Progress Report

Advancing the Caribbean Regional Integrated

Coastal Ocean Observing System (CariCOOS)

1) Project Summary

CariCOOS has strived to meet prioritized stakeholder needs for coastal information with an efficient design minimizing observing assets while developing complementary modeling tools. This initial system has proved effective in providing wind, wave and current data products as well as simulations supporting forecasting for the Atlantic and Caribbean insular shelves. Through the present project we intend to complete the initial CariCOOS phase and develop the required observing, modeling and skill assessment assets and tools needed before proceeding on a shoreward extension of the CariCOOS product domains. Informational access to the nearcoastal regions will allow us to bring our services to specific shore dependent activities/sectors such as port and harbor operations, recreational activities and coastal resource management. Specifically we will focus on support to navigation safety and rapid response recovery in the most important regional ports, minimizing hazards to beachgoers and other recreational users, long term observing of climate change and ocean acidification, remediation, mitigation and adaptation to coastal hazards, data support for marine spatial planning and marine protected areas, and outreach and education to develop an "ocean literate" society. This project will continue support for the regional association in its mission including continued stakeholder engagement and representation and continuing CaRA's outreach and key alliances. We propose to undertake all steps necessary for certification of CaRA as a RICE as set forth in the Ocean Observing Act.

2) Progress and Accomplishments

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

- ***Recruit technical personnel***
  All technical personnel positions have been filled through contract renewals

- ***Contract subawards***

  Scopes of work documents for the upcoming program year have been requested from University of Maine, WeatherFlow Inc. and U. Virgin Islands. These will be reviewed and incorporated into subaward drafts for institutional review.

- ***Maintain existing data product availability and distribution***

  CariCOOS coastal buoy data has been successfully maintained, "pushed" to NDBC and made available to the community through CariCOOS data interfaces and web products. Mesonet data streams have also been operationally distributed through MADIS, WeatherFlow and CariCOOS data products and interfaces. Both data streams are available through the CariCOOS THREDDS server. Model output is discussed below.

  Data streams continue to be served through our CariCOOS web page. Additional features include facilitating access to the "top eight" most accessed products (as indicated by GOOGLE Analytics) by including button icon links to these.

- ***Convene and host CariCOOS DMAC subsystem review design and training meeting.***

  The DMAC consultation workshop originally planned for the 2011-2012 fiscal year has been moved to the 2012-2013 fiscal year to take advantage of the new server capabilities and ongoing changes. GCOOS and PacIOOS representatives will be invited.

- ***Commence enhancement of DMAC subsystem***

  CariCOOS DMAC action plan is being implemented in collaboration with Dr. Matt Howard of GCOOS. Initial activities include the improvement to our THREDDS server structure and content; SWAN model output and CariCOOS buoy data have been added; Weatherflow metocean observations will follow. Also, CariCOOS has acquired two mirroring data servers to provide responsive and secure data services, full deployment is expected to be finalized by September 2012. THREDDS services will be migrated to these new servers, to be physically located one each at Mayaguez and at Isla Magueyes, therefore assuring DMAC redundancy and continuity. ERDDAP and ftp download capabilities will be added to the new servers.

- ***Purchase a replacement ADCP and SBE37 instrument for coastal data buoys***

  One Nortek Aquadopp with Z-cell and 2 SBE37SM thermosalinographs were purchased. The SBE37SMs were installed aboard CariCOOS buoys and the existing ones were

removed for shipment to the manufacturer for calibration and revision. The Aquadopp is on hand pending launching of Data buoy E.

- ***Provide yearly maintenance to the existing CarICOOS coastal buoy array***

CariCOOS buoys A, B and C were removed from the water by contractor Commercial Divers, serviced by U of Maine Physical Oceanography Group and redeployed. CariCOOS buoy A, which had been inoperative since January 12 was diagnosed with a data logger software related malfunction; software was updated in all CariCOOS buoys.

- ***Deployment and operation of an additional CariCOOS coastal data buoy in Vieques Sound.***

Deployment of a CariCOOS data buoy in support of ferry and recreational operations in the Vieques Sound and Culebra region is pending finalization of formal stakeholder site consultation before proceeding with the required permitting process.

- ***Operate and maintain CariCOOS 1 Wave Buoy***

CariCOOS 1 Wave buoy has been operating continuously since deployment. Wave data are of the highest quality. Failure of the thermistor aboard this buoy is a minor drawback. Since replacement of this sensor would entail shipping the buoy to the manufacturer in Europe, and the data is not of the finest quality we are prepared to go without the temperature data at Rincon. We note that there are several other temperature sensors in the water around the islands including the high quality SBE37SM instruments aboard the data buoys. The buoy has been scheduled for maintenance and battery replacement in July, 2012.

- ***Operate and maintain 12 coastal weather MESONET stations and add 1 station***

The CariCOOS/WeatherFlow MESONET continues uninterrupted operation. The following mesonet related activities were implemented by WeatherFlow Inc:
  - • Repair San Juan NavAID
  - • Refurbish stations at Yabucoa-El Negro, Las Mareas, Guayama, PR
  - • Rebuild Savanna Island (US VI) with a redundant data-logging system
  - • As proposed, a new station was added at WICO dock, St. Thomas USVI in support of cruise ship operations.

- ***Validate SWAN, ADCIRC and WRF (wind) forecasting skills***

As reported, the CariCOOS SWAN wave model has been properly validated (Anselmi et al., 2012) and it is being run operationally and data distributed through CariCOOS THREDDS (http://dm1.caricoos.org/thredds/catalog/content/swan/catalog.html), data interfaces and graphical products (http://www.caricoos.org/drupal/node/164).

Given poor performance displayed by ADCIRC current model runs, three courses of action are being pursued:

1) Extension of ADCIRC computational grids to include the Western Tropical Atlantic and evaluation of performance response being carried out by former CaRA intern J. Gonzalez and J. Westerink at Notre Dame U.

2) Resumption of a subaward to L. Cherubin, U. Miami for the implementation of a regional HYCOM-ROMS GCM incorporating current, SST, Salinity and altimetry data assimilation schemes. Pre-operational HYCOM-ROMS exercises are currently run in CariCOOS computational facilities. Cherubin is providing training to CariCOOS personnel. Moreover, CariCOOS Co-PI S. Leonardi and sponsored students are implementing high resolution ROMS for San Juan and Charlotte Amalie harbors which will assimilate boundary conditions from the CariCOOS-HYCOM-ROMS regional output.

3) Securing access to the operational AMSEAS NCOM model provided by NAVO, US NAVY at 3 km resolution. Initial skill assessment indicates AMSEAS provides reasonably accurate temperature, salinity and current forecast for the outer shelves and deep waters in the region domain. Further validation will proceed as buoy, cruise and discrete data becomes available.

Wind model validation: An objective validation of data generated by GFS, NAM, and WRF-NWS models with data measured at meteorological stations in the region was undertaken and an internal report was produced by Co-PI Luis Aponte. Assessment of the relationship was conducted using linear regression, coefficient of determination, and coefficient of correlation. The study reveals that, for most of the weather stations assessed, the WRF model shows better agreements to the adjusted in-situ wind observations for both speed and direction. Recommendations arising from the study include CariCOOS implementation of WRF-NW in order to provide redundancy to the NWS implementation and its use for initialization of other CariCOOS modeling applications (i.e. SWAN) and use of the validation framework developed to optimize the WRF model for the CariCOOS region by running two WRF models using the NMM and the ARW cores and, once an optimum model is achieved, to be passed on to NWS.

- *Maintain WRF, ADCIRC, SWAN model output*

Addressed above and in previous report (Dec 2011)

- *Purchase and install sidescan for bathymetric data system aboard existing PWC platform.*

Sidescan-sonar purchased, installed and trial runs performed. The fully equipped PWC mounted aboard its beach-tire trailer was a highlight of the General Assembly.

- *Implement inshore high resolution SWAN and ADCIRC for San Juan & Charlotte Amalie*

CariCOOS co-investigator Stefano Leonardi is currently developing high resolution ROMS (ca. 100 m. resolution) domains for San Juan Bay and Charlotte Amalie Harbor. These

will utilize boundary conditions to be provided by the regional CariCOOS HYCOM ROMS implemented by L. Cherubin (U. Miami). Associate Director Miguel Canals is leading the implementation of the high-resolution San Juan and USVI domains and it is expected that these domains become operational in early August 2012.

- ***Implement water quality measurements including pH and optical properties***

Optical Properties
Five stations off the coast of southwest Puerto Rico (Guánica, La Parguera) were visited. In situ data were collected on a bi-weekly basis. Water samples were collected at approximately 1 m deep. Total suspended matter (TSM), corresponding to all material larger than 0.7 µm was determined by standard weight difference. Samples for chlorophyll a and colored dissolved organic matter were analyzed by fluorometry and spectrophotometry respectively.
Water column absorption, attenuation, and backscattering were measured using optics rosette mounted WetLabs AC-9 In-situ Spectrophotometer and Sequoia HydroLight instruments. Remote sensing reflectance was computed with measurements collected with the GER-1500 field spectroradiometer.

Ocean Acidification

Complementary chemical, physical, and meteorological measurements monitored within the La Parguera Marine Reserve are used to track the dynamics and controls on local carbon chemistry. A moored autonomous pCO_2 system (MapCO2) is deployed over the forereef of the Cayo Enrique shelf reef (17.95 N, -67.05 W) 1.6 km from the coast. Autonomous capability of the MapCO2 buoy provides continuous 3 hourly measurements of both air and dissolved CO_2 mole fraction along with temperature, salinity, and dissolved oxygen. The data are transmitted daily via Iridium satellite link for quality control at NOAA PMEL. These data are routinely merged with oceanographic and meteorological data available from the nearby ICON/CREWS station. These autonomous observations are validated and supplemented through discrete sampling. Bi-weekly surface water samples are collected at the MapCO2 buoy and 11 km offshore from the MapCO2. The offshore station (17.87 N, -67.02 W) is one mile from the shelf-edge at a depth of approximately 500 m. Profile measurements of chemical and physical parameters are continually taken using a SBE25® conductivity, temperature, and depth recorder (CTD). Seawater samples are collected using a Van Dorn type sampler bottle at approximately 3 m depth. The seawater samples are drawn from the sampler into 250 mL BOD flasks and stored at room temperature for analysis within 24 hours for total alkalinity and spectrophotometric pH.

- ***Implement CaTS occupations***

Occupation of the serial oceanographic station to the south of PR, the Caribbean time Series Station-CaTS was successfully occupied on one occasion. Further occupation has been impossible due to heavy weather. An attempt on May 17 resulted in near loss of sampling equipment.

- **Publish newsletters & brochures & handouts**

  Various brochures, posters and handouts were produced and distributed at meetings such as the Puerto Rico Harbor Safety & Security meetings, the General Assembly, the Modeling Workshop, and the NOAA SECART "NOAA in the Caribbean" meeting. CaRA/CariCOOS news items are regularly posted at http://cara.uprm.edu/?q=node/45. The CariCOOS banner is regularly posted in PR's nautical newspaper "La Regata" courtesy of the Editor and CaRA Council Member Benito Pinto.

- **Complete site-specific rip current and beach safety interpretive maps for the two beaches with highest incidence of drowning accidents.**

  A field validation study was conducted in April 2012 at Domes Beach in Rincon, PR to validate the BOUS22D wave model and develop a custom beach safety interpretive map, following the methodology developed at Jobos Beach (Lopez et al., in preparation). These beaches are the deadliest beaches in Puerto Rico for beachgoers and site-specific maps and warning signs will be delivered in July 2012 to UPR Sea Grant, who will coordinate installation with state agencies.

- **Co-host Sandwatch, Cajaya, PR weather camp, in-service teacher training**

  o Planning is well advanced for the PR Weather Camp for 24-30 June.
  o CariCOOS has also taken steps to co-host, with PR NASA Space Grant Consortium, a Summer Teacher's Workshop incorporating the CariCOOS Spanish language educational module entitled "Climas Costeros de Nuestras Islas".
  o CariCOOS has made arrangements to host US Coast Guard Auxiliary personnel at our Magueyes Island facilities to provide expertise in using CariCOOS web-based data and data products for their navigational instruction activities.

- **Convene Stakeholders Council and General Assembly**

  The CaRA 2012 General Assembly was convened on March 21 at the Hotel Villa Parguera in La Parguera. Ninety three attendants including Regional Association (RA) members, guests, CaRA officers and CaRA/CariCOOS personnel were welcomed. Eleven Council members attended. A strong delegation from the US Virgin Islands attended including four Council members and the Honorable Barbara Peterson Administrator of the Island of St. Thomas. Eight new signatories subscribed to the CaRA MOA and were welcomed to the Association. Agenda, draft minutes, attendance list and a photo gallery of the meeting can be found at http://cara.uprm.edu/?q=node/5.

- **Convene CI-FLOW Workshop**

  Responding to intense community interest, with the participation of the IOOS office, and in lieu of, but in the spirit of the proposed "CI-FLOW" workshop, CariCOOS convened a "CariCOOS Workshop on Testbeds and Simulation of Hurricane Wave, Surge, and Rainfall Runoff Events for Puerto Rico" March 29 and 30, 2012. A "Whitepaper on the establishment of an islands wave, surge and hydrologic testbed based on Puerto Rico

and the U.S. Virgin Islands" proposing a detailed plan of action is being drafted as output of this workshop.

3) Scope of Work

Major activities scheduled for the upcoming reporting period, besides finalization of unattained milestones as described above and continuation of system maintenance and operation and data/product delivery include: **A)** completing the redesign and full implementation of a CariCOOS DMAC system **B)** the deployment of an additional buoy in Vieques Sound in support of recreational and ferry operations **C)** Continuation of CariCOOS O&E program including co-hosting Puerto Rico Weather Camp in July 2012 (NOAA-NCAS) and Sea Grant Cajaya 2012 summer camps as well as attendance at Harbor Safety and Security Committee meetings. **D)** Continued development of regional and high resolution (harbor) HYCOM-ROMS model implementations including forecast skill assessments and required observational efforts, development of end user applications, such as particle tracking and operational deployment of the model(s) in redundant systems. **D)** Continued web page development and optimization.

4) Leadership Personnel and Organizational Structure
No changes in leadership personnel or organizational structure have occurred.

5) Budget Analysis:

Total costs budgeted for program year 1, not including indirect cost, totaled $1, 204,673.
Funds expended or encumbered during this program year totaled: $883,748. As previously reported, a significant fraction of the remaining balance corresponds to salaries due to the temporal offset between the closure of the previous award and commencement of the one here addressed.

6) Issues

- We have maintained one data buoy in storage as a spare but this has proved unnecessary. Given the need for "in situ" marine weather data off the east coast of Puerto Rico, a sub-region with intense recreational as well as passenger and cargo ferry operations, we commenced consultations for identifying a site for locating our former "spare" buoy. These however have not been finalized. We have therefore rescheduled the preliminary Vieques Sound deployment date to fall 2012.