Phased Deployment and Operation of the Mid-Atlantic Regional Coastal Ocean Observing System (MARCOOS)

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<th>Investigator</th>
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<td>Old Dominion University</td>
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<td>Stevens Institute of Technology</td>
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<td>University of Delaware</td>
<td>A. Cope</td>
<td>NOAA Mount Holly WFO</td>
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<td>A. Gangopadhyay</td>
<td>University of Massachusetts</td>
<td>T. Herrington</td>
<td>Stevens Institute of Technology</td>
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<td>University of Rhode Island</td>
<td>E. Howlett</td>
<td>Applied Science Associates</td>
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<td>J. Kohut</td>
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<td>M. Oliver</td>
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<td>O. Schofield</td>
<td>Rutgers University</td>
<td>H. Seim</td>
<td>University of North Carolina</td>
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<td>J. Titlow</td>
<td>WeatherFlow Inc.</td>
<td>D. Ullman</td>
<td>University of Rhode Island</td>
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<td>J. Wilkin</td>
<td>Rutgers University</td>
<td>R. Wilson</td>
<td>SUNY, Stony Brook</td>
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<td>W. Wittman</td>
<td>Public Service Electric/Gas</td>
<td>N. Vorona</td>
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<td>A. Voros</td>
<td>NY/NJ COAST</td>
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NOAA Award Number: NA07NOS4730221
Award Period of Performance: October 1, 2008 – March 31, 2009
2) PROJECT SUMMARY: The Middle Atlantic Coastal Ocean Observing Regional Association (MACOORA) is one of eleven Regional Associations (RAs) within the U.S. Integrated Ocean Observing System (IOOS). The MACOORA footprint encompasses 9 states, 66 million people, four major estuaries, one of which is the world’s largest, and the world’s largest Navy base. MACOORA ports handled cargo worth over $259 billion in 2005 (over 23% of the total US waterborne commerce) including over $130 billion at the Port of New York/New Jersey alone. Through MACOORA, the user community has identified the priorities for MACOORA-wide regional and sub-regional scales. The two MACOORA priority themes for the regional components of the Integrated Coastal Ocean Observing System (IOOS) are:

**MACOORA Regional Themes**

1. **Maritime Safety** – providing regional surface current maps to improve Search And Rescue and hazardous material spill response, as well as products to improve rip current forecasting.
2. **Ecological Decision Support** – providing regional 3-D temperature and circulation data and forecasts for the recreational, commercial and fishery management communities.

MACOORA formed the Mid-Atlantic Regional Coastal Ocean Observing System (MARCOOS) to generate quality controlled and sustained ocean observation and forecast products that fulfill user needs. MARCOOS products will support the two priority regional themes and provide critical regional-scale input to MACOORA’s nested subregional efforts on Coastal Inundation and on Water Quality. MARCOOS will accomplish this by coordinating an extensive array of existing observational, data management, and modeling assets to generate and disseminate real-time data, nowcasts and forecasts of the ocean extending from Cape Cod to Cape Hatteras.

MARCOOS will (a) **collaborate** with NOAA WFOs to link existing regional coastal weather networks to evolving NOAA WRF regional forecasting capabilities – to **provide** an improved ensemble of weather forecasts, (b) **operate** the existing Mid-Atlantic HF Radar Network and leveraging Coast Guard drifters that are linked to statistical and dynamical models - to **provide** an ensemble of regional nowcasts and forecasts of 2-D surface currents, and (c) **operate** the existing satellite receivers and leverage the Navy investment in a regional glider capability linked to the dynamical models - to **provide** an ensemble of 3-D circulation, temperature and salinity nowcasts and forecasts. The MARCOOS data management team will facilitate implementation of an end-to-end system consistent with DMAC standards. A management structure that establishes and monitors performance metrics will ensure quality. Education & Outreach (EO) teams will engage additional users and provide frequent and timely feedback, while an economic impact team assesses benefits of MARCOOS information.
Progress and Accomplishments

Milestones:

<table>
<thead>
<tr>
<th>Task</th>
<th>Year 1 Goal Summary</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
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<tbody>
<tr>
<td>1.1</td>
<td>Atmospheric Data Integration</td>
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<td>1.1.1</td>
<td>Setup WRF atmospheric forecasting computer at Mount Holy WFO</td>
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<td>1.1.2</td>
<td>Integrate WRF forecast results with USG-DOE</td>
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<td>1.1.3</td>
<td>Improve regional WFO staff on WRF forecasting resources</td>
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<td>1.1.4</td>
<td>Maintain data flow and model validation activities with WFO</td>
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<td>2.1</td>
<td>RF-Radar Equipment</td>
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<td>2.1.1</td>
<td>Inventory 28/6/RF-Radar Sites in online database</td>
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<td>2.1.2</td>
<td>Standardize hardware and software settings throughout network</td>
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<td>2.1.3</td>
<td>Build network-wide diagnostic monitoring</td>
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<td>2.1.4</td>
<td>Install redundant high-speed communications where possible</td>
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<td>2.1.5</td>
<td>Continue site relocations as identified</td>
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<td>2.1.6</td>
<td>Analyze existing antenna patterns for best performance</td>
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<td>2.1.7</td>
<td>Continue to develop best practices for the national network</td>
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<td>2.1.8</td>
<td>Operate &amp; update systems consistent with existing &amp; evolving best practices</td>
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<td>3.1</td>
<td>SAROPS DA/QC</td>
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<td>3.1.1</td>
<td>Standardize DA/QC radial data settings throughout network</td>
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<td>3.1.2</td>
<td>Test and evaluate new merging algorithm and vector metrics</td>
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<td>3.1.3</td>
<td>Evaluate new DA algorithm in RAM and integrate into operational system</td>
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<td>3.1.4</td>
<td>Test and evaluate merging pattern sensitivity</td>
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<td>3.1.5</td>
<td>Reset settings with benchmark group based on above tests</td>
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<td>4.1</td>
<td>Underwater Glider Operations</td>
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<td>4.1.1</td>
<td>Purchase CAMGOS glider</td>
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<td>4.1.2</td>
<td>Develop concept of operations, recovery resource list, dive/inter zone, etc. document</td>
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<td>4.1.3</td>
<td>Norex efficiency LED database through OPENWAP</td>
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<td>4.1.4</td>
<td>Demonstrate CAMGOS-undersea glider capability</td>
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<td>4.1.5</td>
<td>Participate in fisheries current</td>
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<td>4.1.6</td>
<td>Conduct demonstration project</td>
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<td>5.1</td>
<td>Satellite Data Acquisition</td>
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<td>5.1.1</td>
<td>Operate and maintain local L-Band &amp; X-Band satellite systems</td>
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<td>5.1.2</td>
<td>Link satellite data to online server for leveraging product development</td>
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<td>5.1.3</td>
<td>Incorporate leveraged products from other sources in MARCOOS</td>
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<td>6.1</td>
<td>Numerical Weathering</td>
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<td>6.1.1</td>
<td>STPS implemented in B5 and NPS</td>
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<td>6.1.2</td>
<td>STPS implemented through MARCOOS domain</td>
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<td>6.1.3</td>
<td>Operate and maintain STPS</td>
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<td>7.1</td>
<td>Dynamical Modeling</td>
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<td>7.1.1</td>
<td>Work dataset for assimilation, quality control, error estimates and DACM...</td>
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<td>7.1.2</td>
<td>Develop real-time data assimilation</td>
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<td>7.1.3</td>
<td>Formulate quantitative skill metrics</td>
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<td>7.1.4</td>
<td>Assimilation methodology developed for real-time models</td>
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<td>Drifter assimilation evaluation</td>
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<td>DACM</td>
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<td>8.1.1</td>
<td>Support MARCOOS DACM needs</td>
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<td>8.1.2</td>
<td>Weather data in NCEP format</td>
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<td>Intergrate HF-Radar Operational-computer online</td>
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<td>8.1.7</td>
<td>Improved DACM-UCI OPENWAP database</td>
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<td>8.1.8</td>
<td>Coordinate with national DACM efforts</td>
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<td>9.1</td>
<td>Education &amp; Outreach</td>
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<td>9.1.1</td>
<td>Equipped MARCOOS community on nearshore currents and waves</td>
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<td>9.1.2</td>
<td>Expand research with Boulder university partnerships</td>
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<td>9.1.3</td>
<td>Leverage MARCOOS project to assess 3-D visualization techniques for fisheries...</td>
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<td>9.1.4</td>
<td>Leverage NUR grant to build enhanced user community capability</td>
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<td>10.1</td>
<td>Summary Benefits</td>
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<td>Background assessment of economic impact of fisheries</td>
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<td>10.1.2</td>
<td>Fisheries planning current for fisheries demonstration fisheries groups, glider...</td>
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<td>10.1.3</td>
<td>Initial assessment of demonstration impacts</td>
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Year 1 Goal Summary: The focus was on the observation and forecasting of 2-D surface currents to support Maritime Safety. Priority is given to operating the full regional HF Radar network, and linking the surface currents to Short Term Prediction System (STPS) statistical forecasts, the Coast Guard’s Environmental Data Server (EDS), and their SAROPS system. SAROPS-required uncertainty estimates will be determined through evaluation of the HF Radar and STPS surface current system with Coast Guard surface drifters. Three dynamical ocean forecast models will be run in their native domains and forced by nowcast/forecast surface meteorological products from both NOAA NCEP and the NOAA Weather Research & Forecasting (WRF) model (to be set up at the Mount Holly WFO). These NOAA wind fields will be compared with a high resolution weather meso-net from WeatherFlow Inc. The models will be adapted to assimilate MARCOOS satellite, HF Radar, glider, and drifter data as available. Year 1 MARCOOS regional glider flights leveraged from existing ONR assets are partially supported as part of the ongoing DoD MURI program. Efforts will determine which assimilation and wind field...
forcing best improves surface current forecasts. The first MARCOOS glider will be built. Education efforts will leverage Sea Grant expertise to include HF Radar wave and current near shore products into NWS rip current forecasting activities, and leverage the Centers for Ocean Science Education Excellence (COSEE) – Mid Atlantic’s expertise to coordinate product development with the recreational, commercial, and fishing management communities. Relative economic impacts of recreational and commercial fishing will be assessed, along with the regional value of ocean-related activities.

**Year 2 Goal Summary:** General goals for Year 2 are as follows. Weatherflow will continue to increase the number of nearshore weather stations deployed and reporting data to the NWS, and, working with COAST, continue to catalogue the many high resolution forecast models run by NWS, academics and industry into a growing regional ensemble, providing data & model comparison tools for evaluation. The HF radar operations group will continue to improve their uptime statistics for the Mid-Atlantic regional network as measured by the number of sites contributing data to the National HF Radar Network and the average latency, and they will continue to adjust site locations to improve the beam patterns and operational resiliency for the antennas as needed. The HF Radar QA/QC group will use Coast Guard drifters to continue to evaluate different methodologies for producing the total vector current fields, defining the initial operational total vector product to be used for Search And Rescue by April, 2009. UConn’s STPS will be expanded to the full region, will be evaluated using Coast Guard drifters, and will be made available in real time by April of 2009. ASA will lead the effort to put HF Radar data and STPS results into the Environmental Data Server (EDS) so that it can be ready for the use in the Operational version of the Coast Guard’s Search and Rescue Optimal Planning System (SAROPS) by May of 2009. Satellite Sea Surface Temperature imagery will be declouded by UDel and provided via a webpage to the public and via opendap to modelers. A total of four Glider missions will be run with the Regional Glider Consortium, two in the spring and two in the fall, both timed to coincide with NMFS cruises. The ASA-led data management work will begin shifting away from the HF Radar as it is completed and towards Glider data as it spins up. Three dynamical modeling groups, UMass, Stevens and Rutgers, supplemented by other funds, will move towards real-time forecasting and evaluation with available datasets and drifters. Data management will include bringing the dynamical models, as they are ready, into the EDS, and organizing the MARCOOS contribution to the 7 IOOS core variables. We will meet with the full range of fishing communities, including fisheries scientists & managers, recreational fishers and commercial fishers to refine our products for Ecosystem Decision Support. We will meet with the lifeguard associations to demonstrate MARCOOS wave products for their use in predicting the likelihood of rip currents. We will develop new approaches to communication with our constituents. Economic impacts will continue to be assessed. Our message of demonstrating development of IOOS capabilities will be carried to the region’s governors.

The accomplishments in the first half of Year 2 are described below.

1. **Atmospheric Data Integration & Gridded Diagnostic Product.**
Lead: Jay Titlow, WeatherFlow.
Working Group Members: Andrew Voros, Eoin Howlett, Al Cope, Scott Glenn

WeatherFlow is working with several regional NWS offices, including Mt. Holly NJ and Wakefield VA, to assimilate their mesoscale model output. An example of this is given in Figure 1.

![Figure 1: Mesoscale model output for Boston Harbor.](image)

The impetus is to collect all models being run within the MARCOOS domain. Statistical verification can then be performed on an ongoing basis to determine the best method of creating a region-wide gridded wind diagnostic and prognostic set of fields. This would allow a model-to-model verification system to be established that would serve not as a competition, but to establish the roots of an ensemble approach, creating the optimum input wind product that matches the regional nature of meteorological events such as hurricanes and nor'easters.

Since regional mesoscale models tend to yield their best results as weather systems migrate through the geographical "center" of a domain, it is hypothesized that a final product may blend the various models by weighing the degree of influence by any one model as a function of a system location as it traverses through the MARCOOS domain. For example, if a tropical system is moving south to north through the domain, it may be that initially the domains centered within southern portions of the MARCOOS footprint wield a greater influence within a composite gridded product. Then, as the system advances, the southern domains fade while those in the north take on a greater influence. This approach is untested but by simply assimilating as many models as possible, the components may fall into place to develop creative, more certain solutions.

Observations used to verify these models include NWS, WeatherFlow, C-MAN and various MACOORA member existing infrastructures. These additional non–NOAA observations are critical to the verification process because they are a) a truly independent data source, b) located in meteorologically challenging areas, and c) littoral in nature. WeatherFlow continues to participate in regular monthly conference calls,
work sessions, and interfacing with NWS meteorologists and other MARCOOS members to create optimum strategies on coastal atmospheric behavior affecting oceanic processes.

2. HF Radar Site Operations

Lead: Hugh Roarty, Rutgers.
Working Group: Mid-Atlantic HF Radar Consortium (MAHFRC)

The goals for year 2 have been to operate and update the system consistent with the existing best practices. Three field technicians and a regional coordinator monitored the systems and responded to outages as they occurred. Depending on the severity of the issue and availability of personnel, site downtime ranged from hours to weeks. The average radial data availability of the long range sites increased to 87% in the first half of year 2 from 78% in year 1. The average radial data availability of the standard range sites increased to 78% in the first half of year 2 from 67% in year 1. A spare multi frequency (5, 13 and 25 MHz) system was purchased from Codar to serve as a spare for the entire network. This spare was deployed in January 2009 to temporarily replace 25 MHz hardware at Breezy Point, NY while the field equipment was sent back to CODAR for repair and the data stream remained intact. Communication between the coordinator and regional technicians was maintained through monthly group phone calls as well as correspondence with the regional operators on a weekly basis. In addition, a web log (http://marcoos.us/wp/wp) was created for the operators to share information and facilitate in the repair of malfunctioning radars. This site is password protected. The username and password can be furnished by Hugh Roarty (hroarty@marine.rutgers.edu), MARCOOS HF Radar Regional Coordinator, upon request. We also conducted the first webinar for the operators; utilizing the website http://www.elluminate.com/ to share and comment on the real time metrics we have been tracking to gauge network status and health.

Three new sites were added to the network in 2009. Rutgers obtained an additional CODAR system that had been on loan to Mote Marine lab. A site visit to the Martha’s Vineyard Coastal Observatory was made in January 2009. A planned test of the system is scheduled for May 2009. This will begin the gap filling strategy that was outlined in the MARCOOS Gap Filling document as part of the planning effort for a national system (http://www.marcoos.us/downloads/publications/MACOORA_HFGapFilling.pdf). The University of Delaware added a standard range system at Indian River, DE. The communications to this site are being finalized now and the site will be online in May 2009. A long range system was installed at Little Island Park, VA. Before the data for this system was added to the network, the site underwent a twenty point inspection. This standard operating procedure in order for a site to be admitted to the network can be found on the MARCOOS web site at http://www.marcoos.us/publications.htm.

In addition to measuring surface currents, the HF Radar systems can also measure wave parameters. We will be providing this data in a netCDF data format available through the Rutgers OPeNDAP server.
The only change in HF Radar operator personnel was the departure of Robert Hess as central region operator. He has been replaced by Ethan Handel. Mr. Handel has already completed the Codar Introductory Training Course. A discussion of the HF Radar site metrics as well as reports from each of the regional operators is given in Appendix I. The HF Radar group received 2 letters of support which are shown in Appendix II. One letter is from the Texas HF Radar operators, and the second is from a data provider to the fishing community.

3. **HF Radar Data QA/QC**
   Leads: Josh Kohut, Dave Ullman, Sage Lichtenwalner

The major accomplishment in this effort is the quality controlled MARCOOS HF Radar totals are being served through the Coast Guard’s Environmental Data Server (EDS) and then into the Coast Guard Search and Rescue Optimal Planning System (SAROPS) as of May 4, 2009. See the press release in Appendix V. Figure 2 shows the MARCOOS HF Radar product in SAROPS. The pink square off the coast of NJ is the initial search area. The rainbow pattern on the right hand side of Figure 3 shows the probability distribution of the search area after some time has passed. The figure also shows the path of Coast Guard Self Locating Datum Marker Buoy (SLDMB) through the coverage field as a dark blue line.

Prior to the introduction of this new OI product to the Coast Guard decision tool, an extensive validation and evaluation of this product was done. Using a test period in the winter of 2007, totals generated with both the existing Unweighted Least Squares (UWLS) algorithm and the new Optimal Interpolation (OI) algorithm were compared to 4 moored ADCPs and 7 drifter tracks (one track is shown in Figure 4). The analysis included sensitivity to input parameters to OI including expected variances and spatial scales. The evaluation showed that the new OI and existing UWLS had similar skill in regions of good system geometry. However, in regions of poor coverage like the offshore edge of the CODAR domain, the OI was much more robust in filling gaps and eliminating outliers.

Both the new optimal interpolation (OI) total vector product mapped to the national 6km grid and the original unweighted least squares (UWLS) product are being served via the Rutgers OPeNDAP server. These two vector products are made available for the Short Term Prediction System. The results of this effort are discussed in Section 6. As of the draft of this report, the Coast Guard Environmental data server is injecting the OI total vector product and the STPS based on this new product for application in SAROPS.
Figure 2: MARCOOS HF Radar product as displayed in the Coast Guards SAROPS interface.

Figure 3: MARCOOS HF Radar product as displayed in the Coast Guards SAROPS interface as well as the preview of the MARCOOS STPS product shown in the preview window in the upper left.
Figure 4: Map showing the coverage of the HF Radar with the percent coverage represented by the color bar with the path of the SLDMB (green-start and red-end diamonds with the black line) as well as the location of the ADCP (blue circle).

A side by side comparison of the OI totals and UWLS is shown in Figure 5.

Figure 5: UWLS total vector map (left) and optimal interpolation total vector map (right). The OI is able to fill gaps left by the UWLS processing.


Lead: Oscar Schofield.
Working Group: Wendell Brown, Bill Boicourt, Josh Kohut

The two MARCOOS spring glider deployments in the region were timed to overlap with the National Marine Fisheries Service spring trawl survey which occurred from 1 March
to 11 May, 2009. The composite hydrography for temperature from the two gliders is shown in Figure 6.

Figure 6: MARCOOS glider transects spring 2009. Temperatures are shown as ribbons below the tracks.

4a Northern Line (Cape Cod to New Jersey)

On 12 March 2009 Rutgers’ glider RU-21 was transported by SMAST’s RV Lucky Lady to a site off Martha’s Vineyard where it was launched without incident. RU-21 proceeded to run the MURI line toward New Jersey. The battery usage was high due to low water temperatures. The decision was made to recover the glider off Barnegat Light, NJ on 31 March 2009. The glider travelled a distance of 450 km and took 3,864 vertical casts of temperature and salinity.

4b. Southern Line (New Jersey to Cape Hatteras)

Glider operations in the southern MARCOOS domain were also successful, with two flights surveying the shelf region from Tuckerton, NJ, south to Virginia and North Carolina. The fall, 2008 flight recovery proved dramatic. After launch, glider RU22 was tasked to cross the shelf four times in a southward zigzag pattern. Near the latter part of the flight, strong northerly winds drove a rapid southward flow over the southern Middle Atlantic Bight, with an intensified, downwelling coastal current over the inner shelf. This coastal current threatened to carry glider RU22 toward the Gulf Stream off Cape
Hatteras, NC before a recovery vessel could reach it. The standard recovery vessel from UNC Coastal Studies Institute was not capable of operating in the high sea conditions, so a larger vessel was chartered out of Lynnhaven Roads, VA. This vessel, the Cape Crusader, steamed 5 hours south of the entrance to Chesapeake Bay, and, with the MARCOOS glider team onboard, retrieved the glider. The glider travelled a distance of 823 km and took 3,084 vertical casts of temperature and salinity.

The spring 2009 MARCOOS glider flights were also successful, although the planned synchrony of the northern and southern flights was disrupted by a malfunctioning pressure sensor on the southern glider—RU23—launched off Tuckerton, NJ. RU23 was quickly replaced by RU22, which performed well. As with the October 2008 flight, a storm loomed near the latter part of the flight, forcing defensive maneuvers to prevent either rapid southward movement toward the Gulf Stream or sweeping into the shipping lanes near the entrance to Chesapeake Bay without a comfortable cushion of battery power for maneuvering. These defensive maneuvers were successful in keeping the glider north of the Bay entrance during the storm. Immediately following the storm, the MARCOOS glider team on the Cape Crusader recovered RU22 approximately 40km off the entrance to the Bay. Glider RU22 travelled a distance of 600 km and took 6,637 vertical casts of temperature and salinity.

The first MARCOOS Glider Program plan was developed in spring 2008 to help define the goals, guide the program evolution, and set working protocols for what is envisioned as a distributed system of 10-15 gliders operating simultaneously in the Middle Atlantic Bight. Presently, the MARCOOS Glider Group consists of members from 6 institutions distributed throughout the MAB. At the time of full build-out, operations and communications protocols will grow to enable efficient operational maintenance of this larger number of gliders. This document is intended as a working, routinely modified handbook for present operations, as well as a clearinghouse record for updates of these protocols as the system evolves. For the spring 2009 glider flights, operations of the extended MARCOOS Glider Group were significantly improved, with planning, coordination, and operational decision making.

5. Satellite Data Acquisition
Lead: Matt Oliver
Working group: Oscar Schofield, Lisa Ojanen, and John Wilkin.

The most popular satellite product that MARCOOS produces is sea surface temperature (SST). We have developed a cloud filtering algorithm that increases the data quality of the SST. This is an important step not only for end-users of SST imagery but also for modelers who assimilate the SST data into their ocean forecasts. Cloud filtered images are being delivered in real time to the web:
(http://marine.rutgers.edu/mrs/sat_data/?product=sst_decloud&region=bigbight&nothumbs=0)
that show the difference between the unfiltered and the cloud filtered data. Also, this data is being delivered to a public Open-Dap server:
(http://tashtego.marine.rutgers.edu:8080/thredds/cool/avhrr/catalog.html?dataset=cool-avhrr-bigbight),
and to the University of Massachusetts, Dartmouth. The code for this algorithm is open
source, and has been delivered to NOAA Coastwatch East-Coast Node for their evaluation and use.

Ecological Indicators:

We are in the process of collaborating with the National Marine Fisheries Service to provide maps of pelagic habitats derived from ocean color to fisheries managers. In this joint project with NMFS-Sandy Hook, we are hypothesizing that our satellite derived pelagic habitat maps will be good predictors of NMFS trawl data and will be a significant ecological decision making tool. We have delivered historical SST, chlorophyll and Ocean Color products to NMFS for ecological indicator analysis.

We have also started producing temporal averages (both 8-day and 3-day) of SST. This allows us to estimate and map the variability of SST. Variability of SST over these short time scales shows where ecological fronts may be located. We have been advised by local fishermen that these short term fronts are of great interest. Both 8-day and 3-day images are being delivered to the web for public use (http://marine.rutgers.edu/mrs/sat_data/?product=sst_decloud_8dayavg&region=bigbight&nothumbs=0) (http://marine.rutgers.edu/mrs/sat_data/?product=sst_decloud_3dayavg&region=bigbight&nothumbs=0)

![Figure 7: Eight-day rolling average of SST (Left) and SST variability over those eight days (Right).](image)

6. Short Term Prediction System

Lead: Jim O’Donnell

During the contract period the STPS has been extended to the new MAB 8km domain and operated routinely in a pre-operational mode. Forecast data for this domain is served via an OPeNDAP server here at UConn. Error statistics for the extended domain have been calculated and demonstrate similar results as compared to the previous implementation of the MAB domain. Domain averaged error results however are larger (see Figure 9) for the extended domain. Analyzing the spatial maps for the 24hr rms error since time of prediction detailed in Figure 8, areas of higher rms error can be seen in the northeast and in the southwest region of the domain.
Figure 8: U Velocity (left) and V Velocity (right) rms errors at 24hrs after time since prediction for the MAB 8km grid calculated for the month of March, 2009

Figure 9: Domain Averaged U (blue) and V (red) Velocity rms errors for the month of March 2009

In April the vector maps based on processing of radials using objective interpolation became available for a new 6km grid domain. This grid and domain are based on the footprint of the national CODAR grid. STPS has been implemented for this new data product and forecast data for this domain is also served via an OPeNDAP server here at UConn. Error statistics for this new domain and data product are currently being calculated.

The Block Island Sound (BIS) grid is being realigned to a N/S-E/W configuration. The purpose of this is to fully allow the STPS and Total Vector products from this domain to be interoperable with all OPeNDAP client services. BIS STPS has been in pre-operational mode as well. Forecast data from BIS is also being served via an OPeNDAP server here at UConn. STPS is scheduled to be implemented in Western Long Island Sound (WLIS) the beginning of May. This new data product will be listed on the OPeNDAP data catalog when available.
7. *Dynamic Models*

Leads: Alan Blumberg (Stevens/ECOMSED), Avijit Gangopadhyay (UMass/HOPS),
John Wilkin (RU/ROMS)

The three dynamical forecast modeling systems (Stevens/ECOMSED, Rutgers/ROMS and UMass/HOPS) continue active development in their respective spatial domains (NY inner shelf, MAB and MAB-Gulf Stream). These efforts are coordinated through shared data streams for assimilation and validation, and model interoperability for skill assessment and ensemble forecasting.

Data streams have been unified by establishing an OPeNDAP service hosted by the Rutgers Ocean Modeling Group

(http://tashtego.marine.rutgers.edu:8080/thredds/cool/catalog.html)

that continues expansion and improvement to provide 3-hourly HF radar surface current data (totals) for the MAB and satellite SST individual passes (1-km AVHRR) for Cape Hatteras to Nova Scotia. The data can be accessed by all modeling groups and MARCOOS partners directly from this server. All data are in compliance with the NetCDF CF (Climate and Forecast) Metadata Conventions (http://cf-pcmdi.llnl.gov) promoted for adoption by the NFRA Modelers Caucus, IOOS, and OOI cyber-infrastructure activities.

7a. *HOPS*

The MARCOOS/HOPS Real-Time Forecast has been operational now (May, 2009) for two months starting March 9, 2009. The operational forecasting system was built on the feature-oriented initialization scheme developed by Gangopadhyay et al. (1997) for the Gulf Stream Meander and Ring (GSMR) region and that by Gangopadhyay et al (2003) for the Gulf of Maine and Georges Bank (GOMGB) region. The deep water feature model set for GSMR has been melded with shallow water feature model set in the GOMGB region and further supplemented with the Levitus climatology as the background in a multi-scale objective analysis framework. The initialization field is dynamically adjusted with wind-forcing and used in a SST-assimilative forecast model using the methodology described by Brown et al (2007 a, b). An example assimilated forecast is compared with observation in Figure 10.

The model is forced by atmospheric fields (surface momentum flux, surface heat flux, surface water flux and shortwave radiation) from the Global Forecast System (GFS) at ½ degree resolution, which provides 7-day forecast fields.

The forecast system is presently assimilating 3-day composite SST from the Johns Hopkins University/Applied Physics Laboratory and similar AVHRR passes processed by the MARCOOS group at University of Delaware/College of Marine and Earth Studies. The week-long forecasts are issued generally by Wednesday morning; Monday zero-hour is a typical model initialization state, with SST assimilation carried out on Monday afternoon and Tuesday noontime. Real-time Glider data is being assimilated for several hindcast runs, which will become operational in the coming weeks. The forecast fields (Temp, Salt, Currents) are available at www.smast.umassd.edu/modeling/RTF for different levels at 6-hourly intervals for the full domain, for a zoom domain for Mid-
Atlantic Shelf, and for another zoom region for the Gulf of Maine. The model forecast data in netCDF format are available from this site and from the thredds server [http://aqua.smast.umassd.edu:8080/catalog.html](http://aqua.smast.umassd.edu:8080/catalog.html). The CF-compliant version will be available during summer of 2009.

**References**


Figure 10: Sea Surface Temperature and velocity for April 24 2009 from MARCOOS/HOPS Real-Time Forecast (http://www.smast.umassd.edu/modeling/RTF/index.php) is shown in the upper panel. The initial field was prepared on April 20 and a seven-day forecast was carried out. The observed Sea Surface Temperature composite for April 24/2009 from Johns Hopkins University/Applied Physics Laboratory (http://fermi.jhuapl.edu/avhrr/SW/09apr/index.html) interpolated to the model domain is shown in the lower panel.

7b. NYHOPS

New York Harbor Observing and Prediction System (NYHOPS) forecasts were made available to first responders during the rescue and recovery operations of US Airways Flight 1545. Stevens Institute of Technology received a certificate of recognition for this effort (Appendix IV).

Intensive skill assessment for NYHOPS has been ongoing. An extensive skill assessment for 2 years of NYHOPS forecast water level is almost complete, against data from over 70 tide gages scattered around the NYHOPS region. One intriguing preliminary result of the ongoing investigation is the discovery of an apparent periodicity in the NYHOPS forecast skill for non-tidal water level (Figure 11).
Figure 11: Drift of NYHOPS forecast skill in non-tidal water level. The last meteorological analysis phase comes in at -5hrs (0z); after that, meteorology is from a free-running forecast. Each blue data point represents the RMSE between NYHOPS and one tide gage for that forecast hour (in 6-hourly bins). The error bars depict mean RMSE and standard deviation range in RMSE among all 74 stations for each 6-hour bin. In the initial hours of the NYHOPS daily hindcast period (-24 to 0 hrs), the model appears to be recovering from an initialization “jolt” due to the discrepancy between the initial condition taken from yesterday’s 0hr forecast (that had used 5hrs of forecasted winds) and the observed forcing used in today’s hindcast. Within the active hindcast period, the model appears to be correcting itself from that initial jolt. After the -3hrs bin, the model starts drifting in a free-running mode. There appears to be a 24-hr periodicity in the mean skill drift that may require further investigation.

A similar 2-year skill performance analysis is almost complete for the high-resolution NYHOPS wave module results against NDBC, UCONN, Stevens, and ERDC wave gages. An example for the latest addition in the system of wave gages in the NYHOPS region, the “Entrance to New York Harbor” NDBC gage, is given in Figure 12.
Figure 12: Correlograms (left) and time series comparison plots (right) between the NYHOPS wave module results and significant wave height observed near the New York Harbor entrance (NDBC Buoy 44065). Top panels are for the model hindcast period, center panels are for the first-day forecast, bottom panels show the second-day forecast results. The model skill, as seen in both the $R^2$ and RMSE statistics drifts from the hindcast to the 48-hr period, as expected.

Based on the findings of the 2-year extensive skill assessment of the high-resolution NYHOPS (NYHOPS version 2), a new version (version 3) is in the works, and is expected to become operational this summer. This version includes improvements in the initialization scheme that are designed to dampen the initial “jolt” shown in Figure 11, increased robustness in the wetting and drying algorithm, fully-two-dimensional heat flux forcing (that has shown to increase model skill to SST by nearly 40%), and a
coupling of the NYHOPS wave module. Other changes tested and completed include interoperable, CF-compliant, NYHOPS output files, and a new website interface that will support the new coupled atmosphere and wave modules. Operational assimilation of HF-Radar currents will also be included in the new version as described below.

In his Ph.D. dissertation titled “Surface Current Observations using High Frequency Radar and its assimilation into the New York Harbor Observing and Prediction System”, Dr. Ganesh Gopalakrishnan, (now of Scripps Ocean. Inst., CA), employed a dynamic nudging method to actively assimilate surface currents observed by the MARCOOS HF-Radar network into NYHOPS. The HF radar data are assimilated into the model using a nudging assimilation scheme. The continuous record of HF Radar surface currents obtained at a temporal resolution of 1.0 hour are assimilated into the NYHOPS model on daily forecast basis, into the model hindcasting cycle (Figure 13 and Box 1).

Figure 13: The addition of HF-Radar Dynamic Assimilation in NYHOPS version 3.
\[
\frac{\partial u}{\partial t} = (\text{physics}) - \lambda(u - u^o)
\]

The nudging parameter \( \lambda \) can be approximated as \( \lambda_{(i,j)} = (\gamma / \tau_{(i,j)}) e^{\left(\frac{r_{(i,j)}}{z_d}\right)} \), where \( e^{\left(\frac{r_{(i,j)}}{z_d}\right)} = 1 \), as \( r_{(i,j)} = 0 \) when the model grid \((i, j)\) and the observed data point location \((i, j)\) are the same, and \( e^{\left(\frac{r_{(i,j)}}{z_d}\right)} = 1 \), as HF radar data is continuously assimilated. The nudging parameter \( \lambda_{(i,j)} = 0 \) at all other grid points with no HF radar data. In the present study, an assimilation time scale \( \tau_a \) of 1800 seconds is used, and the depth of influence \( z_d \) of 2.0 m is used in order to restrict the DA to near-surface layers.

Box 1. Explanation of the nudging HF-radar DA scheme.

The HF Radar DA improved the model hindcasts for three-dimensional currents based on the model skill values with respect to M2 and M3 mooring data. A positive model skill of (+27\%) and (+17\%) for \( u \) and \( v \) component is achieved with respect to M2 data for the near-surface layers, and a positive model skill of (+50\%) and (+20\%) for \( u \) and \( v \) component is achieved with respect to M3 data at a depth of 6.0 m from the surface.

The DA improved the model forecasting performance based on the model skill measures with respect to M2 and M3 mooring data. A positive model skill of (+6\%) and (+14\%) for \( u \) and \( v \) component was achieved with respect to M2 data for the near-surface layers, and a positive model skill of (+26\%) and (+8\%) for \( u \) and \( v \) component was achieved with respect to M3 data at a depth of 6.0 m from the surface.

7c. ROMS

ROMS model output is already in CF-compliant format. Using NetCDF Markup Language (ncml) wrappers development is proceeding to serve ECOMSED and HOPS output in a CF-compliant format without modifying the original output files. Full evaluation of the feasibility of this approach is to be undertaken in the next 6 months. The distributed data archive paradigm is being followed to leave responsibility for producing and storing model output in the hands of the respective regional modeling groups. This offers the timeliest approach to providing real-time data, and allows for a measure of redundancy.
Rutgers/ROMS model developments since October 2008 have focused on removing initial and boundary condition bias introduced from the basin scale models used for open boundary conditions. Three North Atlantic basin-scale models have been evaluated for this purpose: the US Navy NCOM and HYCOM models, and the French Mercator system. All show biases in temperature and salinity, but of differing sign and magnitude. Bias reduction by assimilation of high-resolution regional climatology is proving effective at restoring initial/boundary hydrographic properties to the true salinity-temperature water mass properties. This step is essential for effective assimilation of sea surface height anomaly observations from altimetry, and in situ hydrographic data (from gliders, Argo floats, and ships of opportunity).

8. DMAC
Lead: Eoin Howlett
Working Group: Dan Holloway, Dave Ullman, John Wilkin, John Kerfoot

- Participation in RA DMAC conference calls and workshop
- Participation in Google-IOOS KML working group
- Participation in IOOS Modeling working group
- Participation in NSF IOOS – OOI Cyberinfrastructure working group
- Participation in the DMAC ST meeting
- Participation in the CF standard for Unstructured Grids
- Participation in National HF Radar NetCDF Data Definition

- Completion of integration of HF Radar data and STPS derived forecast into USCG SAROPS EDS. This is now operational on staging server and has been delivered to USCG for operational delivery within the USCG on May 4, 2009.
Figure 14: Integration of HF Radar data in Sarops 1.2 with integration of Self Location Data Marker Buoy (SLDMB)

- Implemented a HF-Radar Radials format handler for the OPeNDAP server. The handler reads the current LLUV table formats used by the national HF-Radar data archive to store HF-Radar radials, and was developed for use by another handler being developed to generate surface current fields by combining radials.

The following products are served through OPeNDAP within MARCOOS, in many cases large collections of individual files are aggregated into a smaller number of virtual datasets
- Surface Currents from HF-Radar
- Sea Surface Temperature from Satellite-derived AVHRR.
- Forecasts from Model Results

Next Steps
- Collaborating on the design of a new glider data format that facilitates assimilation by forecasters and makes it available via OPeNDAP
- Continued development of integration of the Google Earth publishing of data with a web client.
• Development of delivery protocols with data providers for the 7 core variables using a combination of OPeNDAP, WCS, WMS, and SOS.

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9: Education/Outreach
Leads: Tom Herrington, Janice McDonnell

Fisheries Outreach Activities
MARCOOS scientists have organized several outreach activities aimed at Fisheries. A meeting between NMFS Scientists, MARCOOS, NERACOOS, and the NSF OOI Coastal and Cyberinfrastructure Implementing Organizations occurred in August of 2008 in Rhode Island; a plan was formulated for MARCOOS glider sampling and model assimilation studies timed to coincide with the NMFS spring and fall regional sampling cruises (Figure 16).

Figure 16: Northeast Observing System, Large Marine Ecosystem #7
This was presented and further refined at the MACOORA annual meeting in Fall River on October 22-23, 2008. The proposed activity was then presented at the MARIBS Fisheries Information Product-Definition Workshop hosted by UMass in Fall River on November 19-20, 2008. Talks, discussions and working groups resulted in greater collaborations between MARCOOS and Fisheries Scientists, Recreational and Commercial Fisherman. Several proposals are now submitted or planned combining the expertise of MARCOOS and NMFS scientists. The role of the recreational fishing community has increased. Starting with the Webpage usability testing conducted in August of 2008 and reported last time, recreational fishers also attended the MARIBS workshop, and are playing a significant role in the potential allocation of a new NDBC weather buoy by the Hudson Canyon. Commercial fisherman in attendance at the MARIBS meeting invited us to their trade shows.

Jarrett Drake – an officer of the Massachusetts Lobsterman's Association (MLA) and participant in the MACOORA October 2008 Annual Meeting and the MACOORA/MARIBS November 2008 Fisheries Workshop- invited us to display a glider at the 6-8 February 2009 Trade Show (in Hyannis, MA). Josh Kohut brought the glider RU-21 to the Cape Codder Hotel late Thursday night 5 February. Josh and SMAST’s Chris Jakubiak, Gustavo Marques, and Wendell Brown worked the booth over the weekend. After the show, Chris Jakubiak transported the glider to Webb for upgrades and checkout preceding the next deployment.

![Figure 17: Glider RU-21 on display at the Massachusetts Lobsterman's Assoc. Annual Meeting Weekend 6-8 February 2009 at the Cape Codder Hotel – Chris Jakubiak presiding.](image)

**Storytelling Workshop**

The Centers for Ocean Science Education Excellence Networked Ocean World (COSEE NOW) hosted a professional development workshop on storytelling for scientists and educators in the IOOS and OOI networks. Forty three scientists, educators and agency representatives joined us for a 1.5 day retreat designed to help explore, share, and learn how to connect with public audiences about the ocean and ocean observing systems (OOS). We learned from experts about using storytelling as a powerful communication tool. This retreat was an important professional development opportunity and chance to link with others in the OOS communication and education field.
Andy Goodman, a nationally recognized expert in storytelling, lead the group in a hands-on experience that explored how to improve our ability to effectively write stories about ocean observing systems science. Through this process, participants learned effective practices of storytelling and ways to improve their personal storytelling skills by drafting a short story based on their own OOS work. In two follow-up conference calls after the workshop, Andy assisted participants in revising their stories. The finished stories will be assembled into a web/print publication for all to use (see www.coseenow.net).

**Telling a Story with Data Visualization**
The stories of science are told with data. But data displays are only engaging if they are accessible and intuitive for their intended audience. Participants learned effective practices of data visualization and engage in a hands-on experience that explored how we might improve our OOS data displays and interpretations for public audiences. Panel members from government agencies and industry shared their experiences developing compelling visualizations for specific audiences. Each reflected on the best practices they have adopted and describe the development and storytelling processes they use when creating new visual displays of information.

The panelists included:
Laura Allen, American Museum of Natural History
Ned Gardiner, NOAA Climate Visualization Project
David Herring, NOAA Climate Program Office
Hannah Fairfield, New York Times
Dan Pisut, NOAA Environmental Visualization Program
Panel Moderator: Sage Lichtenwalner, Rutgers University

We conducted the first step of a charrette on data visualization. Visualization panel members facilitated collaborative breakout groups in which participants drafted solutions to predetermined data design problems. Each group focused on a thematic subject of interest to IOOS. Participants identified an appropriate audience to focus their visualization towards, and refined the story by reviewing and identifying appropriate datasets and other scientific information that should be included.

**Proposed Visualization Challenges**
1) Global Change in Local Habitats – The effects of global climate change will have widespread implications on local habitats. For example, sea grass beds and marshlands serve as prime nurseries for numerous species but as sea level raises these habitats will be lost.
2) Impacts of Coastal Storms – Storms and hurricanes can cause tremendous damage on land, but they also greatly affect ocean habitats. Sea level, coastal currents and satellite data can be sued to show the impacts these storms have on both human and marine environments.
3) Harmful Blooms and Beach Closures – Harmful algal blooms and poor water quality are responsible for increasing illnesses among coastal residents. Monitoring these conditions and helping people make choices to abate or avoid these hazardous situations is a pressing concern.
4) Ecosystem-based Fisheries Management – A tremendous effort is now underway to use OOS data to help understand, monitor and protect marine ecosystems. For example, fisheries researchers in Alaska and New York are using ocean currents (from radars and ADCPs) and vertical profiles of water column properties to better understand the transport and fate of fish larvae. This new information will help policy makers better manage fish stocks.

**Evaluation Results**

All participants filled out a short online survey providing feedback on the workshop. Overall, the participants felt it was a positive and productive professional development experience. Below are some quotes from the program evaluation:

“ Really made me think about how to create focused messages for specified sectors of my very broad GCOOS audience”.

“Bringing this group of professionals together was long overdue”.

“The experts who were brought in to provide real-life examples were excellent. NYT, Museum of Natural History, etc. speakers all provided great insight to effective communication. I plan to take full advantage of any and all opportunities to work with Ari/COSEE NOW to develop new ways to communicate IOOS messages”.

COSEE NOW is working on numerous follow up efforts with this group in an effort to continue to build community and awareness of effective practices.

**9a. Rip Currents:**

The United States Lifesaving Association estimates that the annual number of deaths due to rip currents on US beaches exceeds 100. Rip currents account for over 80% of rescues performed by surf beach lifeguards. In order to warn bathers of the potential danger of rip currents, the local National Weather Service forecast offices in the MARCOOS region started, in 2004, to issue low, medium and high rip current risk level advisories based on observed wave condition offshore of the forecast area. NOAA-Sea Grant and NOAA-National Weather Service convened a technical workshop on rip current research and forecasting in April 2004, in Jacksonville, Florida, to enhance communication and information sharing among National Weather Service forecasters, coastal research scientists, and Sea Grant outreach personnel. The workshop helped each agency identify data gaps, partnership opportunities and future research needs to enhance and improve rip current prediction and forecasting. An additional outcome of the technical workshop was the engagement of the local stakeholders through informational workshops and symposiums. New Jersey Sea Grant in partnership with MARCOOS partners conducted lifeguard symposiums in 2006 and 2008 in Ocean City, NJ, to build an awareness of MARCOOS data and products, and solicit input from surf rescue personal on information needs and delivery requirements. Outcomes from the two symposia indicate that New Jersey lifeguard groups receive weather and ocean forecast
information through the local NWS forecast office and that there is great interest in integrating MARCOOS observations and forecasts into the data products issued by NWS. MARCOOS is presently planning a follow-on regional workshop to the initial meeting held in 2004, focused on advances in rip current research and forecasting, and stakeholder needs and requirements to be held in 2009.

Rip current generation is a function of wave breaking and its strength related to the residual forcing between the mass transport of water by waves into the surf zone and the resulting pressure gradient generated by elevated water level (wave setup) inshore of the bar system. With the advent of Coastal Ocean Observation Systems, the ability to continuously monitor the coastal ocean environment holds promise for real-time detection (Lipa et al., 2008) and forecasting (Herrington, et al., 2000; Bruno, et al., 2006) of rip currents. MARCOOS data products for the near shore region including CODAR derived waves and currents are being evaluated for various applications. These include water quality along the beach, tracking floatable spill events, and monitoring conditions related to rip current occurrence. An analysis of rip current events along the New Jersey coastline during the summers of 2003 and 2004 indicate that the New Jersey coast is subjected to two modes of rip current events; high-energy large wave height events with heights greater than 6 feet and low-energy, long period swell events (Bruno, et al., 2006). This suggests that the rate of wave energy propagation to the coast is an important parameter in the prediction of rip current frequency. To forecast rip current potential, an index scheme has been developed that will be coupled to the operational NYHOPS wave forecast module of MARCOOS. Integration of the CODAR data fields with the forecast model will provide real-time observations of rip current parameters at a spatial and temporal resolution refined enough to forecast conditions favorable for rip current activity on the order of 1-6 km.

10: Economic benefits
Leads: Tony McDonald, Dennis King.

This task involves tracing and estimating the values of MARCOOS work products. These values are generated along multiple pathways based on how MARCOOS work products are used by various types of decision-makers to reduce risks and costs and/or increase benefits.

During the 6 month period ending April 15, 2009 the economics team has accomplished the following tasks:
1) Finalized the baseline economic report on the coastal/ocean economy in the MARCOOS region, which will be shared with other MARCOOS researchers as a reference source, and will provide a baseline for our future work assessing the economic values and impacts associated with the use of MARCOOS data by decision-makers in these industries (King, Wainger, and Cantrell).
2) Finished the fishery scientist survey and analyzed results (King, Hagan).
3) Prepared draft report summarizing fish/ocean interaction and survey results (King, Hagan).
4) Prepared a draft article for publication based on (2) and (3) above (King, Hagan).
5) Prepared an article on increasing importance of linked physical/biological fishery models to support ecosystem based fishery management, etc. (Edwards/Miller).
6) Initiated discussions with other IOOS valuation researchers to prepare guidance/protocols for monetizing value estimates (King/MacDonald/Hagan).

Our survey of fishery scientists regarding uses of ocean observing data was conducted in late 2008 and has produced some compelling evidence about the importance and potential importance of enhanced physical ocean observations in fishery science and management. We are now attempting to impute the economic value of those observations.

Figure 18 illustrates the opinions of the fishery scientists about the value of a few specific MARCOOS observations. Figure 19 shows the results of some general questions about the value of ocean observations in fishery science and management.

**Planned Work (next 6 months)**

During the following 6 months (April 16, 2009 through October 15, 2009) we plan to finalize our analysis and interpretation of survey results; complete collaborations with other IOOS valuation researchers, and prepare several articles/reports that use existing information and our research results to demonstrate and, where possible, monetize the value of MARCOOS work products.

Figure 18: Illustration of fishery scientist perspectives about specific MARCOOS output
Tony McDonald has developed the regional plan for upcoming Mid Atlantic Ocean Summit convening in New York City on June 4th. See Appendix II. We would like to start outreach to states and develop long term plan for this effort. The suggested next steps are:

1. Identify MACORRA/MARCOOS state lead/s for initial outreach to state contacts to indicate interest, capability and willingness to support Governors efforts.
2. MACOORA will develop a set of talking points and fact sheets
3. A conference call is scheduled in next couple of weeks with small group to discuss broader outreach.
4. The MARCORRA/MARCOOS small workgroup should consider a mid and long term strategy for developing a collaboration with the regional governors initiative, and working with states to develop a joint vision and defined role for MACORRA/MARCOOS to support the governor’s regional ocean management initiative.

Figure 19: Representative results from 2008 survey of fishery scientists re ocean observations
Issues

All tasks are on or ahead of schedule. The only issues to report include (a) an update on the previously reported concerns for the personnel level required to support sustained operations of the HF radar network, and (b) the vulnerability of gliders approaching the mouth of the Chesapeake Bay near the end of their battery lifetime, including our proposed solution.

The Mid-Atlantic HF Radar Consortium has identified three implementation phases for our regional HF radar network. Prior to MARCOOS, the network operated at Phase 1 levels, where each site was maintained by the individual operators and data was shared as available. Funding was acquired individually by each operator, so sites would come and go. MARCOOS funded our progression to Phase 2, where a small amount of funding ($10K per site) is provided to compensate operators for normal power and communications costs, but not major repairs. A very small amount of spares money was used to acquire 1 spare transmitter and receiver for the entire region. In addition, 3 technicians distributed between the southern, central and northern subregions were funded, along with a part time regional coordinator. While this is a significant advance over Phase 1 operations, it remains well below the Phase 3 operational level of 2 technicians for every 5-7 radar sites as endorsed by the National Network. The small stockpile of spares and a deficit of about 7 technicians by National Standards results in uptime statistics below what would be required by a National network. At times this is frustrating to operators that do their best to maintain systems while severely understaffed. It is especially difficult as the network is filled in, with the easiest to implement sites already taken and more difficult sites being used for new installations. MARCOOS has made tremendous progress during the step to Phase 2. Some of the well-established sites have been able to maintain uptime statistics consistent with what would be required for a national network. The rate at which we build out the system and achieve the desired level of uptime statistics depends on how rapidly we approach the staffing levels of MAHFRC Phase 3 operations. This experience should weigh heavily in the ongoing staffing projections for the National Network.

The vulnerability of gliders near the end of their operational flight time in the southern end of the Middle Atlantic Bight has been revealed in the last two flights in the region. The primary concern is the potential for rapid, buoyancy-driven coastal currents aided by strong downwelling winds to carry the gliders southward near Diamond Shoals and the Gulf Stream, which both threaten recoveries. The concentration of shipping activity in the Chesapeake Bay entrance lanes presents an additional danger. The proposed solution to these issues is to first recognize that the northern MARCOOS glider will survey the shelf region off New Jersey, as will the Rutgers Endurance Line flights. Then the plan is to launch the southern glider, not at Tuckerton, NJ, but at Cape Henlopen, DE. Launching the glider at this more southern location will allow a greater reserve of onboard power available for storm maneuvering at the end of the flight if necessary. In addition, the flight path can then be configured to deliberately avoid the Chesapeake sea lanes.
Key Personnel

The following are the accumulated changes that have occurred in key personnel.

1. Nancy Vorona replaced Mark Yarosh as the project PI for CIT, the owner of 5 HF Radars in the Mid-Atlantic network. Nancy brings experience in ongoing HF Radar vessel tracking projects with Old Dominion, Rutgers and CODAR Ocean Sensors.
2. Matt Oliver joined the faculty of the University of Delaware and remains involved with MARCOOS leading the work on new satellite data products.
3. Josh Kohut joined the faculty of Rutgers and remains involved leading the HF Radar QA/QC team.
4. Janice McDonnell joined the faculty of Rutgers and remains involved leading the outreach efforts to the recreational fishing community and to the general public.
5. Eoin Howlett from ASA has added John Kerfoot from Rutgers to the MARCOOS data management team as the emphasis shifts away from the completed HF Radar tasks towards the need to develop new data management tools for glider data.
6. Ethan Handel replaced Robert Hess as the HF Radar Central Region Operator.
7. Jeffrey Yapalater, representing the recreational fisherman on the MACOORA Board, has been playing an increasingly important role as a liaison with the fishing community.

Budget Analysis

The second year of the MARCOOS project continued on schedule with our expenditures outlines below from 1 October 2008 through 31 March 2009. Below is a brief overview of our budgetary expenditures for the project period of 1 April 2008 through 30 September 2008.

For this time period, our actual budget expenditures for salary were right on track with initial budgetary requirements with only a few minor adjustments. Dr. Scott Glenn, project principal investigator received his month of summer salary. The technical staff consisting of glider technicians, a CODAR technician and manager and a satellite operations technician received salary support during this time. There is a balance of $52,051 to maintain the staff through 10/1/2009.

Project and computer supplies are exactly on track.

Our telephone service was budgeted under supplies initially, but is necessary to support the communications between our CODAR sites and our central site at our New Brunswick, NJ office. These charges are billed on a monthly basis and provide the ability to transfer necessary data.
Our other services includes items such as ship time, glider communications, shipping charges, CODAR site communications such as phone lines and cable lines and other miscellaneous expenses supporting this project. We are on track and foresee no overspending or under spending issues in regards to this category. Iridium usage is at an all time high but is necessary for glider communications while at sea.

No equipment purchases have been made in this period. Year one was purchasing a glider while year two has been involved in the deployment of the slocum glider.

Travel spending is on track and consists of expenses such as travelling to CODAR sites, deploying gliders (local travel), van mileage, gas and other miscellaneous travel related expenses.

Equipment rental is boat rental time necessary to deploy and recover gliders and is on track. There are four deployments scheduled in a year and the $10,000 will be used for this item.

Repairs and maintenance is for the upkeep of our underwater gliders and our CODAR equipment. We have a balance of $17,358 to use between now and 10/1/2009 which will be used in keeping our gliders and CODARs operational.

Our subcontracts have been issued and are up to date. Spending reports will be submitted by each individual subcontractor – but according to our records, spending has been on track.

References that have benefited from MARCOOS Data & Products


Dunk, R 2007: NJ Offshore & Coastal Wind Energy Analysis, Phase 4, Rutgers IMCS Coastal Laboratory for Applied Meteorology (CLAM), New Brunswick, NJ, Study funded by NJBPU Office of Clean Energy, Trenton, NJ., Rutgers Contract No. 4-25290.


Appendix I: HF Radar Summary Report

MARCOOS High Frequency Radar Year 2 Progress Report

This is a summary of the activities for the High Frequency Radar component of the Mid Atlantic Regional Coastal Ocean Observing System from October 1, 2008 to April 30, 2009.

The operator working group consists of:

- Hugh Roarty, Regional Coordinator
- Adam Houk, Northern Region Operator, half time
- Chris Jakubiak, Northern Region Operator, half time
- Ethan Handel, Central Region Operator, full time
- Teresa Garner, Southern Region Operator, full time

The metrics that were introduced in the Year 1 progress report have been calculated for the first half of Year 2. The data availability of the long range data increased to 87% in the first half of year 2 from 78% in year 1. The data availability of the standard range data also increased to 78% in the first half of year 2 from 67% in year 1. The data availability of the New England sites increased due to a concerted effort of the Northern Regional Operator in December 2008.

Plans have been made to move the HOOK and DUCK sites in May 2009. The low data availability at CEDR was due to a computer malfunction. This computer was replaced using MARCOOS funds. The Codar equipment also failed and was sent back for repairs. Unfortunately the one spare in the network was being used at the BRZY site at that time. The low data availability at MNTK, GCAP and BRZY were all due to communication problems. This will be fixed in Year 2 with redundant communications to all sites. The low range at GCAP and STLI is due to geography of the site location. The width of western Long Island sound is only 10 km where these sites are located. The low range at CBBT is due to a poor site location. A new site has been identified and was tested at Cape Charles, VA on March 12, 2009. A radial map from the new site is shown in Figure 2.
### Figure 1: MARCOOS HF Radar site statistics

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<th>Data Availability %</th>
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<th>Average Vector Solutions</th>
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### MEDIUM RANGE

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Number of Sites: 26

Missing Sites: Red squares indicate data one standard deviation below the mean.

**Figure 2: Potential new site for 25 MHz system in Chesapeake Bay. The existing site CBBT has a poor antenna pattern measurement.**
Northern Site Operator:  Adam Houk
Responsible for Sites: GCAP, STLI, MISQ, BISL, MNTK

The two western Long Island Sound CODAR sites were upgraded in the fall of 2008 with new Raven-X-series cellular modems using 3G EV-DO technology. This has vastly improved the remote administration capabilities for these two sites. The computer at Great Captain Island was replaced with a new Mac-mini in March 2009, as the previous Mac G5 had become increasingly unstable, leading to several lock-ups and significant down-time. The Stehli Beach site Mac has not been replaced yet, although the current G5 computer is stable and up-to-date with the most recent version of the Mac OS and CODAR software available. A spare Mac-mini has been set aside for this site if needed. Both sites have had their UPS backup batteries replaced.

Concerning the three Block Island Sound sites, Block Island and Misquamicut beach have been operating satisfactorily, with only a small problem with the transmitter at Misquamicut in February 2008. Montauk Point has had two main issues within the past six months. From December 2008 to February 2009, the cellular modem was not functioning properly. After initially working fine, the modem began having problems in late December. By February, the issue had been narrowed to a faulty Ethernet port on the modem, was repaired under warranty, and re-installed on site. On February 26th, the receive antenna was found to have lost a set-screw that holds the mounting pole in place, meaning that the antenna was freely rotating, and not oriented in the correct direction. Unfortunately, it is not known at present how long the antenna was free to rotate, but it is possible the problem occurred as far back as late-December, when the antenna had last been checked visually. Therefore, the data from this period must be considered suspect until the exact date of the problem can be determined (if at all). It was around this time that the noise on antenna loop 2 was noticeably higher than the other two loops. Upon further investigation, the receive antenna cable was found to have several abrasions that left the wire shield exposed or corroded, and the antenna itself was thought to have an internal problem on loop 2. The receive cable was re-terminated past the damage, and the antenna box sent back to CODAR for evaluation and repairs in April 2009. A spare combined transmit/receive antenna was installed in its place, but the measured-pattern radials are no good unless the pattern is re-measured with the spare antenna.

Dave Ullman and I had evaluated the situation at Montauk, and decided that, despite the significant pattern distortion in the current antenna configuration, any major alterations to the setup there would be costly, impractical, or both; especially in light of the resistance to any sort of change on the premises by the lighthouse staff. To upgrade the system with a single combined TX/RX antenna would cost at minimum, around $15k.
**Northern Site Operator:  Chris Jakubiak**

Responsible for Sites: NAUS, ERRA, BLCK

We at SMAST UMass Dartmouth are responsible for maintaining our site at Eastham, MA (NAUS) and the two Rutgers sites at Nantucket Island, MA (ERRA) and Block Island, RI (BLCK). Christopher Jakubiak, assisted by Shawna King, keeps this trio of sites operating. Through their dedicated efforts, the three northern sites have generally been operating well for the past six months. However the following issues have arisen in the past six months:

**NAUS-**
1. The operations computer has “locked-up” several times in the past 6 months - requiring a personnel visit to the site to restart the computer. We look forward to the installation of the iBoot hardware so that we can restart a”locked-up” onsite computer remotely from our New Bedford laboratory. This is planned for May 2009.
2. The issue is that our National Park Service hosts request that we shut down the CODAR operation for Friday through Sunday afternoon during the amateur radio operator events at the site in December and April each year. It turns out that the CODAR interferes with amateur radio operator activities at near our Cape Cod National Seashore site –a site is of special historical significance because Marconi made some of his first trans-Atlantic radio transmissions there. We comply.

**ERRA-**
1. Late in November 2008, ERRA was showing very weak radial patterns. We visited the site on 12 December 2008 was visited and repaired a loose connector in the receive antenna.

**BLCK-**
1. Also in late November, BLCK went offline. We visited the site, discovered that the receive antenna had been blown over, due to a broken guy wire, and repaired it. We took advantage of the visit to replace the GPS antenna and module.

Closer to home, we are setting up an OCEANOL Forecast Center (OFC) at SMAST’s Fairhaven, MA facility where our field instrumentation laboratory is located. We just installed our older CODAR Combining Computer (CCC) in the OFC. Our main CCC is located in our New Bedford facility. Both CCCs are pulling and combining radials from NAUS, ERRA, and BLCK.

**R&D**

Shawna King an MS student, who is near completion of her thesis research that involves evaluation of the uncertainty of CODAR-derived surface current fields through comparison of pseudo- and observed drifter trajectories. One of her basic data sets is the suite of MARCOOS Nauset/Nantucket CODAR surface current maps (displayed real-time via the OCEANOL web-site at http://www.smast.umassd.edu/OCEANOL/codar.php.
In the course of this work she has implemented the SeaSonde protocol that visually provides the standard deviation of the CODAR backscattered returns that go into computing each total current vector on each hourly map. (See Figure 3). Her research is part of our MIT Sea Grant-supported research effort to better understand repeatable/predictable tidal eddy motion in the Great South Channel of the western Gulf of Maine (see our report Brown, W.S., G. M. Marques, S. King, C. Jakubiak, D. Brown, E. Levine, & L. Goodman, 2009b. Transient Tidal Eddy Project Data Report: Winter 2008-09, SMAST Technical Report 09-0204, pp 42. - http://www.smast.umassd.edu/OCEANOL/tte.php)

Figure 3: An example of an hourly surface current map that is displayed on the screen of our CODAR Combining Computer. The vector in each of the rectilinear grid cells indicates the current magnitude and direction, while the color indicates the effective standard deviation of the radial backscatter returns that went into its computation (legend to right).
Improving site resiliency has been a major aspect of my work on the central region sites. To start, a photographic database has been created to document the different configurations of hardware at each site. This allows for easier remote troubleshooting in the future. Aside from primary communications, all sites are now being set up with secondary communication lines. Common examples are cable modems as primary communication and analog phone lines as backup. Different means of internet connections are appropriate at different sites, depending on local network availability. The ability to cycle power remotely to each site’s computer and modem has been established as an important aspect to maintaining a resilient network. To implement this, we have been working on installing Powerstones or iBoots at each site. Powerstones allow for remote power cycling via an analog phone line connection, whereas iBoots can cycle power to hardware via Ethernet lines. Uninterrupted power supply is also crucial to maintaining optimal site operations. Battery backup is the most common form of secondary power, although it only allows for several hours (at most) of operation. Solar power has been implemented at a few CODAR sites in other parts of the country where it is cooler and sunnier for more of the year than in our region. Currently, the need for air-conditioning units at our sites during summer months creates a demand for more power than can be provided by feasible solar arrays and battery backups. During winter months, it is generally too overcast and cloudy to be able to rely on solar power. Our 12 MHz site in Sea Bright has been suffering due to it being powered by a temporary connection to ground-fault interruption (GFI) outlet on a nearby building. These outlets routinely trip and require on-site, manual resets to restore power to the site. In the new permit for the continued operation of this system at its current site, we have included the requirement for an electrician to install a separate power circuit, meter, and GFI for the site that will enable power to be wired directly to the weather-proof, climate-controlled equipment shelter to eliminate this problem. Another important aspect of creating more resilient CODAR sites is the installation of lightning protection hardware. Each site has gas discharge tubes (spark gaps) built into the transmit and receive module, and additional equipment is being looked into for further protection.
Southern Site Operator: Teresa Garner
Responsible for Sites: CMPT, HLPN, ASSA, CEDR, LISL, VIEW, CBBT, CPHN, DUCK, HATY

Additions to the Network
A new 5 MHz site (LISL) was established at Little Island Park in Virginia Beach, Virginia on January 23, 2009. This addition to the National Network fills in a large gap in data coverage in the Southern Region and provides information about the dynamics outside the Chesapeake Bay mouth. The installation included a shed built to withstand hurricane force winds and designed to match aesthetically with existing park buildings.

![LISL site antennas & shed](image1)

In August 2008, a third 25 MHz SeaSonde was installed in the Delaware Bay area, roughly 15 km south of the Bay mouth (75.0662°W, 38.6352°N) at the Indian River Lifesaving Station. No Internet connection is available at this site yet, but the University of Delaware has purchased all the equipment to establish a wireless SWAP radio connection. This should be completed by end of summer 2009, and radials will then be passed on to the National HFRADAR archive.

![National Network image of averaged surface current fields outside of the mouth of the Chesapeake Bay after the LISL installation.](image2)

FCC Frequency Assignments & Coordination between HFRADAR Sites
It was necessary to assign a frequency to the new LISL site and change the frequencies at ASSA and CEDR from frequencies originally assigned by NASA. A frequency of 4.537 MHz was applied to all three sites. This frequency does not interfere with MARS radio operations and was determined to be the most suitable frequency by CODAR and NOAA. This affected four other long-range sites operating near or at this same frequency. Alignments and sweep directions for all of the affected sites were recommended by CODAR. HFRADAR operators throughout the Mid-Atlantic co-operated to monitor and watch for signs of interference by other Radars on each of their long-range sites.

New Products: Residence Time Maps from the University of Delaware
Recently, Bruce Lipphardt and Phil Muscarella at the University of Delaware began computing particle trajectories at the Delaware Bay mouth using OMA objective mappings of radial currents from the two SeaSondes nearest the mouth. They created an analysis domain that encompasses the ocean surface where radial data are normally available at least 70 percent of the time. For periods where there are no gaps in the hourly data files, they have used trajectories on a regular grid of initial positions (spaced 0.5 km apart) to estimate the particle residence time for the analysis domain. The figure below shows color contours of residence time (in hours) for all particles launched at the positions marked by small gold colored circles at 0800 GMT on 1 October 2007. Surprisingly, even for this small analysis domain, they routinely find particles that remain in the area for six days or longer. These long residence times result from the regular influence of a strong M2 tide, which produces oscillatory trajectories that are aligned with the axis of the bay mouth outflow. Estimates of surface particle residence time are valuable for oil spill or search and rescue response planning as well as a number of ecological studies in the Delaware Bay estuary.

An animation of hourly residence time maps can be seen at: http://laplace.cms.udel.edu/DELBAY_restime_movie.gif

Network Maintenance
The DUCK site continues to perform poorly. After discussions with CODAR, Rutgers and in-house electrical engineers, UNC has chosen to relocate the receive antenna approximately 200 m to the south in an attempt to improve coverage and performance. New cabling is on order and the relocation is expected to occur by early summer.

Communications at four sites were upgraded to USB modems with faster connection speeds. In addition, scripts and procedures were developed to re-establish communications when they fail due to signal interruption.

Engineering designs of antenna footings to meet permit requirements for the 5MHz transmit and receive antennas were commissioned and are nearly complete. Draft copies are in hand. These drawings will be stamped by a professional engineer and will certify that the footings can withstand 110 mph winds.

Potential Site Location Changes within the Network
Progress has been made in finding potential alternate locations for the CEDR and CBBT sites. A promising new location on the Eastern Shore was found for CBBT at the Sunset Beach Resort and a successful test was performed at this site. Private property on the mainland near Metompkin Bay might provide a new location for the Cedar Island site if permission from a landowner can be obtained. Attenuation of signal over the shallow Bay is a concern and a site test will be required to see if attenuation levels are acceptable.

QA/QC
On March 10, the antenna pattern at CPHN was measured. The pattern shows a nearly ideal form with little distortion and the site now uses this calibration data to produce measured radials. In an effort to improve data quality at CBBT, its antenna pattern was re-measured on the same day. Significant distortions appear in the pattern, and the pattern is significantly different from the two previously measured patterns. These results provide further reason to pursue an alternate location for this site.

Comparisons of CODAR surface currents and Nortek ADCP currents are ongoing for a location in the lower Chesapeake Bay near Ocean View Beach in Norfolk. Wave data comparisons with an AWAC wave buoy are also ongoing at this same site. Poor comparison with the waves may improve with use of a new shallow water algorithm under development at CODAR.

Uptime statistics on both NC sites has been excellent over the last six months, reporting more than 99% of the time since October 24, 2008. However, coverage (e.g. number of radial solutions) has been very different at the two sites, with DUCK averaging less than 250 solutions over its footprint and HATY averaging roughly 750 solutions.

Outreach
Coast Guard Sector Hampton Roads has expressed interest in using the HFRADAR data in the Chesapeake Bay for a Geographic Response Plan (GRP). In May, Larry Atkinson and Teresa Garner from ODU will attend a Coast Guard working group meeting in order to determine what data and products the observational community can provide for their
project. The focus of the GRP is oil spill response and pollution tracking.

Information and sample HFRADAR data were provided to a senior student at Millersville University to complete a project on tidal analysis.

In support of a new Vessel Tracking Project, information and sample HFRADAR range series data were given to Chris Morris, an engineering graduate student at ODU for image analysis.
Appendix II

Letters of Support

October 22, 2008

Dr. Hugh Roarty
Coastal Ocean Observation Lab
Institute of Marine and Coastal Sciences
Rutgers University
New Brunswick, NJ 08903-0231

Dr. Roarty,

On behalf of the Shoreline Environmental Research Facility, I would like to thank you and your HF radar team for providing field support and expertise in reviving the HF radar network for the Texas coastline. You and your team member Clinton Haldeman provided invaluable assistance and experience in deploying the HF radar systems that led to the successful first steps of the important endeavor.

I would also like to highlight the partnership between the Mid-Atlantic Coastal Ocean Observing Regional Association and the Gulf of Mexico Coastal Ocean Observing System as part of this project. Strengthening this partnership is one way of overcoming the challenges of building a national HF radar network for the United States. The knowledge base of both the experienced and novice operators is raised through this partnership. The environmental challenges experienced by the Texas HF radar sites are quite onerous when compared to the sites within the Mid Atlantic. This was evidenced by the destruction of the HF radar sites at Rollover and Bay Harbor with the passage of Hurricane Ike.

I look forward to future collaborations between MACOORA and GCOOS as we develop and demonstrate new technologies that will change oceanography.

Sincerely,

James S. Bonner, Ph.D., P.E.
Professor and Director Center for the Environment
Clarkson University
Dr. Hugh Roarty  
Coastal Ocean Observation Lab  
Institute of Marine and Coastal Sciences  
Rutgers University  
New Brunswick, NJ 08903-0231

October 17, 2008

Dr. Roarty,

I wanted to write and express my gratitude for allowing Ocean Imaging access to the HF Radar-derived ocean surface current data covering the Mid-Atlantic coast and New York Bight. While we have just released these data (at no additional cost) to our recreational and commercial fishing customers on your coast, we do not as yet have any direct feedback as to their value, however end-users of this information from fishing communities in other parts of the country have expressed to us a quantifiable benefit from using HF radar derived currents. In these days of high fuel costs, this especially holds true for our commercial customers who can save time and fuel dollars simply by knowing the prevailing currents. I have little doubt that with more exposure to the data, our customers fishing in the Mid Atlantic coastal regions will derive tangible benefit from your data as well. I will keep you informed of our progress in disseminating these data to coastal fishers and the feedback we do receive.

Sincerely,

Mark Hess  
Director of Operations  
Ocean Imaging
Appendix III

Mid Atlantic Governors Letter to Council on Environmental Quality

March 6, 2009

Ms. Nancy Sutley, Chairwoman
Council on Environmental Quality
722 Jackson Place NW
Washington, D.C. 20503

Dear Ms. Sutley,

On behalf of the states of New York, New Jersey, Delaware, Maryland, and Virginia, we are pleased to inform you of an effort to develop an interstate agreement on ocean and coastal management in the Mid-Atlantic region. As a native New Yorker, you have personally experienced the strong connection between the people of the Mid-Atlantic states and our ocean and coastal resources. Our region is defined as much by a productive and diverse marine environment as it is by the presence of large cities and urban areas. Because we share these resources with one another, the challenges facing them affect each of our states in similar ways. We therefore have directed our staffs to develop a formal agreement which will commit us to addressing priority ocean issues within the region, such as energy development, climate change, water quality, and habitat protection.

We believe that two key elements are necessary to make this effort successful. First, the approach that we are embracing must acknowledge the severity of the challenges faced by our ocean ecosystems, and must address the important role of humans within those systems. We intend to develop an agenda that will promote significant, achievable improvements to our collective management of ocean and coastal resources.

Second, and equally important, we will need the full and continued support of our partners as we develop and implement our agenda. To that end, we are planning to engage in a robust public process that will include soliciting input from the business, academic, and non-governmental communities. The Mid-Atlantic will be the first region to commit to a regional approach to ocean management during President Obama's Administration. We believe that this presents you and your federal colleagues with a significant opportunity to demonstrate the President's commitment to regional collaborative efforts. As a first step toward that commitment, we are requesting that the federal government designate a lead, or co-leads, to provide direct support as we identify the most appropriate and effective opportunities for partnership in a regional context.

Sincerely,

[Seal of New York]
David A. Paterson
Governor

[Seal of New Jersey]
Jon S. Corzine
Governor

[Seal of Delaware]
Jack Markell
Governor

[Seal of Maryland]
Martin J. O'Malley
Governor

[Seal of Virginia]
Timothy M. Kaine
Governor
We also would like to notify you of our intention to convene a Mid-Atlantic Ocean Summit in New York City this coming May. This day-long event will bring together the key officials from our respective states for a meaningful discussion on advancing our regional agenda. The issues we have identified will provide opportunities for a substantial federal role, and we strongly encourage your participation. More information will be provided as event planning advances.

We look ahead with great anticipation to a productive and collegial relationship with you, and hope that this regional effort is the first of many successful partnerships with the new Administration.

Sincerely,

David A. Paterson  
Governor of New York

Jon S. Corzine  
Governor of New Jersey

Jack Markell  
Governor of Delaware

Martin J. O’Malley  
Governor of Maryland

Timothy M. Kaine  
Governor of Virginia
Appendix IV

Department of Homeland Security Impact Award
Appendix V

Press Release for MARCOOS HF Radar delivered through the Coast Guard Search and Rescue Optimal Planning System (SAROPS)

NOAA, U.S. Coast Guard: New Ocean Current Data to Improve Search and Rescue Activities

May 4, 2009

A new set of ocean observing data that enhances the ability to track probable paths of victims and drifting survivor craft should improve search and rescue efforts along the U.S. coast. The data comes from the Integrated Ocean Observing System (IOOS), part of a joint effort among NOAA, the Mid-Atlantic Coastal Ocean Observing Regional Association, the U.S. Coast Guard, and the Department of Homeland Security.

The new data sets include surface current maps from high frequency radar systems. The technology measures speed and direction of ocean surface currents in near real time, which the Coast Guard can then use to guide its search and rescue operations with greater accuracy. The maps can also be used to support other scientific work, such as oil spill response, harmful algal bloom monitoring, and water quality assessments.

"IOOS is known for providing information about tracking, managing and adapting to changes in the marine environment. Using it operationally for search and rescue is an important step," said Zdenka Willis, NOAA IOOS program director. "This is about saving lives."

The data will feed into Coast Guard servers to improve environmental observations for the agency’s operational Search and Rescue Optimal Planning System. A short term predictive system that allows 24-hour forecasts for sea surface currents based on the most recent ocean observations will also be available in the Mid-Atlantic region.

"The Coast Guard is continuously striving to enhance its Search and Rescue capabilities by obtaining the latest operational environmental products that NOAA has to offer. Better data means search efforts can be focused on smaller areas, saving more lives by allowing us to locate and assist distressed persons more quickly," said Jack Frost USCG’s Program Manager for Search and Rescue Optimal Planning System (SAROPS).

"From the recreational fisherman to the family swimming at the beach, people in the Mid-Atlantic region will enjoy a safer life as a direct benefit of applying joint technology and understanding to meet community needs," said Judith Krauthamer, executive director of the Mid-Atlantic Coastal Ocean Observing Regional Association.

NOAA understands and predicts changes in the Earth’s environment, from the depths of the ocean to the surface of the sun, and conserves and manages our coastal and marine resources.