



CARICOOS

CARIBBEAN COASTAL OCEAN OBSERVING SYSTEM INC

THE CARIBBEAN COASTAL OCEAN OBSERVING SYSTEM (CARICOOS): A RESPONSIVE STAKEHOLDER-DRIVEN OBSERVING SYSTEM ADDRESSING REGIONAL AND NATIONAL NEEDS IN THE US CARIBBEAN

REVISED SCOPE OF WORK FOR FY21

Covered Period:

Total Federal Funding for FY20: \$ 2,587,784

Award number: NA21NOS0120089

Recipient Institution: Caribbean Coastal Ocean Observing System Inc.

Principal Investigator: Julio M. Morell, julio.morell@upr.edu

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Program Office: NOS Integrated Ocean Observing System (IOOS)

Total Award Period: July 1, 2021 to June 30, 2022

Project Web Site: <http://www.caricoos.org>

The following Revised Work Plan for FY 2021 corresponds to Special Award Condition 2 for Award Number: NA21NOS0120089 to the Caribbean Coastal Ocean Observing System Inc. for efforts in the proposal entitled “A Responsive Stakeholder-Driven Observing System Addressing Regional and National Needs in the US Caribbean”.

1 PROJECT SUMMARY

Consistent with US IOOS’s mission, CARICOOS efforts have been focused on providing high-priority coastal ocean data and information to meet stakeholder’s needs in the US Caribbean Archipelago, as well as organizational requirements and RICE certification criteria. The workplan below will support the continued operation of all CARICOOS subsystems (Observational, Forecast-Modeling, Data Management and Cyberinfrastructure, and Outreach and Education) during FY 2021 and the continued delivery of all data products and services currently available to CARICOOS stakeholders. Moreover, funding will also provide for a limited, yet significant enhancement of said products and services.

Enhancements pertinent to the commercial and recreational maritime sectors, as well as entities responsible for rapid response operations, include the addition of one (1) High Frequency Radar (HFR) to the existing network, which will improve surface current data coverage along the Puerto Rico-US Virgin Islands sea-lane (a US Coast Guard priority). Allotted resources will also allow for improvements to our sea state and coastal circulation forecasting capabilities, and the development of a tool to provide navigational support in ports and approaches. Initiatives proposed towards mitigating coastal hazards include improvement of the beach breaker forecast, expansion of the beach pathogen efforts and implementation of a camera-based monitoring project for assessing beach morphology evolution.

Additions pertinent to the climate variability and coastal weather sector include the deployment and operation of an additional mesonet station, as requested by the NWS-WFO San Juan; the operation of underwater gliders in support of hurricane intensity forecasting, in collaboration with NOAA-AOML; and the resumption of upper ocean observations at the Caribbean Time Series Station by means of a CARICOOS SeaGlider.

CARICOOS stakeholders have expressed the need for information in support of management decisions and measures for safeguarding the multiple services coastal ecosystems provide to the region. Required information includes an assessment of their status and identification of threats (i.e. extreme climate events, chronic anthropogenic disturbances, and emergent issues such as Sargasso inundation). Responding to the above, CARICOOS will commence a regional effort, focused on coastal barrier/ecosystems (reefs, seagrasses, mangroves/wetlands and beach dunes), to fulfill the above needs through the integration of new and existing data and products (i.e. OBIS/MBON coral reef monitoring, remotely sensed turbidity, ocean acidification/hypoxia, Sargasso biomass accumulation, hydrodynamics). In addition, we propose a data analysis effort in collaboration with the Caribbean Fisheries Management Council, for assessing the relationship between sea state and fisheries yield using existing fisheries and sea-state model data. As customary, the above data and information will be managed following DMAC requirements and made available to stakeholders in accessible user-friendly data products and digital platforms CARICOOS.org, CROP.CARICOOS.org, CARICOOS mobile applications ([Pa’ la Playa BEACH APP](#) and [CARICOOS BOATING APP](#)).

2 CONNECTIONS TO USERS/STAKEHOLDERS AND BENEFITS

CARICOOS is, by design, an open and inclusive organization approachable and trusted by stakeholder sectors who understand its mission. Said character has become further ingrained

throughout its development, assuring our mutual accessibility and efficient information exchange with our clientele and partners.

Attuned with its standing as a fully certified Regional Information Coordination Entity, CARICOOS will sustain an organizational and administrative structure led by its Board of Directors (BOD). [CARICOOS' BOD](#) includes representatives active in maritime operations, fisheries management, meteorology, coastal zone management, recreational boating affairs, oceanography/academy, coastal hazards, and coastal and marine affairs. CARICOOS' Technical Leadership (CTL), including PIs and subsystem leads, will continue to provide expertise in coastal/ocean engineering and oceanography and are participants in pertinent regional organizations including the Caribbean Regional Response Team, PR Harbor Safety and Security Committee, Jobos Bay NERRS Scientific Advisory Committee, PR Sea Grant Technical Advisory Committee, PR Climate Change Council, USDA-NRCS Technical Committee, and the Board of Advisors of the Ocean Foundation. Additionally, CTL's members are in close communication/collaboration with the National Weather Service (NWS) Weather Forecasting Office-San Juan (WFO-SJ), EPA, USCG Incident Management Division, PR Emergency Management and Disaster Administration, among others.

In collaboration with the education and outreach subsystem, CARICOOS will continue to gather and prioritize stakeholder needs and carefully match them with the capabilities and resources of the CARICOOS enterprise, to continue operating, optimizing, and expanding a cost-effective ocean observing system for the US Caribbean. The CLT will continue to evaluate satisfactory progress towards annual milestones and, in consultation with its BOD, prioritize the work plan and milestones to be achieved. End-of-year reporting will help assess success in achieving yearly milestones.

3 CARICOOS FOCUS AREAS: GOALS, OBJECTIVES & WORKPLANS

This work plan describes our approach at sustaining CARICOOS' existing capabilities, while also filling informational gaps identified through need assessment efforts and originally proposed under a Tier 1 funding scenario. This section is structured around focus areas. For each area, the objectives, technical approach, and product development are described.

3.1 Support safe and efficient maritime operations

CARICOOS will continue to provide coastal ocean information and augment decision-support tools to enhance safety and efficiency of the full range of maritime operations taking place in the region. In a continued effort to prioritize the US Coast Guard and Harbor Pilots information needs for reducing maritime hazards/risks and supporting rapid response operations (SAR, spills), funds will be invested towards deploying an additional HFR SeaSonde system in Arecibo, Puerto Rico, thus expanding surface current availability along the north coast. Data coverage from this proposed site will overlap with the neighboring HFR site located at the Club de Pesca Recreativa in Toa Baja, Puerto Rico, which is anticipated to be in operation by the end of 2021 (NEPA documentation for this station is here enclosed the). CARICOOS is currently conducting

the pertinent tests for identifying an optimal location in Fajardo, on the northeastern end of Puerto Rico, for the HFR system pending deployment. The installation and operation of these three HFR systems will allow for coverage of the Puerto Rico-US Virgin Islands sea lane, as well as the north coast of Puerto Rico (Figure 1). The deployment timeline is dependent on permitting requirements and property owner approval. Surface current availability for this region would allow for regional model validations, where data is currently scarce, as well as assimilation into hydrodynamic circulation models. In terms of operational forecasting, CARICOOS will continue to enhance the CARICOOS Nearshore Wave Model (CNWN), a SWAN-based operational wave modeling system, the CARICOOS Operational Wind Model (COWM) based on the Weather Research Forecast (WRF) numerical weather prediction system, and the CARICOOS Coastal Circulation Model (CCCM), a high-resolution implementation of the Finite Volume Coastal Ocean Model (FVCOM), to provide more reliable sea state predictions in coastal areas of the US Caribbean. The CNWN will be transitioned to a hybrid structured-unstructured (SWAN-PUNSWAN) mesh version by the end of Year 1 eliminating the need for nested grids and significantly improving the nearshore spatial resolution (up to 20 meters). The COWN will be optimized to better resolve the synoptic-, meso- and local-scale processes for a better weather prediction on the coastal areas. The CCCM will be expanded to generate high-resolution domains (from 100 m to 1 m) to resolve complex features near the coast, harbors, and ports and to develop port-specific products and decision support tools. These improvements will positively impact all existing CARICOOS decision-support tools.

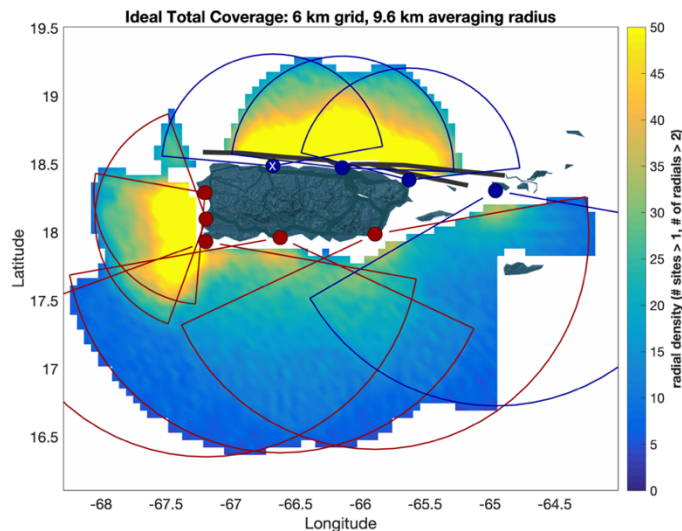


Figure 1. Anticipated CARICOOS HFR network status with the additional site in Arecibo, PR (white "X"). The site locations in blue indicate the additional installations expected to be operational prior to Arecibo. The red sites are currently in operation.

3.2 Support the effective management of coastal living resources

CARICOOS stakeholders including resource managers, NGOs and scientists have expressed concerns on the state of coastal ecosystems after decades of anthropogenic disturbances, ocean warming, recent extreme hurricane and swell events and emergent threats posed by ocean acidification (OA), Sargassum inundation and coral disease outbreaks. CARICOOS will commence an effort to assess the ecosystem health status/trends and threats to coral reefs in the region utilizing data from the regional and national coral monitoring programs recently made available in OBIS format with IOOS-MBON support. Analogous analysis for mangroves and sand dunes will be based on available historical imagery and drone-based observations to be collected in this program year. Trends in diagnostic parameters such as area-coverage, species abundance and diversity will be integrated into data products also depicting historic and recent data on sea surface temperature, wave energy, suspended sediments concentration, and OA levels, where available. Besides the existing study site at La Parguera, Jobos Bay National Estuarine Research Reserve will also be monitored for Sargasso loading, hypoxia, acidification, zooplankton diversity and related water quality parameters. CARICOOS also seeks to enhance its observing asset network by equipping all CARICOOS moored oceanographic data buoys with

inductive modems/cables for acquisition and data transmission of near bottom temperature and salinity data, as well as data from biochemical sensors to be deployed in the future (not funded under this initiative).

3.3 Minimize impact from coastal hazards

In a continued effort to support coastal hazard prevention, preparedness, mitigation, and adaptation, CARICOOS will continue enhancing its ocean-monitoring capabilities of providing accurate coastal information and decision-support products. The Nearshore Breaker Model (NBM), which currently provides breaker forecasts for almost 140 beaches in PR/USVI, will be improved with the new unstructured SWAN model, and will continue to provide 5-day forecasts for the Pa' la Playa Beach App and for the NWS SJ WFO-operational Surf Zone Forecast. Wave modeling efforts will also be enhanced through partner initiatives. CARICOOS will continue to collaborate with DOE's National Renewable Energy Lab (NREL) by providing technical support services for the [Datawell Waverider buoy deployed off the coast of Arecibo](#), Puerto Rico. Buoy observations will be used not only to provide wave conditions, but to measure wave energy density in coastal ocean waters and to validate high-resolution numerical wave models, thereby aiding the engineering, design, and optimization of economical wave energy conversion devices. An ongoing [collaboration between CARICOOS and the USGS](#) seeks to better understand how waves propagate across coral reefs and cause coastal flooding along tropical shorelines using XBEACH and SWASH phase-resolving wave models. This effort will eventually help improve the breaking wave height predictions used in the NBM.

Recently developed [beach water quality products](#), including interactive historical data plots, beach ratings, and nowcasts, will be maintained and enhanced during the upcoming year. CARICOOS will expand beach water quality monitoring efforts by supporting community-driven initiatives, Surfrider's Blue Water Task Force (BWTF) and other local NGOs. Two satellite water quality laboratories will be established in the northwest and northeast coast of PR. Furthermore, CARICOOS will implement remotely sensed video data to monitor shoreline changes at erosion-prone beaches in PR. The system will also provide data and support for other pertinent issues such as beachgoer safety, storm damage assessment, and beach water quality.

3.4 Monitor climate variability

Understanding and monitoring climate variability requires a scale-sensitive observing system. Although our understanding of climate and weather mechanisms that initiate responses is improving, there are still numerous knowledge gaps. Our goal is to continue gathering, analyzing, and assessing data pertinent to climate-related trends and impacts, in order to assess and document climate trends and variations in ocean properties pertinent to regional climate expressions. To support such goal, CARICOOS will:

- Continue to collaborate with NOAA-AOML/RSMSS and US NAVY in a NOAA-OAR funded collaborative project (Chardón-Maldonado and Morell, Co-PIs) entitled "CARICOOS Support for 2020-2021 Hurricane Glider Operation in NE Caribbean" focused on enhancing ongoing hurricane glider efforts by operating a network of underwater gliders in the Caribbean Sea and tropical Atlantic Ocean. These will carry out upper ocean observations of temperature and salinity in support of hurricane intensity (intensification and weakening) operational forecasts. The CARICOOS underwater glider, acquired under the 2020 Fill the Gaps initiative, will conduct seasonal profiles at the Caribbean Time Series station (CaTS) and target sub- and mesoscale structures including eddies, continental river plumes and marine heat waves. Underwater glider data will also serve for documenting the response of the oceanic environment to regional (i.e., eddies, sea

temperature/salinity trends, continental riverine influence) and far-field climate forcing (ENSO, NAO). Fund allotted for glider operations will support boat time for the deployment and retrieval of 1 CARICOOS and 4 AOML gliders and technical personnel for piloting the CARICOOS glider during the hurricane season and the time-series occupation of the CaTS station.

- Install a new meteorological station in the central mountainous range of Puerto Rico, as requested by WFO-SJ, to better understand orographic effects on small-scale convective processes impacting sea state and improve local weather forecasts.
- Continue to provide stakeholders with long-term sustained observations to track ocean, weather, and marine ecosystem changes. Disseminate the results from climate-related assessments and comprehensive studies (i.e., Puerto Rico's State of the Climate - Puerto Rico Climate Change Council). In addition, CARICOOS will initiate a comprehensive analysis of existing data for a wide range of ocean and weather variables (i.e. waves, winds, salinity, temperature, precipitation) to explore the role of climate variability in ocean conditions, regional weather patterns, coastal marine ecosystems, fisheries, among others. This assessment will be performed using the data from CARICOOS observational assets, water sample analysis, numerical models, and satellite-based virtual buoys.

3.5 Data Management and Cyberinfrastructure

The CARICOOS DMAC subsystem, fully integrated into the IOOS-DMAC Service Oriented Architecture (SOA) and operating as the regional Data Assembly Center (DAC), will continue to support the operation and maintenance of various subsystem components. DMAC will continue to openly serve regional data through webpage *Data Download* interfaces, webpage products, dual THREDDS/OPeNDAPP servers, and the ERDDAP interface. Taking into consideration the different local challenges and stakeholder needs, DMAC will seek to maintain and augment the use of cloud computing resources thus assuring a timely flow and archival of data and products. In addition, DMAC will:

- Develop and improve user-friendly tools for data browsing and discovery, and effective core products.
- Maintain long time series of data, develop consistent data quality protocols, synthesize new and existing data streams, and make data accessible.
- Maintain and monitor our convenient and user-friendly bilingual [data portal](#) and mobile applications ([Pa' la Playa BEACH APP](#) and [CARICOOS BOATING APP](#)).
- Maintain and enhance the high-performance computing (HPC) infrastructure for existing and proposed CARICOOS numerical modeling, data analyses, data products, and data management systems.
- Expand and manage marine ecosystems and biological datasets of interest to our stakeholders and provide regional expertise regarding OBIS (Ocean Biogeographic Information System), MBON (Marine Biodiversity Observation Network) and derived applications.
- Support biology-focused contributions to Caribbean regional engagement with IOCARIBE (UNESCO IOC Sub-Commission for the Caribbean and Adjacent Regions) and MBON.

4 STAKEHOLDER ENGAGEMENT AND PRODUCT AWARENESS

Product Awareness. CARICOOS recognizes that a key component for a successful user-driven observing system lies in the effective engagement of target communities in the management and operation of the program. CARICOOS strives for data accessibility to our users through our data portal and mobile applications, which will be continuously maintained and further developed in consultation with stakeholders. Additionally, CARICOOS will continue to operate its network of tablets and TVs at strategic locations (e.g., yacht clubs and beach convenience stores) to promote boater safety and increase product awareness. CARICOOS will continue its active presence on social media to keep users informed about current conditions, new products, and asset status. Issuance of quarterly newsletters and the [CARICOOS NEWS](#) website will also be continued, with the purpose of attracting engaging and informing new and current on pertinent news, activities and additional products.

To ensure an accurate data interpretation, CARICOOS will continue to host general and targeted training workshops for stakeholders and local authorities, from teachers to emergency management agencies, and participate in recreational ocean-related activities (e.g., surfing and fishing tournaments, beach cleanups, etc.) and radio/tv shows.

Education. CARICOOS will continue to operate and update its outreach and education webpage ([CARICOOS SCHOOL](#)), procure an active presence in partnering educational efforts, and develop and maintain its own K12 initiatives. Educational modules, podcasts training videos, and webinars will also be accessible through this site. To better serve linguistic minorities in the region, all video materials will be translated and/or subtitled and edited with sign language interpreters.

Capacity Building, Diversity & Inclusion. CARICOOS is committed to provide opportunities for capacity building within the region, while also promoting diversity and inclusion at the regional and national level. CARICOOS main pools of student talent, the U. of Puerto Rico and U. of Virgin Islands, are Minority Serving Institutions whose population has been historically underrepresented in ocean observing and ocean sciences in general. CARICOOS will continue to support a critical mass of outstanding regional students whose research work becomes essential parts of CARICOOS' products and services. Likewise, we will continue to foster higher education and unique research opportunities through our summer internship program. A Vembu Subramanian Ocean scholarship will be assigned through the subrecipient OCOVI. The scholarship will provide the successful applicant(s) from the USVI (graduate student, or early career professional) with vital support to be involved in activities where they can learn about advanced technology, data collection and analysis, field work, and coastal ocean processes.

5 SYSTEM ENHANCEMENTS THROUGH TARGETED FUNDING

5.1 Regional Ocean Partnership (ROP)

The ROP Data Sharing Initiative seeks to enhance the capacity to share and integrate Federal and non-Federal sources of data to support coastal and ocean management priorities in the Caribbean region. This initiative will continue to strengthen and expand CARICOOS services while providing high-priority data and products to coastal managers and stakeholders. Following this year's workplan CARICOOS will continue assessing needs of coastal managers and key stakeholders in order to identify and prioritize data needs and challenges in the region. Aiming to increase usability of geospatial data products, workshops and webinars will be hosted to train stakeholders on how to access the [Caribbean Regional Ocean Partnership \(CROP\) web portal](#).

In addition, CARICOOS will continue to maintain, develop, and publish data products and tools, with emphasis on spatial mapping tools, including:

- The **Coastal Weather Variability & Hydrodynamic / Ocean Energy atlas**, a user-friendly tool to analyze 40-year (1979-2019) high-resolution weather and hydrodynamic climatology for Puerto Rico and the US Virgin Islands.
- The system of **satellite-based virtual buoys to assess water quality** in coastal Puerto Rico and the US Virgin Islands. This project is led by Dr. Brian Barnes and Dr. Chuanmin Hu through a subaward to the University of South Florida (project details are included in the USF subaward documents).
- The **assessment of status, challenges, and management needs of coastal barriers/ecosystem** (reefs, seagrasses, mangroves/wetlands and beach dunes). This tool will provide a starting point for coastal managers and other stakeholders seeking to explore “at a glance” the status of coastal barriers and ecosystems in the US Caribbean region.
- A Pilot Project for the **Development of a Sargasso Inundation Forecast for Puerto Rico and the USVI**: will assess the feasibility of developing an operational prediction system for coastal Sargassum inundation in Puerto Rico. This project will be led by Dr. Beron-Vera and Dr. Olascoaga.
- The development of the **Sargasso dashboard**, a web interface that will provide, as a starting point, Sargassum inundation forecast, the Sargasso Outlook Bulletin from Dr. C. Hu at USF, the Weekly Sargassum Inundation Report from NOAA-AOML, plots reporting Sargassum biomass loading rates, pH, and dissolved oxygen at pilot stations for Sargassum impact assessment, and satellite imagery depicting Sargassum aggregations.

5.2 Ocean Acidification

The MapCO₂ buoy, located within a coastal marine reserve off the southwest coast of Puerto Rico and part of the National Ocean Acidification Observing Network (NOA-ON), originated in 2008 as the Atlantic Ocean Acidification Testbed (AOAT) for assessing the impacts of ocean acidification (OA) on Caribbean coral reef ecosystems. Autonomous and discrete measurements at this station provide insights on the role of physical and biological processes that modulate surface seawater carbon chemistry and how ecosystem metabolism modulate seawater carbonate parameters at various time scales. Acknowledging the importance of this effort, CARICOOS will continue to provide support for the operation of the MapCO₂ buoy and related discrete bi-weekly water sampling/analysis at La Parguera Marine Reserve with funding from NOAA's NOA-ON. This effort will be paralleled by a CARICOOS regional assessment of dissolved and particulate carbon fluxes required for proper interpretation of MapCO₂ buoy/discrete water sample data.

6 PARTNER PROJECTS

CARICOOS will continue to collaborate and provide support to several projects that share CARICOOS's goals of sustaining coastal ocean observations, as well as conducting fundamental and applied research to better understand coastal systems and enhance the resilience of coastal environments in the US Caribbean. A summary of each effort is provided below:

1. **Puerto Rico Department of Natural Resources**: through a contract with the Puerto Rico Department of Natural Resources, CARICOOS will collaborate in the management of the

Puerto Rico Climate Change Council (PRCCC) activities and in the creation of a digital beach atlas within the PRCCC web portal using data inputs from the Pa' la Playa Beach App.

2. **CARICOOS Support for 2020-2022 Hurricane Glider Operation in NE Caribbean:** funded by OAR and led by Co-PI Patricia Chardón-Maldonado and NOAA-AOML this project seeks to enhance current glider efforts by operating a network of underwater gliders in the Caribbean Sea and tropical Atlantic Ocean to provide real-time physical data. Gliders lines will be occupied yearly from the onset to the end of the 2021 and 2022 hurricane season. Together with NOAA/AOML, CARICOOS will coordinate and execute the glider deployments and recoveries, including emergency recoveries and backup piloting.
3. **Development of Techniques for Tropical Seaweed Cultivation and Harvesting:** funded by DE-FOA-0001726 MARINER program funded through a subaward to CARICOOS PI Julio Morell. CARICOOS will collaborate in providing hydrodynamic and numerical model data for the seaweed culture area. Experimental observations of nutrient uptake dynamics when coupled with hydrodynamics should provide for understanding algae requirements and growth limitations in the study site.
4. **A wave modeling test bed for Puerto Rico:** funded by USGS and led by CARICOOS Co-PI Miguel Canals. CARICOOS is collaborating with the USGS on an effort to provide real-time and scenario-based estimates of potential coastal flooding, beach and dune erosion and dune overtopping in Puerto Rico.
5. **Oceanographic Pathways and Hydrodynamic Connectivity Between Marine Protected Areas in the US Virgin Islands and Eastern Puerto Rico:** CARICOOS will continue collaborating on this project led by CARICOOS co-PI Miguel Canals and funded by the Caribbean Fishery Management Council that will build on the CARICOOS FVCOM model to examine hydrodynamic connectivity between Marine Protected Areas in Eastern PR/USVI.
6. **Development of the Puerto Rico Digital Ocean Energy Atlas: Unlocking Puerto Rico's Marine Renewable Energy Potential:** funded by the Puerto Rico Science and Technology Research Trust (PRSTRT) and led by CARICOOS co-PI Miguel Canals. This project will use computational fluid dynamics to rigorously analyze, for the first time, the wave energy, ocean current, and geothermal (OTEC) resource availability for Puerto Rico, as well as its inter-annual variability. The results of this atlas will be disseminated to CARICOOS stakeholders through the CARICOOS ROP effort.
7. **Scalar Transport across the Sediment-Water Interface:** NSF CAREER award to CARICOOS Co-PI Sylvia Rodriguez-Abudo. This project seeks to advance fundamental knowledge on the transport mechanisms governing seawater/porewater exchanges to better predict mass transport in coastal benthic boundary layers including contaminants, nutrients, and biogeochemical processes.
8. **Experimental and Numerical Investigation of Grain Shape Effects on Littoral Sediment Dynamics:** funded by the DoD and led by CARICOOS co-PI Sylvia Rodriguez-Abudo this project seeks to improve predictions of irregularly shaped sediment dynamics in the littoral zone while advancing the representation of women and minorities in the fields of coastal engineering and littoral geosciences.
9. **Strengthen Resilience from Extreme Weather through Ecological Restoration of Sand Dunes (PR):** funded by NFWF and led by Dr. Robert Mayer (UPRAg) and CARICOOS Co-PI

Patricia Chardón-Maldonado. CARICOOS is providing observations and model data, as well as expertise, for decision-making processes in the installation of sand-trapping devices and wooden boardwalks to promote accumulation of sand and increase the resiliency of coastal communities to environmental stressors.

- 10. Early Warning of Synoptic Air Quality Events to Improve Health and Well Being in the Greater Caribbean Region:** CARICOOS will collaborate with Dr. Pablo Méndez Lázaro from the Medical Sciences Campus at the University of Puerto Rico on a project funded by NASA that seeks to develop an early warning system about the synoptic air quality events. CARICOOS is providing observations and model data, as well as the platform to communicate and deliver the acquired observations.

7 SYNERGISTIC ACTIVITIES AND SERVICES

As part of our mission of providing unquestionably high-priority decision supporting information for enhancing safety in our coasts and ocean, improving efficiency of maritime operations and supporting coastal resource management, CARICOOS PIs and Co-PIs participate in the following activities that serve to advance research, education and management efforts in the US Caribbean:

- Local and national newspaper articles and TV interviews regarding beach safety, underwater gliders, climate conditions and weather patterns, coastal and marine resources, among other topics.
- IOOS Federal Advisory Committee
Morell
- The United Nations Decade of Ocean Science for Sustainable Development – Western Tropical Atlantic Regional Planning Group
Morell
- Member of the United Nations Decade of Ocean Science for Sustainable Development – Western Tropical Americas Safe Ocean Working Group
Chardón-Maldonado
- Partner of the CARIB-COAST project
- Authors for the Puerto Rico’s State of the Climate - Puerto Rico Climate Change Council
Morell & Chardón-Maldonado
- Authors for the US Caribbean chapter of the Fifth National Climate Assessment (NCA5)
Chardón-Maldonado & Canals
- Members of the Puerto Rico Climate Change Council (PRCCC)
Morell, Chardón-Maldonado, Rodríguez-Abudo & Canals
- Member of the Underwater Glider User Group (UG2) Steering Committee
Chardón-Maldonado
- Members of the Puerto Rico South Harbor Safety and Security Committee
Morell & Chardón-Maldonado
- Community Based Participatory Research – “Salud para Piñones” and Coastal Conversation and Ecological Restoration with Vida Marina
Chardón-Maldonado

- Coordinator UPRM Research Academy, Member of UPRM Research Committee, and Coordinator of UPRM’s National Graduate Fellowships Workshop Series
Rodríguez- Abudo

8 MILESTONES

PROJECT/INITIATIVE/ITEM	1	2	3	4	EXPECTED COMPLETION DATE
SUPPORT SAFE AND EFFICIENT MARITIME OPERATIONS					
Continue to improve CARICOOS suite of wave, wind, and circulation models to facilitate decision-making by the maritime sector.					Continuous
Continue dissemination of sea state data and data products					Continuous
Develop port-specific products and decision-support tools for the Port of Charlotte Amalie, St. Thomas					June 2022
Continue operation of the Yabucoa Port Metocean observation and prediction system					Continuous
Operate the CARICOOS oceanographic data buoys network					Continuous
Operate the CARICOOS / NREL wave data buoys (Rincón and Arecibo)					Continuous
Operate the CARICOOS HFR network					Continuous
Yearly maintenance of the CARICOOS oceanographic data buoys					June 2022
Yearly maintenance of the CARICOOS wave data buoys (Rincón and Arecibo)					June 2022
Quarterly inspection and maintenance of the CARICOOS HFR stations					June 2022
Install inductive modems on CARICOOS oceanographic data buoy mooring system					June 2022
HFR network expansion: Puerto Rico – US Virgin Islands sea lane (Procurement and Siting)					June 2022
HFR network expansion: North coast of PR					June 2022
MINIMIZE IMPACT FROM COASTAL HAZARDS					
Implement hybrid SWAN-PUNSWAN into CNWM					June 2022
Annual update of PR/USVI Wave Climate Atlas					June 2022
Beach water quality monitoring					Continuous
Maintain and enhance the CNWM, NBM, WRF (1km & 2km), and FVCOM models					Continuous
Maintenance of beach water quality nowcasts					Continuous
Implementing/validating Sargasso beaching forecast					June 2022
SUPPORT THE EFFECTIVE MANAGEMENT OF COASTAL LIVING RESOURCES					
Deploy nearshore eco sensor ensembles for assessing threats to ecosystem (i.e. Sargasso)					June 2022

Operate La Parguera Map CO ₂ buoy and provide data dissemination					Continuous
Bi-weekly carbonate chemistry sampling					Continuous
Yearly maintenance of the La Parguera MapCO ₂ buoy					December 2021
Sargassum biomass and impact monitoring program (OA, hypoxia, zooplankton biodiversity) in pilot project sites in Puerto Rico and US Virgin Islands					Continuous
Develop the satellite-based water quality virtual buoys webpage within the CARICOOS domain					March 2022
MONITOR CLIMATE VARIABILITY					
Retrieval of AOML and CARICOOS hurricane underwater gliders					November 2021
Refurbishment and deployment of AOML and CARICOOS hurricane underwater gliders					June 2022
Seasonal glider deployments in the NE Caribbean					Continuous
Initiate comprehensive analysis of a wide range of ocean and weather variables to explore the role of climate variability in ocean conditions, regional weather patterns, coastal marine ecosystems, fisheries, among others.					June 2022
CARIBBEAN REGIONAL OCEAN PARTNERSHIP					
Coastal Weather Variability & Hydrodynamic Atlas website					June 2022
Sargasso dashboard web interface					February 2022
Coastal Barriers and Ecosystem web site to explore “at a glance” the status of US Caribbean region coastal barriers and ecosystems					June 2022
Host general and targeted training workshops for local authorities and decision makers to present and teach how to use the products in the CROP portal.					June 2022
DATA MANAGEMENT AND CYBERINFRASTRUCTURE					
Compliance with IOOS DMAC metadata, file and data discovery standards and checks					Continuous
Continue CARICOOS DMAC and Regional DAC efforts as detailed in the RICE DMS Plan					Continuous
Continue operating DMAC computational and HPC infrastructure (including cloud S3 & EC2)					Continuous
NCEI-compliant historic data archival					Continuous
Maintain and enhance web portal and mobile apps					Continuous
Continue to develop port-specific web tools in response to stakeholders					Continuous
Continue expanding the regional MBON database					Continuous
Technical transfer to in-house IT, improvement and debugging of our web page					Continuous
Support biology-focused contributions to Caribbean regional engagement with IOCARIBE and MBON					June 2022
OUTREACH AND EDUCATION					

Host training workshops, webinars and podcasts					Continuous
Host the CARICOOS summer internship program					June 2022
Produce short video and Public Service Campaign					June 2022
Issue communications via newsletters, social media, CARICOOS NEWS and CARICOOS School					Continuous
Stakeholder engagement throughout the region					Continuous
Conduct Board of Directors meetings					June 2022
Host CARICOOS Annual General Assembly					February 2022
Continue to procure an active presence in pertinent forums, such as Harbor Safety & Security Committees, PR Climate Change Council, UPR Sea Grant Advisory Board, JBNERRs Research Advisory Board. Continue working meetings with key governmental agencies including US Coast Guard, WFO-San Juan, PR CZM office, among others.					Continuous
Consult stakeholders via direct/virtual communication and interaction at CARICOOS General Assembly meeting and at sector focused meetings					Continuous
Participate in recreational ocean-related activities to promote safety through the use of CARICOOS product and services					Continuous
Continue O&E formal and informal activities focused on enhancing awareness and appropriate utilization of CARICOOS products and services					Continuous

BUDGET NARRATIVE

Budget subtotals are provided below in SF-424A format, with a detailed budget justification for each category. The following narrative indicates the costs to be incurred to carry out the activities proposed for the first year of the five-year funding cycle.

Categories	Amount
A. Personnel	\$244,650.00
B. Fringe Benefits	\$63,810.08
C. Travel	\$35,000.00
D. Equipment	\$410,415.89
E. Supplies	\$185,060.75
F. Contractual	\$1,357,603.00
G. Construction	\$0
H. Other	\$160,000.00
I. Total Direct Charges (sum A-H)	\$2,456,539.72
J. Indirect Costs	\$131,244.28
K. Totals (sum I-J)	\$2,587,784.00

A. Personnel (\$244,650.00)

Senior personnel:

Total of \$1450,000 is requested for salary support per year for CARICOOS Inc. senior personnel.

As CARICOOS Principal Investigator and Executive Director **Prof. Julio Morell** (50% FTE; 6 months) will be responsible for the overall direction of the CARICOOS project and subawards. In addition, he will also be responsible for the ocean acidification programs (NOAA's NOA-ON), the AOML-CARICOOS hurricane glider program, the Sargasso inundation forecast/impact assessment project and coordinates MBON efforts in the region.

Dr. Patricia Chardón-Maldonado (75% FTE; 9 months), will serve as co-Principal Investigator, CARICOOS Deputy Director and Technical Director. She will co-lead, with Prof. Morell, all CARICOOS administrative and technical activities. The latter include the CARICOOS buoy program, the CARICOOS numerical modeling efforts, the CARICOOS glider program and the Sargasso inundation forecast and impact initiative. Chardón-Maldonado will also assist the Executive Director with general project implementation and personnel supervision, assist in the direction of all CARICOOS subsystems, and participate in outreach and stakeholder engagement activities throughout the US Caribbean. In addition, Dr. Chardón-Maldonado will lead the design and implementation of the CARICOOS nearshore meteorological and hydrodynamic modeling efforts and remotely sensed coastal video system.

Technical and administrative support personnel:

Total of \$99,650 is requested to support the following technical and administrative personnel:

An **accountant (75% FTE; 9 months)**, E. Loperena, will be responsible for CARICOOS financial transactions and record keeping, ensuring that statement and records comply with applicable laws and regulations, computing taxes, preparing tax returns, managing payments, inspecting account books, and accounting system, and making best-practices recommendations to directors, grant administrator and project administrators. She will manage ASAP transactions.

A **chemical oceanographer (50% FTE; 6 months)** will co-lead efforts towards meeting stakeholder needs which demand chemical and biogeochemical expertise in research, field studies and product development. Stakeholder sectors to be supported include but are not limited to coastal management, entities carrying out ecosystem restoration, regulatory entities, and others. In addition, the selected scientist will co-lead the ongoing ocean acidification monitoring programs and collaborate with the PR Climate Change Council, analogous activities, and entities in the region. The contracted scientist is expected to pursue applied research opportunities attuned with CARICOOS mission and goals.

An **administrative assistant (50% FTE; 6 months)** will provide support in accounting, purchasing and related tasks. He/she will report to the grant administrator and assist the administrator in program management affairs as requested.

An **oceanographic data analyst (54.8% FTE; 6 months)** will assist CARICOOS scientists in the analysis of climate and oceanographic data from historic, current, and proposed observing assets including remote sensing data products.

B. Fringe Benefits (\$63,810.08)

Fringe benefits for senior, technical, and administrative personnel are computed at the 14.40% rate which include: 6.20% Social Security, 1.45% Medicare, 1.75% State Disability Insurance, 5% Retirement, \$605 per month for medical insurance, and \$362 per year for unemployment/incapacity insurance. These fringe benefits are in accordance with the Federal Insurance Contributions Act (FICA;), the Federal Unemployment Tax Act (FUTA), the Puerto Rico unemployment and disability taxes, and the Puerto Rico workers' compensation insurance.

C. Travel (\$35,000)

Travel support totaling \$35,000 is requested for the following project-related travel (Data source: US General Services Administration and Federal Pay):

1. Attend IOOS Programmatic meetings

Two senior personnel (CARICOOS Directors) to attend mandatory meetings in Washington, DC.

Destination	Approximate Date	No. of Travelers	No. of Days	Airfare	Lodging	Per Diem	Total
Washington, DC	March 2022	2	3	\$402/flight x 2 persons	\$257/night x 2 persons x 3 days	\$76/per day x 2 persons x 3 days	\$2,802

2. Meeting with stakeholders and for general board affairs

CARICOOS Inc. Chairman, Directors and Program Coordinator to meet with stakeholders and for general board affairs.

Destination	No. of Travelers	No. of Days	Airfare	Per Diem	Mileage	Transportation	Lodging	Total
Ponce, Puerto Rico	4	4	-	\$21 per day x 4 persons x 4 days	100 miles (roundtrip)	\$0.86 /mile x 100 miles x 4 persons x 4 days	-	\$1,712
San Juan, Puerto Rico	4	4	-	\$21 per day x 4 persons x 4 days	240 miles (roundtrip)	\$0.86 /mile x 240 miles x 4 persons x 4 days	\$250/night x 4 persons x 4 days	\$7,638
St. Thomas, US Virgin Islands	2	4	\$174/flight x 2 persons	\$55 per day x 2 persons x 4 days	-	\$96/day (Car Rental) x 2 persons x 4 days	\$225/night x 2 persons x 4 days	\$3,356
St. Croix, US Virgin Islands	2	4	\$174/flight x 2 persons	\$55 per day x 2 persons x 4 days	-	\$96/day (Car Rental) x 2 persons x 4 days	\$225/night x 2 persons x 4 days	\$3,356
Subtotal								\$16,062

3. Intraregional travel

Intraregional travel by CARICOOS personnel as required for the installation, maintenance, and redeployment of assets, as well for participation in outreach and education and other stakeholder engagement events. *Considering the use of a personal vehicle and several visits to the station for maintenance.*

a. HF Radar Stations

Destination	No. of Travelers	No. of Days	Per Diem	Mileage	Transportation	Total
Ponce, Puerto Rico	2	8	\$21 per day x 2 persons x 8 days	100 miles (roundtrip)	\$0.86 /mile x 100 miles x 8 days	\$1,024
Cabo Rojo, Puerto Rico	2	16	\$21 per day x 2 persons x 16 days	50 miles (roundtrip)	\$0.86 /mile x 50 miles x 16 days	\$1,360
Maunabo, Puerto Rico	2	8	\$21 per day x 2 persons x 8 days	205 miles (roundtrip)	\$0.86 /mile x 205 miles x 8 days	\$1,746
Añasco, Puerto Rico	2	8	\$21 per day x 2 persons x 8 days	20 miles (roundtrip)	\$0.86 /mile x 20 miles x 8 days	\$474
Toa Baja, Puerto Rico	2	8	\$21 per day x 2 persons x 8 days	180 miles (roundtrip)	\$0.86 /mile x 180 miles x 8 days	\$1,574

Arecibo, Puerto Rico	2	8	\$21 per day x 2 persons x 8 days	110 miles (roundtrip)	\$0.86 /mile x 110 miles x 8 days	\$1,093
Fajardo, Puerto Rico	2	8	\$21 per day x 2 persons x 8 days	310 miles (roundtrip)	\$0.86 /mile x 310 miles x 8 days	\$2,469
Subtotal						\$9,740

b. Oceanographic data buoys

Destination	No. of Travelers	No. of Days	Per Diem	Mileage	Transportation	Total
Ponce, Puerto Rico	2	2	\$21 per day x 2 persons x 2 days	100 miles (roundtrip)	\$0.86 /mile x 100 miles x 2 days	\$256
San Juan, Puerto Rico	2	2	\$21 per day x 2 persons x 2 days	243 miles (roundtrip)	\$0.86 /mile x 243 miles x 2 days	\$502
Fajardo, Puerto Rico	2	2	\$21 per day x 2 persons x 2 days	310 miles (roundtrip)	\$0.86 /mile x 310 miles x 2 days	\$617
Subtotal						\$1,375

c. Travel for Caribbean Regional Ocean Partnership (ROP) initiative related meetings with stakeholders, workshops and training, and other stakeholder engagement events. Estimates consider local prime locations and maximum days expected for meetings because currently the information is unknown.

Destination	No. of Travelers	No. of Days	Airfare	Mileage	Transportation	Lodging	Total
San Juan, Puerto Rico	1	3	-	240 miles (roundtrip)	\$0.86 /mile x 240 miles x 1 person x 3 days	\$257/night x 1 person x 3 days	\$1,390
Ponce, Puerto Rico	1	3	-	100 miles (roundtrip)	\$0.86 /mile x 100 miles x 1 person x 3 days	\$200/night x 1 person x 3 days	\$858
Fajardo, Puerto Rico	1	3	-	260 miles (roundtrip)	\$0.86 /mile x 260 miles x 1 person x 3 days	\$322/night x 1 person x 3 days	\$1,637
St. Thomas, US Virgin Islands	1	3	\$173/flight x 1 person	-	\$96/day (Car Rental) x 1 person x 3 days	\$225/night x 1 person x 3 days	\$1,136
Subtotal						\$5,021	

D. Equipment (\$410,415.89)

** Statement on equipment ownership: All equipment acquired through this funding opportunity will become part of the CARICOOS assets and utilized solely for purposes consistent with CARICOOS mission.*

The following major equipment acquisitions are required for the continued operation of existing CARICOOS assets and subsystem and new initiatives:

- A Nortek Aquadopp ADCPs, at a cost of \$24,530.00 each and a SeaBird CT, at cost of \$6,690.00 each, will be required for replacing aging instruments deployed with CARICOOS data buoys.
- An ATON system (\$44,600.00) will be installed on a channel buoy to test its capability of measuring real-time current observations in the navigational channel for port decision markers.
- Funds are requested for expanding the CARICOOS HF radar network. A staggered deployment schedule includes one new antenna per year at \$178,400.00.
- Funds are requested for acquiring two CTDs instruments reporting conductivity, temperature, depth, dissolved oxygen, pH, turbidity and Chl a/ CDOM fluorescence with a cost of \$78,097.95 each for a total of (\$156,195.89) These will be installed on nearshore bottom mounts and aboard light-weight buoys in to be deployed in the inner shelf. These ensembles of sensors will be deployed along with inductive modems on CARICOOS oceanographic data buoys mooring systems.

Lease vs buy analysis for oceanographic equipment: *In general, it is significantly more expensive to lease than to purchase oceanographic equipment for operational multi-year installations, especially when taking in consideration the cost of insurance for instrumentation deployed in the field.*

E. Supplies (\$185,060.75)

Funds requested for materials and supplies (\$185,060.75) are distributed as follows:

- Materials and expendables (\$56,200) required for data buoys operations and maintenance are distributed as follows:
 - Instrumentation installed on the oceanographic data buoys (San Juan, Ponce, Vieques and St. John buoys)
 - Alkaline batteries for five (5) Aquadopp Z-Cell 600 kHz current meters (\$900.00)
 - Lithium batteries for five (5) SeaBird SBE 37SM conductivity, temperature, depth (CTD) sensors (\$1,200)
 - Spare electronic parts (data logger, batteries, adapters) for wind sensors (\$2,000)
 - Instrument maintenance, refurbishment, and calibration

- Five (5) SeaBird SBE 37SM CTD (\$6,600)
 - Five (5) Aquadopp Z-Cell 600 kHz current meters (\$7,200)
- Wave data buoy (Rincon buoy)
 - Wave buoy supporting expendables including batteries, O-rings, and replacement antenna (\$11,000)
 - Sandblasting, priming, and painting of the buoy (\$6,000)
 - Mooring components, cables, and anchoring hardware (\$6,000)
- Aids to Navigation (ATON) real-time current observation system
 - System mounting clamp, cables, hardware, and telemetry system components (\$12,000)
- Materials for any emergency recovery/repair (life jackets), spare electronic parts (connectors, cables, adapters), buoy lettering, hardware, and tools (\$3,300)
- Materials and supplies for the maintenance and refurbishment of HFR systems, Windnet stations, underwater gliders, and ecosystem sensor ensembles (\$77,000) are distributed as follows:
 - HF Radar systems
 - Coaxial cables, connectors, and adapters for communication and power transmission lines (\$3,000)
 - Seven (7) 8,000 BTU Window Air Conditioners (\$2,000)
 - Hardware and tools for installing or reinforcing the antennas, electronic enclosure, or cables (\$1,000)
 - Electrical power installation for St. Thomas and San Juan systems (\$14,000)
 - Purchase or repair services of electronic components such as front transmission board panels, fans, and power supplies (\$20,000)
 - Wi-Fi routers with sim card for seamless internet connection (\$2,100)
 - Windnet stations to measure wind conditions in Ponce, Cabo Rojo, Lajas and Rincon
 - Batteries, cables, hardware for maintenance and repairs (\$2,000)
 - Underwater gliders
 - Battery refurbishment kit for CARICOOS Seaglider M1 including replacement main and secondary batteries, O-rings, and replacement anode (\$11,500)
 - Maintenance and calibration of external sensors such as thermistor, oxygen optode, pressure sensors and conductivity/temperature cell (\$3,400)

- Ecosystem sensor ensembles (details in the Equipment category)
 - Batteries to power four (4) sensor ensembles (\$13,000)
 - Anti-foulant kits to control biofouling (\$700)
 - Stainless steel bottom mounts (\$4,300) to attach and deploy the systems for short-term deployments
- Foreseeable expenditures (\$35,160.75) for:
 - Shipping and handling charges (\$13,000)
 - Office supplies and operations materials such as paper, ink, filing, storage, and basic supplies (\$11,270)
 - Computer infrastructure such as Uninterrupted Power supply systems (\$1,200), PC's (\$5,000), peripherals (\$3,000), batteries (\$690.75), and software costs (\$1,000)
- Materials and supplies for outreach and education efforts included photo and video materials, infographics, and printer supplies (\$16,700).

F. Contractual (\$1,357,603.00)

Subawards: A total of \$776,681.00 is requested for subawards. The subrecipient's budget and budget justification considers the costs of the activities to be carried out in year one of the five-year funding cycle. A breakdown of these costs and subaward institution is shown in the table below:

Subawards	Amount
University of Puerto Rico-Mayaguez (PIs: M. Canals & S. Rodríguez-Abudo)	\$307,575
Ocean and Coastal Observing Virgin Islands (PI: L. Sylvester)	\$78,980
Planning, design, and implementation of the changes and expansions of CARICOOS data buoys (PI: N. Pettigrew/U. of Maine)	\$300,000
Evaluate the Response of Coastal Habits to Sargassum loading and Zooplankton Monitoring Program (PIs: E. Otero & A. Rodríguez-Santiago /UPR-Mayaguez)	\$60,126
Enhancing and maintaining satellite-based virtual buoys to assess water quality in coastal Puerto Rico and the US Virgin Islands (PIs: B. Barnes & C. Hu / U. of South Florida)	\$30,000
Subtotal	\$776,681

A description of each subaward follows, beginning from the top row:

- A subaward to the University of Puerto Rico-Mayaguez will support the participation of Dr. S. Rodríguez and Dr. M. Canals as Co- Principal Investigators in the here proposed effort. Dr. Rodríguez will continue coordinating the Beach Hazard subprogram while Dr.

Canals will lead the hydrodynamic observing and modelling efforts (waves and currents). Both will collaborate in programmatic affairs and provide vision and overall expertise to CARICOOS. The subaward will also support a Grant Administrator, an HF Radar lead, an administrative assistant, and student participation.

- A subaward to the Ocean and Coastal Observing – Virgin Islands (OCOVI) NGO (PI: L. Sylvester) will support CARICOOS outreach and education efforts in USVI, which will include stakeholder need assessment, education and the continued engagement of USVI government, private entities, and potential collaborators. In addition, OCOVI will assistance in the deployment and maintenance of existing and proposed observing assets, securing permits and logistic support, underwater glider deployments/recoveries in USVI waters and monitoring Sargassum beaching in the USVI shores.
- A subaward to the University of Maine (PI: Dr. N. Pettigrew) for the upgrade, maintenance, monitoring and data management of the 5 oceanographic data buoys, as well as reporting buoy data in real time. All buoys provide waves, winds and other meteorological measurements, sea surface temperature and salinity and full water-column currents. Funds will support the full renovation of all buoys and to expand their observing capabilities by equipping the buoys with inductive modem for water quality sensors (eco sensor ensembles).
- A subaward to Dr. E. Otero and Dr. A. Rodríguez-Santiago at UPR-Mayaguez for assessing the impact of anoxia arising from Sargasso decomposition on zooplankton biodiversity and biomass of coastal ecosystems (mangroves, cays) study using microscope based and metagenomic analysis.
- A subaward to the University of South Florida (PI: Dr. B. Barnes) for the maintenance of the satellite-based virtual buoys product which is being used to assess water quality in Puerto Rico and USVI. The data is derived from NASA’s Moderate Resolution Imaging Spectroradiometer (MODIS) instruments.

Contracts: A total of \$580,922.00 over five years is requested for contractual services. A breakdown of these costs per year, tier levels and contractors are shown in the table below:

Contractual	Amount
Professional Services	
CARICOOS Inc Board of Directors Chairman	\$13,000
Operations Manager/Finance Officer	\$10,500
Data Management and Cyberinfrastructure (DMAC) lead/consultant	\$9,120
Data Management and Cyberinfrastructure (DMAC) coordinator	\$31,000
Computing Specialist	\$20,000
Grant Compliance Officer	\$17,000
Caribbean Regional Ocean Partnership (ROP) Project Coordinator	\$23,382
Research Technician	\$17,000
Field Technician	\$11,520
CARICOOS Observing Assets & Field	

Retrieval and redeployment of CARICOOS oceanographic data buoys in PR and USVI	\$55,000
Weatherflow, Inc., weather station operation and data delivery	\$29,550
Surfrider, coliform monitoring services	\$26,100
Beach Water Quality monitoring services in PR and USVI	\$20,000
Laboratory analysis for DIC of discrete bi-weekly water samples	\$12,000
Vessel time for deployments and retrievals and emergency recoveries	\$23,000
Numerical Modeling and Data Analysis	
MBON targeted efforts (reformatting and analysis of ecosystem data)	\$22,730
Website	
Web product development and maintenance/Candela Creative	\$20,000
Webpage domain and cloud infrastructure hosting	\$13,200
Communications/Telemetry	\$20,000
Outreach & Education	
Digital Media Outreach: Educational modules, training videos and educational podcasts	\$ 15,000
General Assembly Venue	\$ 35,000
Legal Services	
Legal Counsel	\$ 12,000
Regional Ocean Partnership	
Assessing the status, challenges, and management needs of coastal barriers/ecosystem services	\$25,000
Forecasting Sargasso Arrival in Puerto Rico: A Pilot Project (PI: F. Beron-Vera/U. of Miami)	\$ 35,000
Product Development: Decisional Support Tools	\$50,000
CROP Website: Maintenance	\$7,500
Workshops & Training	\$7,320
Subtotal	\$580,922

A description of each contract follows:

Professional Services

1. Chairman-CARICOOS Inc.

Amount: \$13,000

Performance Period: July 1, 2021 to June 30, 2022

Justification: CARICOOS Inc. Board of Directors Chairman will lead CARICOOS Board of Directors (CBOD) and assure compliance with CARICOOS by-laws and its status as a 501C(3) under the Federal Internal Revenue Code and as 1101.01 under the Internal Revenue Code of Puerto Rico. Moreover, he will represent CARICOOS Inc. in public meetings and provide expertise in outreach and educational initiatives.

2. Operations Manager/Finance Officer

Amount: \$10,500

Performance Period: October 1, 2021 to June 30, 2022

Justification: E. Vélez will oversee all CARICOOS Inc. administrative and fiscal operations. In addition, will assist CARICOOS Inc. Board Chairman in the coordination of CARICOOS Inc. Board of Directors activities and will work closely with the CARICOOS Inc. Executive Officers and Grant Administrator.

3. Data Management and Cyberinfrastructure (DMAC) lead/consultant

Amount: \$9,120

Performance Period: October 1, 2021 to June 30, 2022

Justification: Dr. J. Capella will oversee all data management and cyberinfrastructures improvement, implementations, activities, and compliance with IOOS-DMAC requirement. He will co-lead the DMAC-CARICOOS team and contribute to the administration and coordination of activities. In addition, Dr. Capella will serve as the Point of Contact for data providers, data users, IOOS PO office and for his DMAC counterparts at the other ten coastal observing systems across the nation.

4. Data Management and Cyberinfrastructure (DMAC) coordinator

Amount: \$31,000

Performance Period: January 1, 2022 to June 30, 2022

Justification: The DMAC coordinator will assist the DMAC lead/consultant with the data management, data processing and product development. He/she will expand CARICOOS capacity to integrate new ocean- and climate-related observations and provide support for standardized data access through publicly available interfaces (THREDDS, ERDDAP).

5. Computing Specialist

Amount: \$20,000

Performance Period: January 1, 2022 to June 30, 2022

Justification: J. Torres will provide technical support and maintenance to CARICOOS computational infrastructure efforts. In addition, he will assist, as required, the DMAC leadership.

6. Grant Compliance Officer

Amount: \$17,000

Performance Period: July 1, 2021 to June 30, 2022

Justification: The Grant Compliance Officer will conduct routine compliance reviews of grant programs, provide guidance on program contractual requirements, assist in preparations for external monitoring visits, reviews, and audits and monitor compliance with CARICOOS policies, procedures, and practices. In addition, the Grant Compliance Officer will provide guidance in interpreting and executing applicable state and federal regulations.

7. Caribbean Regional Ocean Partnership (ROP) Project Coordinator

Amount: \$23,382

Performance Period: January 1, 2022 to June 30, 2022

Justification: Dr. Y. Detrés will lead stakeholder engagement and need assessment efforts required for furthering the Caribbean Regional Ocean Partnership (ROP) initiative and CARICOOS system growth design.

8. Research Technician

Amount: \$17,000

Performance Period: October 1, 2021 to June 30, 2022

Justification: L. Rodríguez will provide the following services for CARICOOS. He will assist in the refurbishment and piloting of profiling gliders for the hurricane glider program and climate monitoring efforts. He will also operate small vessels, carry out the collection of field samples and assist executing logistic arrangements required for the above services as required for the Sargasso impact assessment and Ocean Acidification Monitoring program (NOA-ON). As required, he will also provide technical diving services including underwater photo/videography as well as instrument deployment and retrievals.

9. Field Technician

Amount: \$11,520

Performance Period: October 1, 2021 to June 30, 2022

Justification: This position will participate in operational fieldwork to install and recover oceanographic instrumentation, assist with the fabrication, maintenance and refurbishment of oceanographic instrumentation and observing assets.

CARICOOS Observing Assets

1. Retrieval and redeployment of CARICOOS oceanographic data buoys

Amount: \$55,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: A total of \$55,000 are requested for a yet undetermined contractor for activities required for the removal of buoys from station, bringing these into a designated shore facility for refurbishment and redeploying them once they are ready.

2. Operation and maintenance of CARICOOS Mesonet Network

Amount: \$29,550

Performance Period: June 1, 2021 to June 30, 2022

Justification: A contract to WeatherFlow, Inc. for the installation of a new weather station and for the continued operation, maintenance, and access to data from 18 coastal Mesonet stations.

3. Coliform monitoring effort

Amount: \$26,100

Performance Period: June 1, 2021 to June 30, 2022

Justification: A contract to Surfrider Foundation Inc. to manage a volunteer-based coliform monitoring effort for western and northwestern PR beaches.

4. Monitoring Beach Water Quality in Puerto Rico and US Virgin Islands

Amount: \$20,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: Development of a weekly beach water quality monitoring program in Puerto Rico and US Virgin Islands including required analytical laboratory services of beach samples associated with said monitoring and nrt submission of all analyzed data for dissemination. The initiative will start with selected areas/beaches.

5. Laboratory analysis of discrete bi-weekly water samples

Amount: \$12,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: Analysis for DIC of discrete bi-weekly water samples from the MapCO2 buoy site monitoring at the University of New Hampshire Coastal Carbon Lab

6. Securing services of vessels and crew

Amount: \$23,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: A total of \$23,000 are required for securing the services of vessels and crew required for the deployment and retrieval of instrumentation, buoys and ocean gliders. A significant share of these funds may be required for emergency underwater glider recoveries.

CARICOOS Numerical Modeling and Data Analysis

1. MBON targeted efforts

Amount: \$22,730

Performance Period: June 1, 2021 to June 30, 2022

Justification: Support biology-focused contributions to Caribbean regional engagement with IOCARIBE and MBON (as requested by IOOS Program Office).

CARICOOS Portal, Data Products and Mobile Applications

1. Webpage maintenance and product development

Amount: \$20,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: A contract to Candela Creative Group for CARICOOS web page and Boat app. maintenance and upgrades including new product development will total \$20,000.

2. Webpage domain and cloud infrastructure hosting

Amount: \$13,200

Performance Period: June 1, 2021 to June 30, 2022

Justification: A total of \$13,200 are requested for securing CARICOOS webpage domain and cloud infrastructure hosting.

3. Communications and telemetry services

Amount: \$20,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: A total of \$20,000 are requested for communications and telemetry service providers required for transmitting real-time data from mooring and land-based observing assets.

Outreach & Education

1. **Educational Modules, Training and Educational Initiative**

Amount: \$15,000

Performance Period: October 1, 2021 to June 30, 2022

Justification: Production of instructional material including videos and graphical tools promoting environmental awareness, support & partnerships campaign, webinars, virtual conferences & podcasts.

2. **CARICOOS General Stakeholder Assembly**

Amount: \$35,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: A total of \$35,000 will be required for contracting the venue and other expenses related to the yearly CARICOOS General Stakeholder Assembly (GA).

Legal Services

1. **Legal Counseling**

Amount: \$12,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: Contracting legal counseling regarding interpretation of legal federal and state policies, regulations and practices applicable to the project.

Regional Ocean Partnership (ROP)

1. **Assessing the status, challenges, and management needs of coastal barriers/ecosystem services**

Amount: \$25,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: CARICOOS stakeholders have expressed the need for indispensable information in support of coastal ecosystem management. Responding to the above request, CARICOOS will commence a regional effort towards fulfilling said need and focused on coastal barrier/ecosystems (reefs, seagrasses, mangroves/wetlands and beach dunes), through the integration of existing data and products.

2. **Forecasting Sargasso Arrival in Puerto Rico: A Pilot Project**

Amount: \$35,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: A contract to Dr. Beron-Vera and Dr. Olascoaga will support the project entitled **Forecasting Sargasso Arrival in Puerto Rico: A Pilot Project** that will assess the feasibility of developing a prediction system for the coastal beaching of Sargassum (HAB) in Puerto Rico for a total of \$35,000.

3. **Product Development: Decisional Support Tools**

Amount: \$50,000

Performance Period: June 1, 2021 to June 30, 2022

Justification: A total of \$50,000 are requested for contracting the development of the following products:

- a. Coastal Weather Variability & Hydrodynamic Atlas - Web interface that will provide user-friendly access to the 40-year high-resolution weather and hydrodynamic atlas for Puerto Rico and US Virgin Islands.
- b. Sargasso dashboard – Web interface to provide, as a starting point, Sargassum arrival forecasts, outcast from Dr. C. Hu, Sargassum bulleting from NOAA-AOML, plots reporting biomass loading, pH, dissolved oxygen at pilot stations for Sargassum impact assessment, and satellite imagery depicting Sargassum aggregations.
- c. Coastal Barriers and Ecosystems – Web interface that provides for coastal managers and other stakeholders to explore “at a glance” the status of US Caribbean region coastal barriers and ecosystems.

4. Caribbean ROP website maintenance

Amount: \$7,500

Performance Period: June 1, 2021 to June 30, 2022

Justification: A contract to Candela Creative Group for the Caribbean Regional Ocean Partnership website.

5. Workshops and Training

Amount: \$7,320

Performance Period: October 1, 2021 to June 30, 2022

Justification: A total of \$7,320 will be required for contracting the venue and other expenses to hold workshops and trainings.

G. Construction (does not apply)

H. Other (\$160,000.00)

- A total of \$19,000 are budgeted for membership of the IOOS Association; \$5,000 of these will be directed to DEI pertinent initiatives.
- An allocation of \$70,000 is required for CARICOOS Inc. office and laboratory rental, maintenance, and utilities. The total of square footage is approximately 2,128.96. The owner of the rental space is the University of Puerto Rico at Mayaguez at an estimated a cost of \$2.74 per sq. ft including maintenance and utilities. The space rent for one-year totals 2,128.96 sq. ft. at a rate of \$2.74 per sq. ft. x 12 months = \$70,000.
- Liability Insurance costs for CARICOOS totals \$14,000. Said insurance will cover CARICOOS Inc. Chairman and Board of Directors, Executive, Deputy and Technical Director, DMAC Coordinator, Chief IT/HP computing tech and others from liability arising from dissemination of CARICOOS data and products. The above cost also includes General Liability policy for CARICOOS Inc.

- Funds totaling \$12,000 are required for participant support costs (non-CARICOOS employees) associated with participation in workshops, conferences, seminars, symposiums or other short-term instructional or information sharing activity. CARICOOS is deeply committed to provide opportunities for capacity building within the region, while also promoting diversity and inclusion at the regional and national level. CARICOOS main pool of student talent, U. of Puerto Rico and U. of Virgin Islands, are Minority Serving Institutions, whose population has been historically underrepresented in ocean observing and ocean sciences in general. To this end, CARICOOS will continue to support a critical mass of outstanding students whose research work become essential parts of CARICOOS' products and services. Likewise, we will continue to foster higher education and unique research opportunities through our summer internship program. A new travel grant program will be implemented during this upcoming cycle to provide our students with supra-regional opportunities including coastal management and policy, ocean observing in mid and high latitudes, among others.
- To prevent data from being unavailable due to lack of electrical power or server failures CARICOOS data is stored in the cloud through Amazon Web Services. In addition, operational computer models operate in AWS servers. Cost for these services total \$45,000/year and include two high performance computer (\$29,000) interfaces for numerical modeling efforts and two data storage interfaces (\$16,000) for data archival.

I. Total Direct Charges

	YR1
Total Direct Charges	\$2,456,539.72

J. Indirect Charges

Indirect costs are computed at the applicable “*de minimis*” indirect cost rate (CFR§200.414(f)). Indirect cost totals the 10% of the Modified Total Direct Cost (MTDC) which includes all direct costs except equipment, participant support, rental of space and the portion of each subaward in excess of \$25,000.

K. Total Direct and Indirect Costs

	YR1
Total Direct Charges	\$2,456,539.72
Indirect Costs	\$131,244.28
TOTAL DIRECT AND INDIRECT COSTS	\$2,587,784.00