MARACOOS SEMI-ANNUAL REPORT: 12/1/2014 – 05/31/2015
NOAA Award Number NA11NOS0120038 (June 2011 – May 2016)

1) PROJECT SUMMARY

The Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) continues to implement its partnership-based strategy to support stakeholder needs through sustained regional ocean observation and forecasting in the Mid-Atlantic Bight (MAB) from Cape Hatteras to Cape Cod. Over the 5-year project duration, MARACOOS is (1) uniting and integrating the organizational activities of MACOORA (established in 2004) and the operational activities of MARCOOS (established in 2007); (2) maintaining and expanding the existing observing, data management and forecasting subsystems focused on the transition from data-generated to model-generated ensemble ocean forecast products that target multiple users; and (3) expanding end-to-end operations across all five regional themes through (a) enhanced education and engagement activities, (b) the leveraging of resources beyond IOOS through expanded Users and Advisory Councils, and (c) the application of IOOS Association-endorsed metrics to measure and demonstrate success.

2) PROGRESS AND ACCOMPLISHMENTS

MARACOOS has exploited both successes and lessons learned in moving forward toward its 5-year goals. Chief among these goals are the aim to expand from observation to forecasts and the aim to expand the suite of valued information products across the 5 MARACOOS themes. In order to achieve these goals and thereby realize the potential envisioned in the 5-year plan, we see increasing user engagement and expanding leveraging of new and existing partnerships as crucial. Simultaneously, traditional performance metrics are being refined to gauge the spatial coverage and temporal reliability of the MARACOOS observations, and new metrics are being developed to assess the accuracy of these observations and our forecast products. Our milestone schedule is found on page 13, Section E of the MARACOOS proposal. In this report, progress towards milestones and metrics for each of the 5 subsystems are outlined first, followed by highlights of significant meetings and events. In sections A-K, the work accomplished during this reporting period to fulfill those milestones is discussed in greater detail. **Milestones and Metrics:** Management Subsystem. During this reporting period, bi-weekly board meetings and operations meetings were held via conference call. The bi-weekly operations meetings included discussions on the Weather Forecast Ensemble Validation, Satellites, HF-Radar, Gliders, DMAC, Education & Outreach, Ocean Forecasts, Fisheries, CBIBS, and QARTOD.Observing Subsystems: a) Weather Ensemble: The MARACOOS weather ensemble operations continue to run four times per day at 00, 06, 12 and 18UTC out to 36 hours. WeatherFlow currently utilizes up to 11 forecast models in the ensemble. b) *Satellites:* There were 0 days of data acquisition gaps for the University of Delaware X-band dish, University of Delaware Geo-Stationary Dish, and the Rutgers University L-band dish. The Geo-Stationary satellite receiving dish at the University of Delaware (UDel) receives 40-80 scans of sea surface temperature (4km resolution) in the MARACOOS region. As the data volume of this feed is enormous, MARACOOS held a week-long experiment in late November to collect and store Geo-Stationary SST to determine its usefulness for MARACOOS supported activities. The data is now available for use here: (http://thredds.demac.udel.edu/thredds/catalog.html?dataset=GOESSSTAggregate). The Rutgers X-Band dish has not been operational since June 2014 but is currently under repair and expected to be fixed during summer 2015. c) *HF-Radar*: The MARACOOS metric for long range data coverage and availability has surpassed the 80/80 metric goal (80% coverage 80% of the time) again during this period. d) *Gliders*: Glider operators focused on data analysis during this reporting period as well as coordinating glider deployments for the upcoming Gliderpalooza 2015. DMAC and Education and Outreach Subsystems: The uptime for observations and model data in the MARACOOS Data Center continues to be >99% and the auto-monitoring system provides feedback on most of the data feeds. Modeling Subsystem: During the reporting period the ESPreSSO data assimilation system suffered several interruptions to data availability from certain services on the MARACOOS and NASA PO-DAAC THREDDS data servers. These did not interrupt the forecast itself because that proceeds in the absence of assimilation data provided river, meteorology and boundary forcing data are available. Two ESPreSSO forecast interruptions did occur due to Rutgers network or system administration disruptions. From May 17 onward, access to the blended infrared/microwave SST products from GHRSST via REMSS exceeded 2-day latency and those data have not entered the assimilation data stream since then. These experiences highlight the numerous dependencies that stem from assimilating the full suite of ocean observations from a distributed network of real-time research services. The 4-cycles-a-day NYHOPS forecast system at Stevens Institute of Technology was 100% operational during this 6-month reporting period. The model's boundary conditions were updated without service interruption. A parallel experimental NYHOPS model (NYHOPSv3b), also ran 4 cycles-a-day initiated in August 2014, has also had 100% operational service to date (May 31, 2015). The SMAST-HOPS model continued to make weekly nowcasts/forecasts (Wednesdays) and was available during 90% of the reporting period (couple of weeks were missed due to winter blizzards in the northeast).

Meetings/Engagement Activity Highlights: During the reporting period, MARACOOS was engaged in regionally based meetings and efforts that reached several thousand individuals in the areas of fisheries, water quality, coastal inundation primarily, with efforts also aimed at maritime safety and offshore wind. Several thousand more individuals were reached through MARACOOS' electronic outreach. MARACOOS and its partners have engaged with national and international organizations to represent MARACOOS and IOOS capabilities, as well as to proactively search for opportunities to partner and leverage existing funding streams. Additionally, MARACOOS held two face-to-face Board meetings and conducted a Board meeting call every two weeks and an Operations meeting call every two weeks. In May, MARACOOS held its Annual Meeting in Annapolis over the course of 2 days, with interesting speakers, panel sessions, and opportunities for stakeholders to provide input in the activities of MARACOOS partners.

A) Atmospheric Data Integration: For the MARACOOS domain: (36 to 43 N, and 78 to 69.5 W), WeatherFlow generates a gridded ensemble of surface meteorological fields from a variety of available high-resolution mesoscale numerical weather prediction (NWP) forecasts (ensemble members). The ensemble products, which include the gridded data, production imagery, and statistics, are available to the MARACOOS community.

The MARACOOS weather ensemble operations continue to run four times per day at 00, 06, 12 and 18UTC out to 36 hours. WeatherFlow currently utilizes up to 11 forecast models in the ensemble. WeatherFlow is taking advantage of available high-resolution (spatial resolution of 4km or better) NWP forecasts generated by government, academic, and private sectors that cover all or significant portions of the MARACOOS domain. The current list of models used in producing the ensemble is itemized in Table 1.

Table 1. Current atmospheric models used in the MARACOOS weather forecasting ensemble

Institution / Model	Runs Used (UTC)	Resolution (km)	West Lon	South Lat	East Lon	North Lat
Rutgers University WRF	00	3	-78.934	34.470	-69.189	42.391
Sterling VA WFO WRF	06,18	4	-82.942	35.391	-73.057	41.818
WF RAMS Chesapeake Bay	00,06,12,18	2	-77.700	36.200	-74.910	39.890
WF RAMS Cape Cod	00,06,12,18	2	-71.600	40.800	-69.404	42.996
WF RAMS Atlantic Coast (New)	00,06,12,18	2	-78.900	34.200	-73.356	40.752
WF WRF Atlantic Coast (New)	00,06,12,18	2	-78.900	34.200	-69.000	42.760
WF WRF Atlantic Coast B (New)	00,06,12,18	2	-78.900	34.200	-73.356	40.752
NOAA/OAR HRRR	00,06,12,18	3	CONUS			
NOAA/NCEP NAM	00,06,12,18	4	CONUS			
NOAA/NCEP WRF-ARW	00,12	4	CONUS			
NOAA/NCEP WRF-NMMB	00,12	4	CONUS			

The ensemble system produces hourly output files for each ensemble runs. The GRIB version 2 output files contain 2km spatial resolution U and V component winds, temperature, relative humidity, pressure, and longwave and shortwave radiation budget fields at the surface. In addition to the mean fields standard deviation fields are also included. Products include:

1. The WeatherFlow MARACOOS website (http://co.weatherflow.com/maracoos/) allows users to view map and time series displays of surface wind vector contour plots and for each ensemble member plus the ensemble product itself.

2. The verification statistic tool that assesses model performance using a unique array of both terrestrial and littoral observations has been integrated with the web viewer. Verification statistics include domain and cycle mean wind speed error, mean absolute wind speed error, and mean wind vector difference for each model and the ensemble. Sample statistics are shown below in Table 2.
3. An archive directory of the GRIB version 2 data files is maintained on the WeatherFlow MARACOOS server and is available for use in a variety of modeling and visualization uses. WeatherFlow continues to work with Applied Science Associates to make the data available on the MARACOOS Assets Manager interface.

Table 2. Weather forecast ensemble statistics

Model	Cycle	Num Obs	Avg. Speed obs	Avg. Speed Model	Mean Error	Mean Abs Error	Mean Vector Diff
MARACOOS Ensemble	2014-12-16-0000	491	4.33	3.00	-1.33	2.31	3.62
Rutgers University WRF	2014-12-16-0000	510	4.34	5.08	0.74	2.13	4.49
WF RAMS Chesapeake Bay	2014-12-16-0000	510	4.34	3.71	-0.63	1.98	3.76
WF RAMS Cape Cod	2014-12-16-0000	510	4.34	3.45	-0.88	2.08	3.64
WF RAMS Atlantic Coast (New)	2014-12-16-0000	207	4.84	4.78	-0.05	1.69	2.84
WF WRF Atlantic Coast (New)	2014-12-16-0000	207	4.84	5.40	0.56	2.06	3.31
WF WRF Atlantic Coast B (New)	2014-12-16-0000	207	4.84	5.08	0.74	2.13	4.49
NOAA/OAR HRRR	2014-12-16-0000	430	4.03	4.89	0.86	2.11	4.07
NOAA/NCEP NAM	2014-12-16-0000	510	4.34	3.96	-0.38	1.91	4.03
NOAA/NCEP WRF-ARW	2014-12-16-0000	510	4.34	5.17	0.83	2.2	4.10
NOAA/NCEP WRF-NMMB	2014-12-16-0000	510	4.34	4.37	0.03	1.99	4.52

B) HF-Radar Equipment:

The Mid Atlantic High Frequency Radar Network performed well during this progress period. The uptimes of the individual sites in the network are provided in Table 3. The long-range average is on par with previous periods. The 13 and 25 MHz networks have recovered from Sandy, although the 13 MHz radar station at Belmar is still down. The station at Belmar will not be ready until 2015 so we sought permission from the neighboring town, Bradley Beach. That station was installed in early January and has been performing well. The station at Nauset, MA (NAUS) is currently experiencing high reflected power. The transmit cable was replaced but the reflected power has persisted. A new transmit antenna was ordered and we expect to install it in July.

Woods Hole Oceanographic operates three stations (LPWR, METS and SQUB). SQUB and METS were taken offline April 10, 2015. Data from these sites is unlikely to be available in the near future, and potentially permanently, as Woods Hole looks to move the equipment to new locations in the coming months. The sites operated by the University of Connecticut and Rhode Island have recovered this progress period and were all above 80%. The SLTR site had a GPS problem but the equipment is back from CODAR and will be installed in the coming progress period.

The spatial and temporal coverage of the 5 MHz long-range network is shown in Figure 1. The network again exceeded the 80/80 metric that was developed by MARACOOS and the US Coast Guard Office of Search and Rescue.

Table 3: Table of data availability for the progress period December 1, 2014 to May 31, 2015. The column to the right represents the percentage of data available on the National Network.

Data Availability to National Network
December 1, 2014 to May 31, 2015

5 MHz #	5 MHz Site	5 MHz %	25 MHz #	25 MHz Site	25 MHz %	13 MHz #	13 MHz Site	13 MHz %
1	NAUS	2.4	1	MISQ	99.6	1	SEAB	20.0
2	NANT	99.5	2	BISL	92.2	2	BELM	71.5
3	MVCO	99.8	3	MNTK	98.5	3	SPRK	100.0
4	BLCK	50.1	4	GCAP	85.0	4	BRNT	72.9
5	MRCH	96.8	5	STLI	94.5	5	BRMR	96.4
6	HEMP	83.0	6	PORT	96.5	6	RATH	75.0
7	HOOK	61.8	7	SILD	98.7	7	WOOD	98.6
8	LOVE	99.6	8	CMPT	64.0			
9	BRIG	98.0	9	HLPN	99.3			
10	WILD	95.0	10	SLTR	8.6			
11	ASSA	96.3	11	VIEW	100.0			
12	CEDR	67.9	12	CPHN	100.0			
13	LISL	99.7	13	SUNS	70.0			
14	DUCK	100.0	14	LPWR	97.3			
15	HATY	99.7	15	METS	66.6			
16	CORE	92.3	16	SQUB	52.8			
Average:		**84**			**83**			**76**

C) HF-Radar QA/QC: The MARACOOS HF radar operators have held twice monthly conference calls to exchange information and develop new procedures. The group is also experimenting with a new weekly inspection procedure for the radar stations.

Rutgers is coordinating with the University of North Carolina and Woods Hole on quality control methods. North Carolina and Woods Hole are focusing on the spectra to radial step and Rutgers is focusing on quality control of the radial files. Rutgers has authored version 1.0 of a Matlab function that will quality control radial data. We examined the IOOS QARTOD Manual for Real-Time Quality Control of In-Situ Current Observations to see which tests for an ADCP could be carried over for use on High Frequency radar data. The three tests devised so far are:

1. Remove radials above a maximum speed threshold
2. Remove radials that have not changed over the past X hours. This is modeled after the Stuck Sensor (Test 15) from the QARTOD manual.
3. Remove radials that exceed a temporal derivative limit, gradient test.

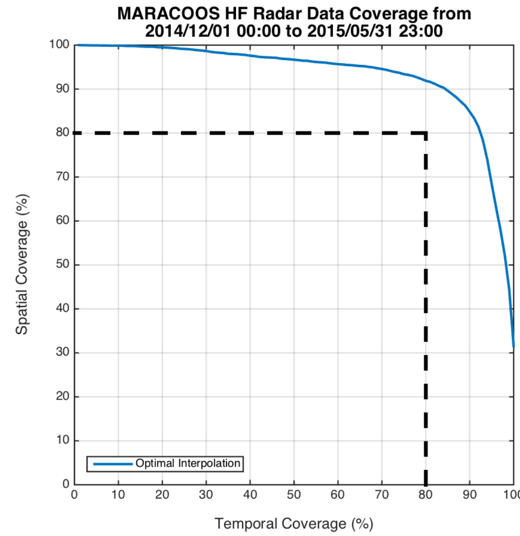

Figure 1: Spatial and temporal coverage of the 5 MHz network from December 1, 2014 to May 31, 2015.

We are currently testing this quality control script by comparing radial data from an HF radar and an ADCP deployed off the coast of New Jersey. The results of this comparison are shown in Figure 2 and Table 4. The correlation and root mean square error showed no noticeable change with any of the three tests or four combinations of tests. Since there was no detrimental affect on the radial data we will implement these tests in real time this coming progress period.

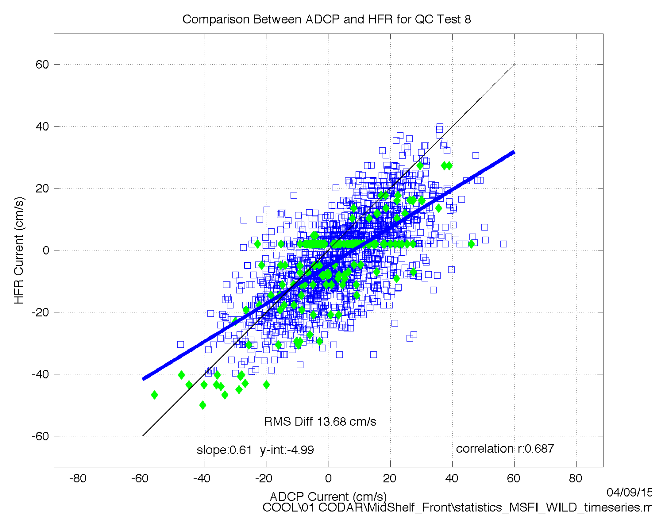

Figure 2: Comparison of ADCP currents on x axis with HF radar currents on the y axis. The green points are those that were flagged by the quality control algorithm.

Table 4: Results of the quality control algorithm test of HF radar currents vs. ADCP currents. The columns show correlation (r), root mean square error, number of data points (N), the percentage and number of data points removed by the particular test.

Test	Category	r	rms error	N	% Decrease	# Decrease
1	All Data	0.7	13.57	1846	0%	0
2	Speed	0.69	13.58	1832	1%	14
3	Stuck	0.7	13.68	1706	8%	140
4	Gradient	0.7	13.56	1843	0%	3
5	Speed & Stuck	0.69	13.69	1692	8%	154
6	Speed & Gradient	0.69	13.57	1829	1%	17
7	Stuck & Gradient	0.7	13.67	1703	8%	143
8	Speed & Stuck & Gradient	0.69	13.68	1689	9%	157

We gave presentations and authored several papers using the surface current data during this progress period. They are: 1) Glenn and Roarty (2015) "HF Radar Applications for Search and Rescue", US IOOS Congressional Briefing, February 26, 2015. 2) Evans, Roarty, Handel, Glenn (2015) "Evaluation of Three Antenna Pattern Measurements for a 25 MHz SeaSonde" Proceedings of the 11th Working Conference on Current, Waves and Turbulence Measurement Conference, St. Petersburg, Florida. 3) Forney, Roarty, Glenn (2015) "Application of Radial and Elliptical Surface Current Measurements to Better Resolve Coastal Features" Proceedings of the 11th Working Conference on Current, Waves and Turbulence Measurement Conference, St. Petersburg, Florida. 4) Roarty, Evans, Glenn, Zhou (2015) "Evaluation of Algorithms for Wave Height Measurements with High

Frequency Radar" Proceedings of the 11th Working Conference on Current, Waves and Turbulence Measurement Conference, St. Petersburg, Florida. 5) Roarty (2015) "The Use of Ocean Surface Currents for Coast Guard Search and Rescue" The United States Coast Guard Academy Science Lecture Series, April 16, 2015.

D) Underwater Gliders: Over the last six months there were no glider deployments in the Mid-Atlantic. The early 2015 MARACOOS glider efforts were focused on data analysis and preparation for the upcoming 2015 summer and fall seasons (Gliderpalooza 2015). Two recent manuscripts led by Wendell Brown (UMass) describe results stemming from MARACOOS-funded glider deployments to examine the Mid Atlantic Bight Cold Pool (Brown, W.S., O. Schofield, S. Glenn, J. Kohut, and W. Boicourt, 2015a. The evolution of the mid-Atlantic bight cold pool based on ocean glider observations, *SMAST Technical Report 15-03-01,* pp 35. http://www.smast.umassd.edu/OCEANOL/reports/MAB/coldPool_2007_fromGliders_SMASTreport_submit_10mar15.pdf; Brown, W.S., O. Schofield, S. Glenn, J. Kohut, and W. Boicourt, 2015b. The evolution of the Mid-Atlantic Bight cold pool based on ocean glider observations, *to be submitted to JMR*). Brown et al. (2015a) describe a glider's-eye view of the seasonal evolution of the Mid-Atlantic Bight Cold. In particular, they show that the core of the Cold Pool – as defined by the loci of local section minimum temperatures – parallels and is very nearby the shelfbreak and by implication the Shelf Break Front. They have also developed an observation-only definition of the evolving landward boundary of the Cold Pool. The marshalling of glider assets during Gliderpalooza 2013 enabled a more complete definition of both the landward and seaward Cold Pool boundaries during September 2013. Wilkin et al. (2014) present a model's-eye view of the Cold Pool. The next steps are to combine the two points of view in the development of future MAB Cold Pool forecasting capability.

The MARACOOS glider team has begun planning for the next major effort in the Mid-Atlantic, Gliderpalooza 2015, which will be to focus on the Summer/Fall 2015 transition of the Mid-Atlantic Bight (MAB) Cold Pool. UMass is deploying a glider in Southern New England off Southern New England for Cold Pool mapping and near OOI/Pioneer buoy array in June/July 2015. Rutgers will deploy a glider in the MAB in September. University of Maryland (with a glider from University of Delaware) will deploy in the Southern MAB in September. There are several other glider deployments planned in the MARACOOS region this upcoming summer/fall that are leveraged by other funded projects. As with past two Gliderpalooza events, the goal is to coordinate a range of ocean efforts, funded by disparate programs from a variety of agencies to demonstrate continental scale coordination of distributed ocean observing technologies to sample ecologically relevant scales. The integrated data is being used to serve a range of science goals while providing a regional data set for hindcast studies that can be used to improve physical, optical and ecological modeling/sampling efforts in the future. The main goals of Gliderpalooza include: 1) provide a unique data set the modelers can use for years to come; 2) provide a standardized dataset over ecological scales and information on fish/mammal migrations; 3) provide a 3-D snapshot of the Mid-Atlantic Bight (MAB) cold pool; 4) provide an extensive distributed instrumented network through the peak period of fall storms including hurricanes, demonstrating a community "surge" capacity; 5) provide a demonstration of the potential U.S. national glider network; 6) provide seamless flow of real-time glider data into the Global Telecommunications System (GTS) via DMAC and into the regional ocean models; 7) demonstrate an initial capacity for real-time evaluation of a distributed ensemble of ocean model forecasts using spatially distributed datasets; and 8) engage undergraduates in ocean observing efforts.

E) Satellites: ***Public Data Feeds and Infrastructure Updates:*** MARACOOS continues to support expanded satellite coverage from the Gulf of Mexico, to Cuba to Newfoundland. We utilize de-clouded sea surface temperatures (SST's) from the Rutgers University L-Band dish and post the data to a publicly available THREDDS server in a Climate Forecast (CF) netCDF format. The MARACOOS CF-compliant SST data feed, which began in 2005, is updated in near-real time (http://tds.maracoos.org/thredds/SST.html). These can now be accessed at greater speed due to computer infrastructure updates on the THREDDS server. This real-time SST data is also visualized via the MARACOOS Asset Map (http://assets.maracoos.org), in Google Earth (http://modata.ceoe.udel.edu/web_kmzs/), and via browser-based map services (http://orb.ceoe.udel.edu/public-access). The UDel X-Band creates a real-time CF-compliant netCDF4 ocean color data feed, which is being updated in near-real time (http://tds.maracoos.org/thredds/MODIS.html). Ocean color data is now processed with NASA SeaDAS instead of the NRL APS system. The ocean color THREDDS feed includes 39 ocean color-related products, including estimates of the inherent optical properties, which are critical for understanding the coastal ocean. The ocean color record covers 2002-present. Data streams from VIIRS are currently being evaluated. The data processing stream has been ported to the University of Delaware Mills Super Cluster for satellite data processing. This has significantly increased the speed of data delivery. Data from the UDel Geo-Stationary satellite receiving dish is available on the web, and is now on an experimental THREDDS server hosted at UDel: (http://thredds.demac.udel.edu/thredds/catalog.html?dataset=GOESSSTAggregate).

We recently assessed the quality of our cloud masking process for the AVHRR data by comparing 205 NDBC time records of buoy and platform SST to our cloud masking products (Fig. 3). We are currently comparing the quality of our cloud masking to Rutgers University coldest pixel algorithm and the NASA SPORT product to see which algorithm best removes clouds.

Rutgers is currently in the process of acquiring a 28 year AVHRR data set from the NOAA CLASS website. Rutgers is currently downloading the five channel level-1 data in order to enable reprocessing of SST data using a coldest pixel algorithm. This new algorithm maintains accurate upwelling center temperatures during summer as compared to current standard SST products such as SPORT composites which eliminate the daily localized cold centers of east coast upwellings. This data set will also serve numerous studies including but not limited to long term climate studies and hindcasting for physical and ecological models. Real-time acquisition and coldest pixel composites are continually being generated in near-realtime for use in atmospheric modeling.

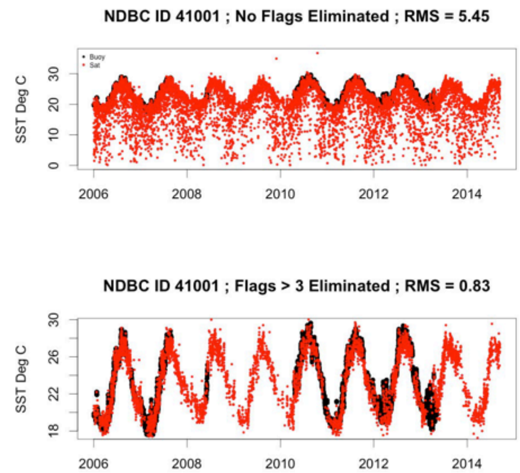

Figure 3: Comparison of unfiltered (top red) and cloud filtered (below red) satellite SST to a NDBC buoy (black) and the reduction in RMS error.

F) Dynamic Models: The Rutgers modeling group continues to focus development efforts on an expanded Gulf of Maine and MAB model to succeed the present real-time ESPreSSO system. A prototype is operating in real-time system driven by NAM meteorology forecast, USGS and Water Service of Canada river data (adjusted for un-gauged portions of the watershed) and assimilating data from the 3 operational altimeters (Jason-2 with coastal corrections; AltiKa and CryoSat in deep water only), infrared and microwave satellite SST (AVHRR, AMSR-2 and WindSat), HF-radar currents, and in situ CTD where available from gliders and Argo. While the ESPreSSO system used blended composite SST, this approach is discontinued because of the loss of diurnal cycle information it incurs, and the introduction of severe errors due to the use of climatology during prolonged cloudy periods.

A large ensemble modeling effort is underway at Stevens Institute of Technology to predict combined overland flooding from inland rain and coastal tide and surge – as well as other parameters such as waves, river discharge, currents, water temperature and salinity – with increased accuracy. As described in the previous report, the Stevens NYHOPS models are presently nested within the NOAA ETSS model: The two operational NYHOPS models get their storm surge open boundary conditions at the continental shelf slope from ETSS. ETSS is forced with the GFS winds and pressure. A new update to the NOAA ETSS products was accommodated this period for use with the operational NYHOPS (in addition to the one described in the previous reporting period). In addition, waves at the NYHOPS open boundary come from the NOAA WaveWatch III model. Uncertainties in the open boundary conditions for NYHOPS coming from a single external source (ETSS for surge and WW3 for waves) need to be studied. A parallel effort on developing a Stevens North Atlantic Predictions (SNAP) model to nest NYHOPS in, as an alternative to ETSS and WW3, is now producing 66 different gridded operational storm surge and wave forecasts to create and study a modeling ensemble based on different meteorological predictions such as the GEFS, SREF, the Rutgers WRF model, and the Canadian Ensemble. 2D surface precipitation fields from these different meteorological models are also used to force a similar number (>60) of independent hydrological forecasts based on the HEC-GeoHMS USACE model that Stevens is implementing for the NYHOPS region, to produce a riverine ensemble product linked to a new NYHOPS modeling ensemble. These different meteorological fields will also be used to force the new NYHOPS ensemble endmembers internally at that model's surface. Research on ensemble techniques for combined hydrology and storm surge forecasting is ongoing, and include not only Stevens-generated endmembers based on NYHOPS (sECOM model), but other models too, for example NOAA ETSS (based on the Slosh model), NOAA ESTOFS (AdCIRC model), and SUNY Stony Brook central (AdCIRC model). Finally, two more papers were accepted for publication, one on street-level flooding (Blumberg et al.), and one on a multiple linear regression model for storm surge predictions (Roberts et al.), and two more are under revision. Stevens investigators were invited to present NYHOPS in the Hudson River Environmental Symposium titled "Seeing the Hudson River in the 21st Century" on May 6th 2015 that reaches a wide audience of regulators and agencies around the Hudson River Estuary region. A presentation on an upcoming NOAA workshop is also scheduled. The workshop, called "Linking freshwater and ocean dynamics towards integrative ecosystem modeling: opportunities and challenges", is planned in coordination with the NOAA North Atlantic Regional Team (NART) workgroup which Stevens and other MARACOOS partners participate in.

The multiscale operational forecasts with SMAST-HOPS model continued with SST assimilation during December 2014 through May 2015. During this period, Dr. Andre Schmidt transferred the operational technology to Mr. M. Monim, a new graduate student, who is now running the forecast system by himself. Dr. Schmidt has accepted a new position of System Administrator at SMAST and is providing support to the MARACOOS group as needed. Monim has also participated in a Rutgers Glider training course and is preparing to participate in the upcoming Gliderpallooza during fall 2015. His research will utilize the assimilative forecasts (and hindcasts) to understand the seasonal impact of Warm Core Rings on the shelf. Monim is developing techniques for assimilating ARGO and Buoy observations in near-real time for the SMAST-HOPS implementation.

In a related effort, past six years (2009-2015) of Gulf Stream north wall (GSNW) and eddy locations are being used to develop an automated method of identifying the GSNW and Rings. This automated methodology (based on Neural Network) will be used for Feature oriented initialization and assimilation/verification in future forecasts. In another effort, a quantitative skill assessment for the model after recent improvements with regional climatology and modified mixed layer-dependent assimilation has started. This assessment will utilize the recently developed MARACOOS DMAC framework, which provides a suit of archived, near-real time and real-time observational information from multiple sensors including Buoys, Drifters, HF Radar fields, Gliders and fixed platforms.

The hindcast study on bottom temperature estimation (1973-2007; September to November period) using past data and model output was completed during this period by Dr. Schmidt in collaboration with Scientists from NOAA and Rutgers. Data from Federal and State surveys, XBTs, Gliders and a model were combined in a multiscale objective analysis to produce the daily bottom temperature maps. The unbiased BT RMSE values are used to estimate two alternate states of bottom temperature as input to a niche model to compute a fisheries habitat suitability index (HSI). The full study report is available as a Working Report from: http://www.nefsc.noaa.gov/SAW-Public/SAW60/Background-papers-bluefish/BlueWG_WP_B4_Distribution,Temperature,Availability.pdf.

G) DMAC: A WAF of MARACOOS services continue to be registered with NGDC and listed in the IOOS catalog. In total, MARCOOS has 859 registered services, including: 430 DAP, 427 SOS, 10 WMS. The TDS server (http://tds.maracoos.org/thredds/catalog.html), which is currently running version 4.5.3, includes the following data: UDEL SST (NOAA AVHRR and MODIS), UDEL Chlorophyll (MODIS), WeatherFlow met model data (ensemble, RAMS Chesapeake Bay, RAMS North East, NAM4k, and HRRR), Rutgers WRF met model results (3km and 9km), Stevens NYHOPS model results, Rutgers ROMS model results, and USGS COAWST model results. Google Analytics has been implemented to monitor use and shows thousands of events each month. SciWMS has been updated to include the improvements made under the IOOS COMT project, improving both the performance and rendering of the WMS layers.

In addition, the DMAC team continues to support an SOS server at http://sos.maracoos.org/stable/catalog.html. This SOS server provides data via ncSOS services and was updated to ncSOS version 1.1 in December 2014. The SOS services deliver data from 9 WeatherFlow wind stations, 10 Hudson River Environmental Conditions Observing System (HRECOS) stations, and dozens of USCG surface drifters (SLDMBs). Google Analytics has been implemented to monitor use and shows thousands of events each month. The SOS server for CBIBS has been transitioned from 52N to ncSOS v1.1. All historical observations are now available. Automated harvesting of new observations has been implemented and preliminary quality control is being performed on the new observations being ingested. We are in the process of performing historical quality control for each station. This involves configuring the test constraints for each sensor on each station. We have also spent a significant amount of time on documentation and a thorough set of documentation for the quality control process, software and API are available on Google Drive. Additionally, we are also developing a new release for the CBIBS Public API which is used by mobile clients and the CBIBS website (http://buoybay.noaa.gov/). This new API will be backwards compatible with the older software API but use the newly configured data schema and support quality flags.

The MARACOOS Assets Map continues to provide a popular medium for accessing MARACOOS data. The latency of HFRADAR data displayed on the map has been improved from 10 hours to 2 hours by harvesting the hourly files. We have also begun a redesign of the Assets Map to make it more user friendly and provide additional functionality. The MARACOOS analytics process continues to run for the Asset Map, MyMARACOOS, and the TDS and SOS. The Assets Map typically has close to 1000 hits per month.

The GliderDAC 2.0 continued to progress over the first half of 2015. Additional data providers were added and the DAC 2.0 now includes Rutgers/MARACOOS, CILER/GLOS, CenCOOS/NANOOS/MBARI, SCCOOS/Scripps, NANOOS/OHSU, and NOAA/AOML. Data access options include an ERDDAP instance (http://data.ioos.us/gliders/erddap) and a THREDDS instance (http://data.ioos.us/gliders/thredds/catalog.html). The ERDDAP and THREDDS WAFs have been registered with NGDC and Glider DAC 2.0 has been connected to the IOOS Catalog. In May 2015, a formal review of the DAC was held. The panel endorsed the DAC and recommended continued development.

H) Education and Outreach: With support from NSF (grant #1062894OCE), the Education and Public Engagement (EPE) team continues to focus is on the integration of time series data into undergraduate teaching. We are organizing an intensive hands-on workshop focused on developing effective teaching with data practices using MARCOOS data assets and OOI data visualizations tools. This three-day program, will engage diverse institutions, including community colleges, Primarily Undergraduate Institutions (PUIs), Minority-Serving Institutions (MSIs), research laboratories, and larger research universities, as well as a team of pedagogical experts to:

1) **Crosswalk MARACOOS Science themes presented in popular introductory textbooks used in oceanography courses**. We propose to compare IOOS themes and concepts and popular published textbooks to triangulate where MARACOOS data investigations/activities can be woven into existing courses.
2) **Develop learning objectives and activity outlines** of five data investigations (one per team) that could be developed with MARACOOS data.
3) **Brainstorm with the teams how best to build a community of practice.** In the workshop, we propose to poll our teams for recommendations on how to build long-term working relationships and collaborations on data investigation development.

Finally, we have been working with the Lawrence Hall of Science and Western Washington University to develop a college course using data to teach climate change. We expect to roll out the course in the fall 2015 and pilot it with four pre-college programs in LA, CA, and NJ.

I) Economic Benefits: WATER QUALITY: MARACOOS continues to build out its Water Quality Working Group. The Working Group is intended to provide a forum for stakeholders to develop collaborative observing capabilities in the region's estuaries. Since our kickoff meeting in September 2013, which focused on Delaware Bay, we have developed sub-regional groups for the Chesapeake Bay (Spring 2014) and more recently in the LI Sound region (Summer-Fall 2014). Our process is to identify and work with key practitioners to assess the existing capabilities, and gaps, in regional water quality monitoring.

We are establishing MARACOOS as an "integrator and enabler" in the region's Water Quality monitoring community. In March 2015, we participated in an Innovative Monitoring Approaches workshop coordinated between the Scientific Technical Assessment and Reporting team (STAR) and the Scientific Technical Advisory Committee (STAC) of the Chesapeake Bay Program. This involvement has led to MARACOOS leading a proposal to NFWF as a programming framework that represents a unique program and model of leveraging between local, regional and broad scale monitoring efforts supporting a range of science and management needs including water quality. In addition, MARACOOS was invited to present its WQ monitoring pilot to both the Interstate Seafood Sanitation Assn, in Ocean City, MS, and to Northeast Shellfish SanitationAssociation, in Riverhead, LI, NY. This has led to efforts to assist in installation of low-cost sensor networks with the data to be managed and served by MARACOOS.

Our initial effort in LI Sound is to support development of a Water Quality monitoring network, in collaboration with UCONN, State of CT Bureau of Aquaculture, CT Sea Grant and the local shellfish industry (commercial and recreational). *Vibrio parahaemolyticus* (Vp) is a growing threat to producing safe seafood from Connecticut. Elevated levels of Vp have been identified in CT shellfish growing areas, however the extent and duration of events is unclear due to the small amount of data collected prior to 2014. CT shellfish sales are approximately $30 million annually (www.ct.gov/doag) and the industry has approximately 300 employees. Extended closures reduce sales, threaten jobs, and erode consumer confidence for local seafood. David Carey, CT Bureau of Aquaculture Director, noted "The 2013 *Vibrio* outbreak and closure and recall is a tremendous hit to Connecticut, as the reason many states were purchasing our oysters in the months of June, July and August" was "to avoid exposure to *Vibrio*" (Zaretsky 2013).

<u>FISHERIES:</u> MARACOOS serves the fisheries stakeholder community in many ways, as a convenor of an informal OpenOcean collaborative of fishermen, scientists and managers; as an integrator of data that has relevance to fisheries operations and management (MyMARACOOS); as a collaborator on research proposals; and as an active participant in a variety of regional management bodies (Peter Moore serves as an Advisor to ASMFC, MAFMC and NEFMC). Peter Moore, Grace Saba (Rutgers), and Josh Kohut (Rutgers) will be on a team of scientists that have recently been awarded a grant to examine the climate change effects of three commercially valuable Mid-Atlantic marine species: spiny dogfish, black sea bass, and longfin squid. This study is a high priority for the MAFMC which makes management decisions on the regions marine fisheries.

<u>US NAVY:</u> MARACOOS in a coordinated effort with SECOORA has been supporting Fleet Weather Center Norfolk at Naval Base Norfolk with an updated website this hurricane season. The website is designed to assist and advise the FWC watch floor with easy access to links to partners from both RAs on MARACOOS.ORG. The effort manifests the great potential of how Regional Association intellectual capital can be brought to bear on real life issues the Navy faces every hurricane season.

<u>J) CBIBS Buoys:</u> The Chesapeake Bay Interpretive Buoy System is being used as a development tool for MARACOOS support of fixed platform time series data, including Web Services (SOS), QARTOD QA/QC recommendations, and provision of data to Federal agencies. The CBIBS Data Acquisition software is now running on the Applied Science Associates cloud, and a new CBIBS database with Web Services has been constructed, populated with historical data, and being updated in real time. NOAA, MARACOOS, and ASA are jointly participating in IOOS DMAC QARTOD conference calls, and are seen as the lead RA in implementing QARTOD standards. Data are served via IOOS-standard SOS web services, and QARTOD QA/QC is being applied in real time. Through MARACOOS, ASA has been tasked with developing a complete end-to-end system for collecting, quality checking, archiving, and delivering CBIBS data, as well as documenting the system for IOOS certification purposes. Discussions proceed with NDBC on ways to archive QARTOD flags, again leading RA activities in this field. In addition to CBIBS physical data, the database will support collection of Acoustic Tag data from the CBIBS system in support of the Mid-Atlantic Acoustic Tagging Observation System (MATOS), a component of the IOOS Animal Tracking Network.

MARACOOS continues to provide support for CBIBS long-term planning and operations and maintenance, as well as expanding operational and forecasting activities in the Chesapeake Bay. Discussions have been held with Chesapeake Bay Program, shellfish user groups, and ecological forecasters to integrate CBIBS data into their activities and to look at new observing assets and tactics to improve Chesapeake Bay management products.

K) QARTOD: An Ocean Optics QC manual has been completed and is posted on the IOOS QARTOD web site at www.ioos.noaa.gov/qartod. A manual addressing the QC of Dissolved Nutrients was initiated on April 21, 2015 and is scheduled for completion in the fall. The Dissolved Oxygen manual has been refreshed and posted, and the Waves manual update is underway and will be completed in July. QARTOD Board of Advisor meetings were held on Feb 23 and May 26, and the next one is scheduled for Aug 31, 2015. In FY 2016 QARTOD will undertake manuals for HFR surface current mapping, gliders (tentatively planned), and an update to the Temperature and Salinity manual. Additionally, the QARTOD team will work with those implementing the QC tests to guide operators and adjust the manuals as needed.. Rutgers is focusing on quality control of the HF Radar radial files (see above section 2C) and has also developed a working group to establish standard operating procedures (SOPs) for quality assurance as well as quality control of real-time glider data.

Hampton Roads Sea Level Rise pilot: MARACOOS is anticipated to be the integrating agent in the 2 year pilot project to address sea level rise in the Hampton Roads region. Launched June 3rd and 4th 2014 at Old Dominion University, the pilot will use a whole of government plus industry approach in the form of a Hampton Roads Interagency Task Force that has full Pentagon and White House support. A key objective in this pilot is to integrate federal and non-federal data that will serve as a demonstration for other regions in the entire country. The Federal agencies, State, Hampton Roads Planning District Commission, cities and industry will all be involved. A charter has been signed, and the new website is at www.centerforsealevelrise.org. Interaction with MARACOOS staff continues as the Pilot goes it the final year (Phase 2).

3) SCOPE OF FUTURE WORK

At this time there is no expected change in the scope of future work.

4) LEADERSHIP PERSONNEL AND ORGANIZATIONAL STRUCTURE

During this reporting period, MARACOOS Board Member changes occurred during the public Annual Meeting in May. Nominations were solicited early in 2015 and submitted to the Nominations committee for consideration and recommendation to the full Board. Elections were held on May 8, 2015. Doug Wilson, Andrew McGovern, Michael Bruno and Bill Boicourt were reelected to the Board for an additional 3-year period. Fredrika Moser (Maryland SeaGrant) was elected to the Board as well for the same period. Joe Vietri (US Army Corps of Engineers), Drew Minkiewicz (Attorney and commercial fisheries sector representative), and Steve Woll (Weaterflow) were appointed to 3-year, Board-appointed slots. The total Board complement is currently at 17 with the potential for up to 1 additional board-appointed member in the future. The staff remained as in the previous reporting period.

5) BUDGET ANALYSIS

The total budget for years 1 through 4 is $10,695,316. Year 4 subcontract totals for the 17 subcontracts and Rutgers, the prime, are shown in Figure 4. Current balance remaining for the lead and all subcontracts as of June 2015, is shown in the right hand column. Note that many of the subcontractors billing lags several months, so these totals are not indicative of the total spent to date.

#	Distribution	Years 1-4	Remaining Balance
LEAD	Rutgers	$ 3,546,670.00	$ 376,629.35
1	Applied Science Associates Inc	$ 1,359,205.00	$ 19,242.00
2	Caribbean Wind LLC	$ 415,000.00	$ 138,363.00
3	Center for Innovative Technology	$ 194,458.00	$ 27,270.00
4	Old Dominion	$ 58,641.00	$ 870.78
5	Old Dominion Univ Res. Found.	$ 50,000.00	$ 505.00
6	Old Dominion University	$ 494,875.00	$ 107,488.00
7	Stevens Institute of Technology	$ 335,012.00	$ 67,255.00
8	University of Connecticut	$ 355,254.00	$ 77,036.00
9	University of Delaware	$ 352,453.00	$ 101,773.00
10	University of Delaware	$ 1,831,690.00	$ (3,549.00)
11	University of Maryland	$ 248,422.00	$ 29,058.00
12	University of Massachusetts Dartmouth	$ 911,590.00	$ 116,343.00
13	University of North Carolina	$ 17,783.00	$ 16,646.09
14	University of Rhode Island	$ 116,648.00	$ 40,262.00
15	VIMS	$ 12,000.00	$ 12,000.00
16	WeatherFlow Inc	$ 335,615.40	$ 13,660.40
17	Woods Hole Oceanographic Inst.	$ 60,000.00	$ 18,712.00
	Total	$ 10,695,316.40	$ 1,159,564.62

Figure 4: MARACOOS years 1-4 budget distribution with total and remaining budget listed for the prime and all subcontractors.