

## Progress Report

# Advancing the Caribbean Coastal Ocean Observing System

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Project title: Advancing the Caribbean Coastal Ocean Observing System

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## **1. Introduction**

CariCOOS's development plan offered to meet prioritized stakeholder needs for coastal information through an efficient design minimizing observing assets while developing complementary modeling tools. Its initial implementation phase proved effective in providing wind, wave and current data products as well as forecasts supporting numerical modeling of these for the Atlantic and Caribbean insular shelves. Additional initiatives included development of a storm surge modeling program as well as remotely sensed water quality products. A Data Management and Communication subsystem, including web based data and product interfaces was also emplaced.

In its second phase, CariCOOS proposed the continued operation of the initial phase and the development of observing, modeling and skill assessment assets and tools required for the shoreward extension of the CariCOOS product domains. Said extension responds to the need for supporting decision-making by specific nearshore dependent activities/sectors such as port and harbor operations (navigation safety and rapid response), recreational activities, as well as coastal hazards and resource management.

Here we report progress toward milestones set for the current program year. CariCOOS has been effective in maintaining operational status of all observing assets including five data buoys, one wave buoy, one Ocean Acidification (OA) monitoring buoy, two HF radars, a 15 Mesonet stations as well as continued operation of current, wave and weather models.

Major milestones accomplished by the modelling subsystem team include 1) extending the high resolution wave model domains so that every single meter of inhabited coastline in the US Caribbean is finally covered by a high-resolution wave model grid within the CariCOOS Nearshore Wave Model; 2) finalization of the Storm Surge Maps (Atlas) for Puerto Rico (PR) ; these along with the maps issued last year for the US Virgin Islands (USVI), provide for appropriate urban development and response planning for the CariCOOS archipelago (excluding the uninhabited Navassa) 3) The CariCOOS-Sea Grant Nearshore Breaker Model is now fully operational and the breaker height predictions are provided to NWS San Juan for use in their rip current risk prediction for PR and the USVI system.

The observing subsystem has also been significantly enhanced. Acquisition of second long range HF Radar (CODAR) will, in conjunction with one previously acquired with IOOS directed funding, provide real time surface current data up to over a hundred nautical miles offshore the southern coast of PR. Data acquired is expected to provide unique operation support data from this hydrodynamic-rich region and also for the enhancement of numerical modelling initiatives. Furthermore, the CariCOOS DMAC team has met all requirements set by the IOOS program and continued to diversify their

data product offer and distribution alternatives including smartphone apps and social media.

In addition to advances in the technical areas outlined above, this project continues to support the Caribbean Regional Association (CaRA) in its mission including achieving certification as a RICE as set forth in the Ocean Observing Act. Toward this end, CaRA Stakeholder Council has met and agreed to recommend to its membership its incorporation as a nonprofit corporation consistent with of § 501(c)(3) of the United States Internal Revenue Code of 1986 (the “US Code”) and §1101.01(a)(2) of the Puerto Rico Internal Revenue Code of 2011 (the “Puerto Rico Code”), as now in effect or as may hereafter be amended (collectively, the “Codes”). Said recommendation will be presented to CaRA stakeholders in its upcoming General Assembly scheduled for March 20, 2015.

## **2. Progress and Accomplishments**

Progress toward proposed **tasks** and ***milestones*** (in *italics*).

### **2.1. Observational Subsystem**

#### ***2.1.1. Operate and maintain the CariCOOS 5 data buoy network including UVI's buoy.***

- CariCOOS buoys B (San Juan), C (USVI), and E (Vieques) have remained operational since redeployment in May 2014. CariCOOS buoy A (Ponce) has malfunctioned due to solar panel and control box issues. Commercial Divers Inc. removed the buoy from its mooring, and it will be repaired and refurbished in January 2015 in collaboration with U. of Maine's Physical Oceanography Group.

#### ***2.1.2. Operate and maintain the CariCOOS Rincón Wave Buoy***

- A new Waverider Buoy was deployed on June 2014 at the Rincón deployment site. The original Waverider buoy, which suffered a sensor failure, was shipped to Datawell and refurbished and is now in storage, ready to serve as a backup buoy if needed.

#### ***2.1.3. Operate and maintain WeatherFlow MESONET and CariCOOS WindNet***

- WeatherFlow conducted maintenance of the weather station located in the Port of Guayama (XMRS) and the job was completed on October 22, 2014.
- Gurabo, PR weather station (XGUR) - the station has had intermittent battery problems since the middle of September. WeatherFlow will replace the entire data-acquisition system within the first months of the next year
- New Culebrita Lighthouse site – Communications are ongoing with Culebra's City Mayor's Office regarding permitting of the site. Installation has been delayed until all permitting issues are resolved with the Mayor's Office.
- Data from the CariCOOS WindNET sensors at Rincon (PTRP4) and Isla Magueyes (IMGP4) is now being disseminated to NDBC every 5 minutes

#### ***2.1.4. Operate and Maintain HF Radar Mona Passage surface current monitoring system***

- As proposed, the FURA and CDDO stations were operated continuously (with only short maintenance-related interruptions) and AIS service was maintained throughout the reporting period. Constant monitoring and the implementation of smart network connected power switches have significantly aided our effort to minimize downtime. In addition, weekly site checkups are conducted in order to assess radar performance and continue to optimize CariCOOS's HF Radar network. Visualization is also being considerably improved with the implementation of new scripts capable of accurately and elegantly displaying the observed data.

#### ***2.1.5. Pre-installation activities (acquisition, siting & permitting) and operational deployment of 5 Mhz HF system for the southern coast of PR***

- A major improvement over the existing system is the inclusion of two new long-range 5 MHz HF radars that will provide near real-time surface current data in the south and southwestern part of Puerto Rico. As part of the installation process, siting was conducted in the Cabo Rojo lighthouse and a proposal was submitted as required by the US Coast Guard. Moreover, an experiment was designed and is currently being conducted in Magueyes Island to assess how coastal morphology in some of the suggested antenna sites can negatively impact its performance. The outcome will be used to conclusively end the siting process by analyzing both coverage and accuracy of the data provided by the experiment. Permitting is also being addressed by requesting experimental licenses to the Federal Communications Commission (FCC) pertaining to the radars operating frequency and bandwidth.

#### ***2.1.6. Operation and maintenance of MAP CO2 buoy and continue discrete sampling program under NOAA's Ocean Acidification program***

- After the hull replacement required early in the year, the buoy has been operating and reporting data as expected.

**2.1.7. Acquire, refit and operate an outboard powered vessel capable of supporting routine nearshore water quality sampling and discrete observing as well as fast response in case of emergencies including search and rescue, pollutant spills or other environmental emergencies**

- Several candidate vessels have been identified and CariCOOS personnel are in the process of evaluating their structural and mechanical integrity.

**2.1.8. Continued dissemination of remotely sensed water quality products (Chl a, Kd 490) for the region and Eastern Caribbean.**

- Chl-a and K490 imagery products have been issued continuously. A new product merging multiple image from adjacent satellite passes is already on line.

**2.1.9. Development of observational techniques for inshore water quality (CDOM, Chl a and suspended sediments) based in situ CTD/optical measurements and initial implementation of inshore sampling program.**

- The water quality group has continued biweekly samplings for dissolved oxygen, CDOM, CTD/O<sub>2</sub>/Chl-fl & beam attenuation, pH, Chlorophyll a, total suspended matter and POC at stations representative of the gradient from the nearshore eutrophic mangrove lagoons environment to outer shelf oligotrophic reefs. Collected data evidences export of dissolved and particulate organic from the former to the latter.

**2.1.10. Assess the technical feasibility of implementing a beach pathogen forecasting program: revision of existing operational systems in other regions.**

- A review of pathogen forecasting programs in other IOOS regions has been initiated. Data needs for the development of local predictive models have been identified. Preliminary information concerning hydrodynamics, dispersion and diffusion processes will be provided by a field campaign scheduled for early 2015 at a local beach in Rincón, PR. Two additional coastal systems (a mangrove shoreline and a commercial port) have been identified. Additionally, some funds have

been allotted for the development of a real time pathogen monitoring device by a collaborator at UPRM (at the proof of concept stage).

**2.1.11. Deployment and recovery of 2 SEAGLIDER AUVs for upper water column heat monitoring and water column structure characterization off the Atlantic and Caribbean coasts of Puerto Rico and the Dominican Republic.**

- Two SeaGliders were deployed on July 2014 as part of the NOAA sponsored project “Sustained and Targeted Ocean Observations for Improving Tropical Cyclone Intensity and Hurricane Seasonal Forecasts” have been recovered and refurbished. These are scheduled for redeployment on February 2015.

**2.1.12. CTD cast at CaTS (bi-monthly) and USVI shelf stations (monthly)**

- This task was postponed since the water column structure data acquired by SEAGLIDER AUV’s (see above) are sufficient to validate the baroclinic structure of 3D circulation models at the moment.

**2.1.13. Acquisition and installation of thermistor array in UVI-EPSCoR buoy**

- No progress toward this task as of yet.

**2.1.14. Continued engagement of private enterprises in the navigation and energy sector as potential sponsors of observing assets required for their marine operations: follow up existing negotiations**

- CariCOOS personnel are participating in a project which will provide real-time oceanographic and atmospheric data as well as a customized operational wave model in support of an Under Keel Clearance management system at Yabucoa Port, operated by Buckeye Global LLC. This project is funded by Buckeye Global LLC through a contract with UPRM.
- An ADCP was deployed on November 15, 2014 to characterize the current velocity structure at Las Mareas Port in Guayama, Puerto Rico, in response to requests by the Southern Coast Harbor Captains to better understand the effects on coastal currents on their approach and docking operations.



**2.1.15. Deployment of Lagrangian drifters (in collaboration with NOAA AOML) as part of ROMS and AMSEAS model validation experiments. Deployments scheduled for August/September and March/April**

- Lagrangian drifters, provided by NOAA AOML Global Drifter Program, are scheduled to be deployed west of Anegada Island (NE Caribbean) on December 2014. These are expected to provide surface current data for model skill assessment as they traverse off the Atlantic coast of the CariCOOS region.

**2.1.16. Deployment of an ADCP in Gregory Channel and related data analysis by UVI personnel in response to a request by Charlotte Amalie (St. Thomas-USVI) harbor pilots who have requested assistance in identifying intense currents in the channel which hamper safe navigation in the area.**

- No progress toward this task as of yet.

**2.2. Modeling Subsystem**

**2.2.1. Maintain currently operational high resolution (HR) WRF (weather) and SWAN (wave) model implementations**

- WRF: CariCOOS WRF implementations at 1 km and 2 km have remained operational.
- SWAN: All SWAN wave model implementations have remained operational and have been fully duplicated in two separate high-performance computers. An additional high-resolution grid has been implemented for St. Croix. **At last, every single meter of inhabited coastline in the US Caribbean is finally covered by a high-resolution wave model grid within the CariCOOS Nearshore Wave Model.**

**2.2.2. Implementation of very high resolution (VHR) WRF and SWAN model at San Juan, Charlotte Amalie, Guayanilla and Yabucoa**

- WRF: Preliminary nested grids for these commercially important areas are based on the Advanced Research WRF model with one-way nested domains having two sub-levels. The first setup has a 1:3 nested ratio, in

which the parent and the two nested domains have a horizontal resolution of 3km, 1km and 333m, respectively. The second setup consists of a 1:5 nested ratio, in which the parent and the two nested domains have a horizontal resolution of 5km, 1km and 200m, respectively. Experimental runs for both model setups have been conducted and model validation and optimization efforts are underway. Figure 1 shows the spatial coverage of the proposed three-level nested setup for the CariCOOS WRF-ARW grids.



Figure 1. Existing operational WRF outer grid (1km resolution, in green), and proposed medium (orange) and high-resolution (red) WRF grids for specific ports.

- SWAN: High-resolution grids already cover these ports. A very high-resolution grid is being developed for Yabucoa Port as part of a project funded by the private shipping industry.

### ***2.2.3. Operational deployment and enhancement of CariCOOS - Sea Grant Nearshore Breaker Model***

- The CariCOOS-Sea Grant Nearshore Breaker Model is now fully operational and the breaker height predictions are provided operationally to NWS San Juan for use in their rip current risk prediction system.
- A training for emergency management personnel which will cover the use and interpretation of the nearshore breaker model has been scheduled for January 14, 2015 in collaboration with the PR Emergency Management Agency and NWS San Juan.

### ***2.2.4. Continue the development and validation of regional high-resolution (HR) CariCOOS-ROMS hydrodynamic model and assessment of potential HFR data assimilation schemes***

- The CariCOOS ROMS model, led by Dr. Stefano Leonardi from UT Dallas, is undergoing further validation and testing before being officially released to the public via the CariCOOS website. At the moment, the model provides improved forecast skill when compared to the NCOM AMSEAS model.
- After being approached by CariCOOS personnel, Dr. Alexander Kurapov (from OSU, now at IOOS) has provided valuable feedback regarding our operational scheme.

### ***2.2.5. Initiate the implementation of a unstructured hydrodynamic model (FVCOM) for nearshore waters***

- Preliminary FVCOM efforts have focused on developing a high-resolution mesh for the San Juan Bay and Estuary, as shown in Figure 2, with the end goal of developing an operational circulation model for San Juan. Additional FVCOM implementations will cover important harbor regions in USVI and Puerto Rico.

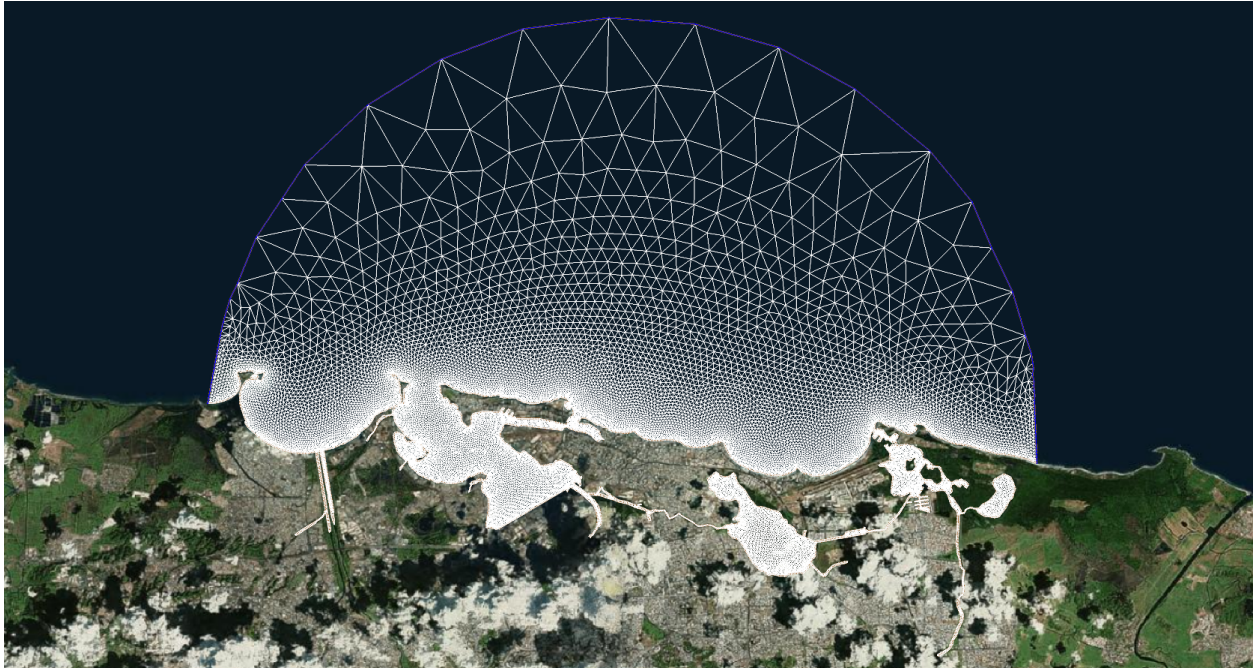


Figure 2. Preliminary FVCOM grid for San Juan Bay and Estuary.

**2.2.6. Continue development of very high-resolution (VHR) ROMS implementations for critical coastal areas including major ports**

- No further progress with this task is expected until the regional ROMS model undergoes further validation.

**2.2.7. Finalization of Storm Surge Inundation (SSI) Map Catalog for all hurricane categories**

- The USVI and Puerto Rico Storm Surge Atlas has been finalized and results have been distributed as asked for.

**2.2.8. Construct and disseminate SSI maps and provide training to pertinent agencies**

- A training workshop on their use for emergency managers has been scheduled for January 14, 2015, at the Cabo Rojo Convention Center. As of this moment the following have asked, and obtained, the results: Puerto Rico Coastal Zone Management Program of the Department of

Environmental and Natural Resources of Puerto Rico; Ada Monzón (meteorologist); the Puerto Rico Water Resources Institute; and the Puerto Rico Sea Grant Program.

**2.2.9. *Conduct an experimental numerical assessment of the potential role of channelized urban rivers as conduits of storm surge to high-density population areas in Puerto Rico***

- Next task in line is to edit the computational mesh in order to include one of the principal rivers in order to evaluate river discharge/storm surge interaction, and the possibility of the rivers serving as inland conduits of the storm surge.

**2.3. DMAC, Products & Computational Subsystems**

**2.3.1. *Continued development of CariCOOS DMAC subsystem while meeting IOOS requirements***

- At the National IOOS level a problem was detected during periodic registry harvest of our Catalog holdings which resulted in duplicate registry entries. This problem was fixed through the modification of service specifications in our Catalog and prompted an overhaul of our THREDDS Catalog
- Our dual redundant THREDDS systems have been merged under a single IP address which always points to an active server in a way that is transparent to the end users.
- Development of the CariCOOS Explorer data interface continues
- The upload of Mesonet-WeatherFlow meteorological data to the GTS system has received significant attention from our developers and should be fully implemented in the near future.
- CariCOOS maintains a presence in the National IOOS-DMAC and QARTOD communities through participation in monthly conference calls.

**2.3.2. *Operate and maintain existing CariCOOS data streams, data products and dissemination interfaces***

- Our web portal, data streams, data products and dissemination interfaces were operational during this reporting period
- New chlorophyll and Kd90 NASA Ocean Color products have been developed in-house and added to our portal and to our THREDDS



- Other tasks are ongoing:
  - CariCOOS has continued in-house processing of Mesonet-Weatherflow
  - Started in-house processing of WindNet meteorological data streams
  - CariCOOS provided products and support to the EcoExploratorio initiative
  - Upgraded Ocean Acidification Trends products are now available in our portal
- The CariCOOS Facebook page has been updated and its use as a dissemination tool is being augmented by our new generation of students and staff

### ***2.3.3. Development of iPhone smartphone apps***

- Significant progress has been achieved with the development of the CariCOOS IOOS iPhone app, which builds upon our Android app which was released early 2014.

### ***2.3.4. Operate, maintain and upgrade computational infrastructure***

- The CariCOOS computational infrastructure is operating in optimum conditions and most components are now fully redundant with duplicate servers running simultaneously at the CariCOOS office in UPRM's main campus in Mayaguez and in the CariCOOS Headquarters in Magueyes Island

### ***2.3.5. Develop new specific data products in response to stakeholder needs***

- A near real-time, fully THREDDS-based, regional meteorological data time series plotting system was developed by a CariCOOS summer intern and is currently undergoing testing and evaluation.
- Additional products are under development.

### ***2.3.6. Contracting consultant for upgrading of CariCOOS web pages***

- Proposals from four web development firms have been evaluated by CariCOOS personnel and the final decision will be made in December 2014. A formal contract will be signed early January 2015.

## **2.4. Outreach and Education Subsystem**

### ***2.4.1. Continue O&E formal and informal activities focused on enhancing awareness and appropriate utilization of CariCOOS products and services***

- The Caribbean Regional Association for Coastal Ocean Observing (CaRA) held a teachers workshop at the University of the Virgin Islands' Marine Science Center on September 13, 2014. The workshop was attended by teachers from various schools (both public and private) on the island of St. Thomas eager to learn more about CaRA/CariCOOS and its potential applications in the classroom setting. Teachers were able to access information about each data buoy currently deployed, observe real time data on wind/waves, as well as monitor coastal weather models.
- Several other talks have been offered to schools and institutions across Puerto Rico and the USVI

### ***2.4.2. Production and publication of You Tube user stories and data product guides***

- Two videos have already been finalized and one of these published (IOOS office has been duly notified). The second one is being readied for publication.

### ***2.4.3. Continued assessment of stakeholder/user needs***

- CariCOOS leadership and collaborators continue to engage and consult stakeholders via direct communication and participation/collaboration in/with organizations detailed below (2.4.6)

### ***2.4.4. Continue and enhance communication and consultation between CariCOOS, CaRA, regional programs, IOOS and IOOS Association***

- CariCOOS has been duly represented at all formal IOOS and IOOS Association activities and conferences.
- CariCOOS Executive Director Morell and Technical Director Canals attended the Director's meeting in Boulder Colorado.

**2.4.5. Provide support to CaRA membership and council and provide logistical and administrative support as required for accomplishment of their mission and meeting requirements for certification as a regional information coordination entity (RICE) as defined under the ICOOS Act.**

- The CaRA Stakeholder Council met on November 24, 2014. The agenda included a presentation by Xavier Torres from the Marichal, Hernandez Santiago & Juarbe Law firm. The Council agreed to recommend CaRA's incorporation as a nonprofit corporation consistent with of § 501(c)(3) of the United States Internal Revenue Code of 1986 (the "US Code") and §1101.01(a)(2) of the Puerto Rico Internal Revenue Code of 2011 (the "Puerto Rico Code"). Said recommendation will be presented to CaRA stakeholders in its upcoming General Assembly scheduled for March 20, 2015.

**2.4.6. Other education and outreach activities**

- Active participation in the following organizations
  - South Puerto Rico Harbor Safety and Security Committee
  - Puerto Rico Climate Change Council (lead team)
  - Jobos Bay National Estuarine Research Reserve (Advisory Board)
  - Sea Grant Puerto Rico (Advisory Board)
- Collaboration with the following organizations
  - NWS- San Juan WFO
  - PR Emergency Management and Disaster Administration Agency
  - Department of Natural and Environmental Resources Coastal Zone Management Program



## **2.5. Contractual**

- Special Appointments (employees) active during the reporting period include
  - Carlos Ortiz (field tech, diving operations)
  - Belitza Brocco (GIS and water quality)
  - José Rodriguez (cyber systems/computational resources)
  - Adolfo Gonzalez (web master)
  - Valentine Hensley (laboratory technician)
  - Yasmin Detrés (E&O Director)
  - Vanessa Gutierrez (Administrative Assistant)
  - Evelyn Guzmán (part-time administrative assistant)

## **2.6. Subawards**

- University of Maine's Physical Oceanography Group, led by N. Pettigrew Ph.D. continues to excel in providing support for CariCOOS data buoy maintenance and data management.
- The OA laboratory led by Joe Salisbury Ph.D. at University of New Hampshire has provided satisfactory support to the Ocean Acidification Monitoring Program.
- S. Leonardi PhD at U. of Texas, Dallas continues its leading participation in the development and validation of CariCOOS ROMS regional implementation. A visit from Leonardi's team is expected in early January.

## **2.7. Partner projects**

- IOOS Coastal and Ocean Modeling Testbed for Puerto Rico and the Virgin Islands (<http://testbed.sura.org/node/522>):
  - The Xbeach model was tested and adapted to the Tres Palmas, Rincon, offshore reef.
  - Material has been acquired for constructing stands for deploying HOBOS at some depth in sandy beaches, and the stands have been constructed
  - The software for using the HOBOS has been bought, and tested
- Sustained and Targeted Ocean Observations for Improving Atlantic Tropical Cyclone Intensity and Hurricane Seasonal Forecasts.:
  - The two SeaGliders deployed on July, 2014 as part of CariCOOS participation in the NOAA sponsored project "Sustained and Targeted Ocean Observations for Improving Tropical Cyclone Intensity and Hurricane Seasonal Forecasts" have been recovered after a 4 month deployment. Over a 1000 S&T profiles down to 1000 meters were collected by each of them during this period. Both AUV have been refurbished and are scheduled for deployment on February 2015.
- Model and data based hydrodynamic connectivity study for the marine protected area network off western Puerto Rico:
  - No progress yet, contract with the Caribbean Fishery Management Council to be signed in December 2015

### **3. Leadership Personnel and Organizational Structure**

- Former Associate Director Dr. Miguel Canals has been designated as the CariCOOS Technical Director by Executive Director Prof. Julio Morell to better reflect the nature of his duties.
- Y. Detrés, former CariCOOS Coordinator for Outreach and Education, has decided to pursue other academic interests and is no longer associated with CariCOOS. Her duties have been partially absorbed by new CariCOOS team member Dr. Sylvia Rodriguez (PhD in Ocean Engineering), a new Assistant Professor at the UPRM Department of Engineering Science and Materials. Dr. Rodriguez will also lead CariCOOS's Water Quality Modeling Efforts.

### **4. Budget**

No major modifications required.

#### **4.1. Personnel**

- No changes in personnel during the reporting period
- Hiring of the postdoc position has been delayed in order to wait for the delivery of the operational circulation model ROMS which will be improved and maintained by the postdoc.

#### **4.2. Subawards**

The following subawards have been formalized:

- U. Maine (N. Pettigrew), Data buoy maintenance and data management
- U. of Texas (S. Leonardi) CariCOOS ROMS implementation
- U. of New Hampshire (J. Salisbury) Ocean Acidification Monitoring Program

Subawards pending formalization:

- U. of the Virgin Islands (P. Jobsis), observations and O&E in the USVI
- U. of Rutgers (Hugh Hoarty), HF antenna loan, Technical support for HF Radar operations and deployments.

### **5. Issues**

No issues worth reporting for this performance period.