developed RSS feeds for individual buoys and preliminary text-a-buoy services using Twitter and RSS. GMRI is developing a Regional Data Management Plan and continues work with NeCODP Executive Committee with developing workplans, and helped hold a Data Management Workshop in September.

Objective 4 – Modeling and Analysis Subsystem

4) Modeling and Analysis Subsystem

The Northeast Coastal Ocean Forecast System – UMassD continued to maintain and operate NECOFS. The FVCOM-GOM3 data assimilation algorithm was modified to improve the computational efficiency. The Scituate inundation model grid was modified by refining the most possible inundation area facilitating sensitivity experiments with comparison to the coarse grid results. NECOFS nesting to the FVCOM global ocean model continues to improve model performance. Work continues on the reanalysis of Global-FVCOM results from 1978 to 2010 for the study of climate changes on the Gulf of Maine ecosystem, particularly on the physical mechanisms of salinity anomaly trends. B. Beardsley has been working together with S. Couture (NHDES), D. Sowers (PREP), J. Cannon (NWS), and others on developing a new inundation forecast system for the Hampton-Seabrook estuary system, NH. UNH has provided the UMASSD team with high-resolution LIDAR data, and B. Beardsley will supervise creation of the subdomain grid for Hampton-Seabrook and nest it to GOM3-FVCOM.

WaveWatch3– The Wavewatch III model was operated at BIO although scheduling model runs on the new computer infrastructure still presents some challenges. The new forecast system is still undergoing development because it has had to be transitioned to a new computer platform at BIO.

Operation of the surface current forecasting algorithm for the national grid – UCONN continued 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.

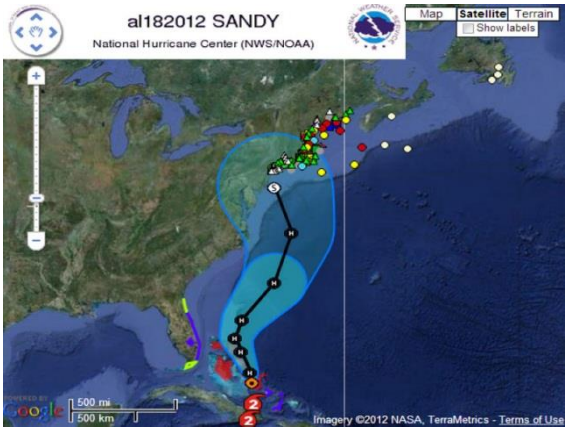
Objective 5 – Education and Outreach

NERACOOS continues to collaborate with NEOSEC (New England Ocean Science Education Collaborative) through projects like the NOAA funded *Families by the Seaside* project, participation in governing council meetings, presenting at the Project WET conference, and has received received funding to develop an exhibit at the Seacoast Science Center in Rye, NH to highlight Right Whale research in Stellwagen Bank National Marine Sanctuary. This year, NERACOOS Co-sponsored the 2012 NEOSEC Biennial Ocean Literacy Summit on November 1 and 2 at the University of Rhode Island, of which 180 registered educators, scientists, and policy makers attended. NERACOOS also continues to participate in the monthly NFRA Education and Outreach Committee calls and activities.

NERACOOS uses a variety of outreach channels to reach its stakeholders including, a quarterly e-newsletter, website features, weekly Facebook updates, participation in stakeholder meetings, conferences, etc., focus groups, and hosting stakeholder forums at our Board of Directors meetings. A Communication Strategy was also created.

RESULTS

On the 29th of October, 2012 Hurricane Sandy combined with a cold front and developed into Superstorm Sandy. The storm came ashore in New Jersey where the wind, wave, and flooding caused extensive damage and power outages in many communities in Connecticut, New York and New Jersey. There were over one hundred lives lost as a result of this storm and damages are still being assessed, but early estimates suggest over $50B in damages, making it the second most expensive storm in US history.



NERACOOS provides nearly half the continuous near real-time at sea assets in the region from Long Island sound to Canada. In Long Island Sound alone, NERACOOS provides all of the at sea near real-time assets, which proved to be very valuable during and after Sandy. The sensors in Long Island Sound operated successfully throughout the storm in conditions never observed before. When combined with the NOAA and USGS water level gauges, the NERACOOS-supported assets will provide critical data to guide future planning for coastal infrastructure protection.

NERACOOS data proved critical for responders, forecasters, and citizens. Data and the storm track were provided through the Real-Time Data Portal (see above graphic). This included hourly information developed for marine operations, such as wind, wave, visibility, air temperature, water temperature at various depths and more. Coastal High Frequency Radars (HFR) from Long Island Sound to Maine were operating and reporting sea surface currents, coastal wave forecasts were available, and coastal inundation forecasts were available before the storm impacted the modeling facility.

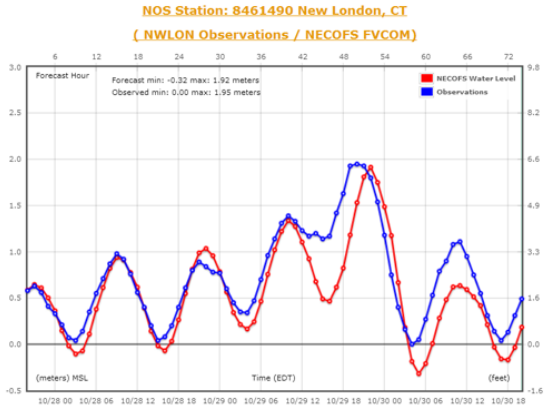
Web traffic for all three days of the storm (10/28 to 10/30) was up 300% with a peak of 800% on 10/29. Over 13,300 page views for the three days with about 20% going to the real-time portal.

NERACOOS information was used to inform the 180 participants of the 2012 New England Ocean Science Education Collaborative (NEOSEC) Ocean Summit in Narragansett, RI on the impact of Sandy. The Summit continued on November 1 and 2 with Dr. Kathy Sullivan, assistant secretary of commerce for environmental observation and prediction and deputy administrator of NOAA, giving a keynote address.

All buoys were operational during the storm with those in the Gulf of Maine reporting for the duration of the storm. Long Island Sound buoys went offline due to power outages on land. Damage was sustained to one surface current measuring High Frequency Radar (HFR) antenna from UCONN group. Data from the UMaine HFR from the national data feed at Rutgers University was down, but was rerouted to the University of California San Diego (UCSD).

Storm surges in LIS and RI were between 8 and 12 feet, which were a little greater than NECOFS forecast was indicating. Highest sustained winds observed near 70 mph at the CMAN station in Buzzards Bay. Many buoys reported wave heights around 30 feet.

This storm created flooding and very large waves around the shores of Long Island Sound (see figure to the right). Early analysis suggests that the areas flooded were larger than expected based on the FEMA flood zones. To better predict future risk the wind and wave conditions during these events must be analyzed. NERACOOS supports three buoys with meteorological sensors in the Sound and another overwater station on a lighthouse. Two wave gauges are also supported. These sensors operated successfully throughout the storm in conditions never observed before. When combined with the NOAA and USGS water level gauges will provide critical data to guide future planning for coastal infrastructure protection.

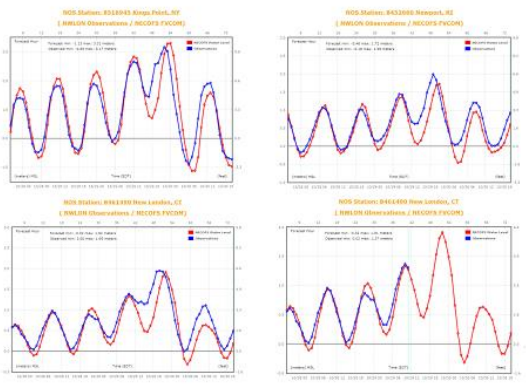


The National Weather Service Weather Forecast Offices in the northeast used the NERACOOS information. John Cannon from the Gray, Maine office reported that one NERACOOS success story of Sandy is “the close relationship that NERACOOS and a front line office such as NWS GYX has. I received quick responses in real-time for data requests during the storm, making the support from NERACOOS and others terrific!”

John Cannon also noted that the NERACOOS assets were particularly helpful during this large storm, particularly the buoy wind and wave data. Very large waves and storm forces winds were observed on October 29th and 30th, allowing operational meteorologists to adjust their forecasts in real-time.

The Coastal Flood Nomogram proved to be particularly valuable prior to Sandy's landfall. Animations suggested that large, battering waves would approach the coast on October 29th (35 feet), causing erosion and splash-over problems in our more vulnerable exposed beaches (see picture to the right of Camp Ellis, Maine). Indeed that occurred and forecasters were able to adjust their conceptual model for potential hazards associated with "Sandy".

NERACOOS forecast models performed well during the storm. The wave and storm tide tracker information was presented at the fall workshop at NWS Gray, Maine for training purposes. Wave Watch Three (WW3) model was operational during storm but the

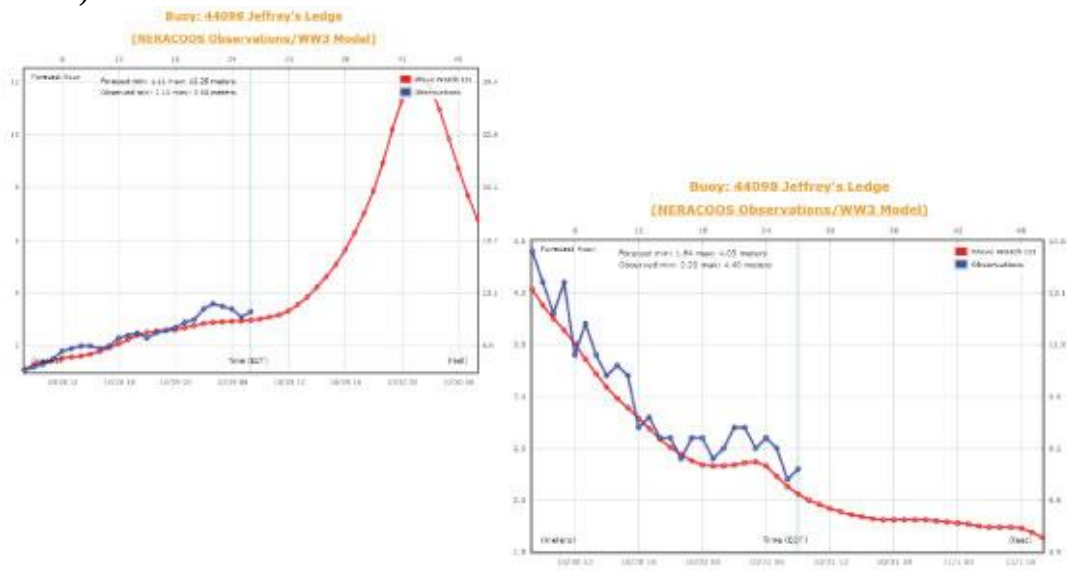


Northeast Coastal Ocean Forecast System (NECOFS) was offline for a couple of days. Both showed good agreement with observations. The figure to the right shows comparisons of the NECOFS sea level forecasts made a couple of days before the storm and observations for a few stations in Long Island Sound and Narragansett Bay. The forecasts did really quite well in predicting magnitude if not timing. Hardening the forecast system infrastructure so that it does not go down during these events and protecting the hindcasts remains a priority.

Bob Thompson from the Taunton, Massachusetts office noted that "the IOOS buoy data were invaluable for Sandy," and explained further. "We use a combination of wave amplitude and water level to ascertain the expected impact of coastal flooding along selected reaches of the coastline. The data helped us with refinement of our near term forecasts and then allowed us to go back and adjust our coastal flood forecast impact procedures. We have subsequent to Sandy refined our coastal flood tables that attempt to assign expected impact at selected locations as a function of total water level and wave height based in part on the wave data observed at the IOOS sites."

In 2011, NERACOOS helped develop the StormReporter into an expanded tool for the region from the initial project in Massachusetts. Bob Thompson explained that the "StormReporter helped us to assess the actual coastal storm impacts along the MA and RI coastline (our forecast area of responsibility). Over 350 StormReporter entries were received from Massachusetts alone! We used StormReporter to get an idea of extent of structural damage, extent of overwash, and severity of erosion. The uploaded images provided by StormReporter really helped to objectify the impact whether the impact was inundation, structural damage, and/or beach erosion. The StormReporter data will provide an archive for future studies on this event."

The NERACOOS Model Forecast/Observation Viewer captured the waves at Jeffery's Ledge (see below).



Dr. Joe Salisbury, University of New Hampshire scientist, provided details for the Jeffrey's Ledge wave buoy in a technical note on "CDIP wave observations in Superstorm Sandy" (Seymour et al, 2012).

"One surprising result of this display is that the growth of Sandy during its northern travel during the last week in October resulted in peaks in the wave height measured in the Gulf of Mexico (St. Petersburg on 29 October) and the eastern Caribbean (Rincon on 30 October) that occur on or after the date of the wave energy peak in New England (Jeffreys Ledge on 29 October)."

"The largest single wave that was recorded by this array of buoys was at the Block Island, RI, site and was equivalent to the height of a five-story building."

IMPACT AND APPLICATIONS

National Security

The observing systems in the NERACOOS region provide critical information to mariners on ocean conditions including the U.S. Navy and Coast Guard.

Economic Development

The observing systems in the NERACOOS region provide critical information to mariners on ocean conditions including commercial shipping operations and harbor pilots, essential components of the nation's economy.

Quality of Life

The observing systems in the NERACOOS region provide critical information to those who manage the regions coastal waters including those responsible for Harmful Algal Blooms research, alerts, warnings, and closures.

Science Education and Communication

NERACOOS works closely with NEOSEC to promote science education and communication with diverse audiences. NERACOOS provides information that helps audiences develop their own understanding of the ocean's influence on weather and climate, and the relationship between oceans and humans. This "Ocean Literacy" is critical to sustaining our ocean and coastal regions. NERACOOS works closely with NEOSEC, the New England Ocean Science Education Collaborative, to promote Ocean Literacy. The Ocean Literacy Principles provide framework to engage people in education and outreach activities related to ocean observing.

TRANSITIONS

Most activities of NERACOOS are being used by others as IOOS is an end-user driven system to deliver information to those who use and manage the coasts and ocean in the northeast U.S. and Canadian Maritime Provinces of New Brunswick and Nova Scotia. As such, many NERACOOS products and services are incorporated into programs throughout the operational spectrum. For example, the buoys of the Gulf of Maine array have a data return in excess of 90% which is comparable or exceeding the returns of the operational National Data Buoy Center observations in the region. These are routinely used by the National Weather Service's Weather Forecast Offices in the region.

National Security

See comment in the impact section above.

Economic Development

See comment in the impact section above.

Quality of Life

See comment in the impact section above.

Science Education and Communication

See comment in the impact section above. An example would be the "Earth as a System is Essential" (EaSiE) project of the Maine Mathematics and Science Alliance (MMSA) which incorporates NERACOOS information into classroom lesson series.

RELATED PROJECTS

The Northeast Ocean Data Portal (www.northeastoceandata.org)
The Northeast Coastal and Ocean Data Partnership (www.necodp.org)
The New England Ocean Science Education Collaborative (www.neosec.org)
Families by the Seaside (http://www.neosec.org/projects/families-by-the-seaside)
Earth as a System is Essential (http://www.easie-mmsa.org/)
NSF OOI Pioneers Array (www.oceanobservatories.org)
National Federation of Regional Associations for Coastal and Ocean Observing (www.usnfra.org)
U.S. IOOS Super-Regional Modeling Testbed (http://testbed.sura.org/)

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J.R. Morrison, T. Shyka, and C. Durette, 2012. A regional build out plan for the Northeastern Regional Association of Coastal Ocean Observing systems (NERACOOS). Poster at Ocean Sciences.

Community White Papers with NERACOOS affilicate authors Summited on 6/30/2012 for inclusion in the 2012 IOOS Summit Proceedings

Title	Lead Author	Contributing Authors
Priorities For Governance Of Data Management And Communications For Ocean Observations	Alexander, C.	J. Thomas[2], K. Bennedict[3], W. Johnson[4], R. Morrison[5], J. Andrechik[6], E. Stabeneau[7], M. Gierach[8], K. Casey[9], R. Signell[10], H. Norris[11], R. Proctor[12], K. Kirby[13], D. Snowden[1], J. de LaBeaujardiere[14], E. Howlett[15], S. Uczekaj[16], K. Narasimhan[17], E. Keys[18], M. Trice[19], and J. Fredericks[20]
Harmful Algal Bloom (HAB) Sensors In Ocean Observing Systems	Anderson, D. M.	G. Doucette, G. Kirkpatrick, C.A. Scholin
Ferry-based Sampling For Cost-effective	Codiga,	W.M. Balch2, P.M. Holthus3, H.W.

Generation Of Long-duration, Repeat-transect, Multidisciplinary Observation Products In Coastal And Estuarine Systems	D.L.	Paerl4, J.H. Sharp5, R.E. Wilson6
National, International & Interdisciplinary Collaboration and Opportunities	Fredericks, J.	Arko, Chandler, Maffei, Pearlman, Smith, Stocks, Waldmann
An Integrated Coastal Ocean Acidification Observing System (ICOAOS)	Jewett, L.	D. K. Gledhill[1], K. Arzyus[2],J. Newton, J, Salsbury
Economic Data for OOS Evaluation and Enhancement	Kite-Powell, H.	
Promoting Research And Innovation Enabled By Observatory Science	Lohrenz, S. E.	Contributing Authors
A Us IOOS Coastal Ocean Modeling Testbed To Improve Prediction Of Coastal And Estuarine Systems	Luettich, R.	Rich Signell[2], Don Wright[3], Gary Crane[4], Liz Smith[5]
Environmental Monitors On Lobster Traps And Other Fixed Gear	Manning, J. P.	
Student-Built, Fishermen-Deployed, Satellite-Tracked Drifters	Manning, J. P.	
Rapid Detection Of Climate Scale Environmental Variability In The Gulf Of Maine	Morrison, J. R.	N.R. Pettigrew[2], J. O'Donnell[3], J.A. Runge[4]
The Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)	Morrison, J. R.	Contributing Authors
Linking The IOOS Animal Tracking Network With The Ocean Tracking Network	O'Dor, R.	F. Whoriskey[1], H. Moustahfid[2]
Building Coastal IOOS for the Next Decade: Following up on the Regional Build Out Plans	Quintrell, J.	Harvey Seim, Ann Jochens, Mike Crowley, Debra Hernandez, Josh Kohut, Ru Morrison, Molly McCammon, Holly Price, Leslie Rosenfeld, Suzanne Skelley, Julie Thomas
IOOS Modeling Subsystem: Vision And Implementation Strategy	Rosenfeld, L.	Richard Signell[2], Yi Chao[3]
Integrated Sentinel Monitoring for the Northeast Region	Runge, J.	Jeffrey Runge, Joseph Salisbury, Ivona Cetinic, Jonathan Hare, Michelle Dionne, Catherine Johnson, Ben Cowie-Haskell, Donald Anderson, Melville Coté, Jr., Brian Thompson, J. Ruairidh Morrison
From Gulf of Maine Council on the Marine Environment/EcoSystem Indicator Partnership (ESIP)	Tilburg, C.	
Fixed Platforms in an Integrated and Interdisciplinary Ocean Observing System	Virmani, J.	Lynn Leonard[2], Jennifer Dorton[3], Robert H. Weisberg[4], Josie Quintrell[5], Anne Jochens[6], Ru Morrison[7], James O'Donnell[8]

OUTREACH MATERIALS

One pager outreach materials and other outreach materials can be found at the NERACOOS website: www.neracoos.org/about/documents