

# CARICOOS USER NEEDS ASSESSMENT



CARICOOS

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## ABOUT CARICOOS

The Caribbean Coastal Ocean Observing System (CARICOOS) is one of eleven regional associations that constitute the coastal component of the [US Integrated Ocean Observing System \(IOOS\)](#). The mission of CARICOOS is the timely delivery of high-priority accurate and reliable ocean data to its stakeholders in the US Caribbean Exclusive Economic Zone. Since 2007, CARICOOS has provided citizens and entities in Puerto Rico and the US Virgin Islands with coastal ocean information, data, and products required for minimizing exposure to coastal hazards, supporting safe and efficient maritime operations and management of our coastal resources. Through continuous and enhanced observational and modeling capacities CARICOOS integrates data streams into practical tools for information delivery to stakeholders. CARICOOS observational and modeling efforts provide information to address the main focus areas: Maritime Operations; Coastal Hazards; Coastal Resources; and Climate Variability. With support of IOOS-NOAA, as well as congressional allocations, CARICOOS currently operates five oceanographic buoys, one ocean acidification monitoring buoy, seventeen coastal weather stations, five high frequency radars (HFRs) and six ocean glider lines, as shown below:

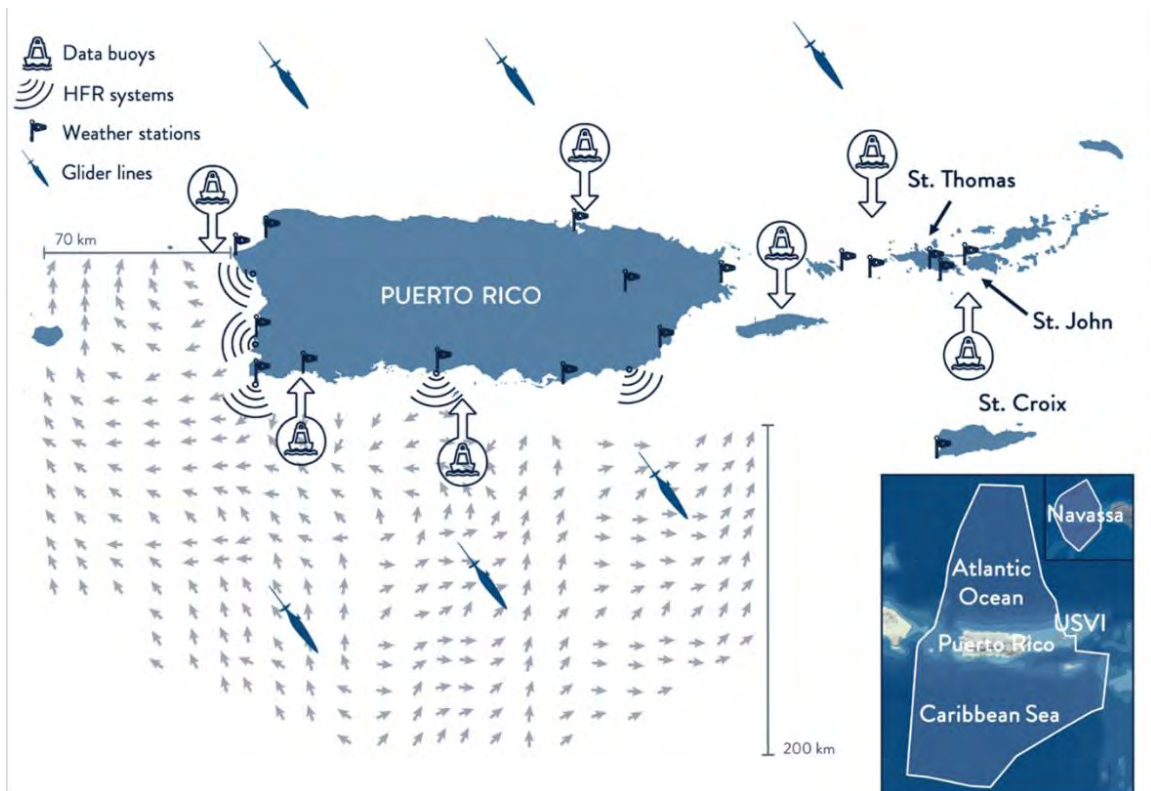


Figure 1 CARICOOS Observing Assets. The inset shows the extent of the US Caribbean EEZ.

CARICOOS also maintains operational forecasting models of winds, waves and coastal circulation. Additionally, CARICOOS shares data and products from partners and agencies. Through direct consultation with stakeholder groups, CARICOOS has also developed integrated data products aimed at specific user needs such as the Yabucoa Port Dashboard for harbor pilots, Breaker Height Forecasts and Pa' La Playa App for beachgoers, and the CARICOOS Boating App for recreational boaters. The CARICOOS Outreach, Education and Engagement subsystem operates the CARICOOS School, CARICOOS NEWS, CARICOOS newsletter and social media accounts in Facebook, Twitter, Instagram and YouTube. Some metrics about CARICOOS web interactions are shown below:



Figure 2 CARICOOS website statistics in 2019.

Over the upcoming years, CARICOOS foresees expanding its ocean-based observing and forecasting resources and improving services in the U.S. Caribbean region.

## EXECUTIVE SUMMARY

The goal of CARICOOS is to provide comprehensible and accessible coastal intelligence to satisfy user-specific needs, while still serving as the primary source of reliable and timely ocean data in the U.S. Caribbean region. CARICOOS carried out this needs assessment process to gather relevant information to address key stakeholder and sector needs in order to guide the 2021-2026 strategic planning and improve our capacity to support coastal and marine activities in the Caribbean region.

The content of the need's assessment report reflects an extensive stakeholder consultation process that began in February 2020 with initial meetings and data collection efforts and concluded in November 2020 with the writing of this report. Input from the CARICOOS Board of Directors guided this process. CARICOOS data collection efforts included interviews, focal group meetings and online and telephone surveys with a number of stakeholders representing federal, state and local government, maritime operations, academia and research, ecosystem restoration, tourism, recreation, and the private sector. Need assessment findings were classified by CARICOOS' main focus areas: Maritime Operations; Coastal Hazards; Coastal Resources; and Climate Variability.

- **Maritime Operations:** CARICOOS provides coastal ocean information (real-time observations and forecasts) and decision support tools to improve the safety and efficiency of marine operations taking place in the US Caribbean region. Situational awareness, operational support, and information sharing are fundamental necessities for maritime and port operations. Coastal ocean real-time observation and modeling capabilities support efficient and safe transportation, search & rescue operations (SAROPS) and planning responses to oil and hazardous spills.
- **Coastal Hazards:** The CARICOOS region is constantly threatened by storm surge inundation, strong winds, and severe waves resulting from tropical and winter storms in the Caribbean and Atlantic waters, respectively. These coastal threats account for one of the highest per capita drowning rates in the US. Furthermore, the recurrent presence of potentially pathogenic organisms in coastal waters and the geological/geographical potential for a tsunami landfall represent unique challenges and opportunities for the region. Most of the identified needs associated with the coastal hazards programmatic area were related to beach safety, impacts of natural hazards and extreme events, and monitoring of beach pathogens.
- **Coastal and Marine Resources:** Services provided by coastal barriers and ecosystems are of particular importance to the well-being of Puerto Rico and the US Virgin Islands. While fostering economic activity

by attracting tourism and supporting fisheries and blue economy initiatives, these barriers provide essential protection from extreme wave events resulting from tropical cyclones and winter storms in the North Atlantic. During the last decades, sand dunes, coral reefs, mangroves and seagrasses have faced major challenges from overexploitation, exacerbated sediment and nutrient runoff and anthropogenic ocean warming. Additionally, ocean acidification has reached levels that are already compromising coral calcification and favoring carbonate sand dissolution. Moreover, with their integrity already compromised, coastal ecosystems were impacted by hurricanes Irma and Maria and major winter swell events. Furthermore, the seasonal arrival of massive quantities of pelagic sargassum since 2011 is now recognized as an additional persistent menace with diverse deleterious expressions. Interest in coastal ecosystem management and conservation has developed recently in response to increasing threats and acknowledgement of the declining conditions of ocean ecosystems. Stakeholder needs communicated during the consultation process are associated with ecosystem health, living marine resources monitoring, water quality and ecosystem restoration.

- **Climate Variability:** The U.S. Caribbean region is highly vulnerable to climate variability. These islands face diverse challenges including sea level rise and increased frequency and intensity of hurricanes and winter storms, with consequences to lives, infrastructure and resources. In addition, higher sea surface temperature and ocean acidification might increase coral bleaching and mortality with resulting degradation of coral reefs and disruption of ecosystem integrity and valuable ecological services. While these processes are normal for our latitudes, there is scientific consensus that they can be intensified by a changing climate.

Our transparent and inclusive needs assessment process helped us identify new challenges, emerging issues, and opportunities for CARICOOS. These findings are a valuable tool to help us sustain existing activities of interest to our stakeholders and implement additional efforts to support coastal ocean users and advance CARICOOS mission in the region.

## 1. NEEDS ASSESSMENT SUMMARY

Formal consultation with key stakeholders is essential to expand CARICOOS' ocean observing and forecasting capabilities and improve our services in the region. CARICOOS conducted a needs assessment process from February to October 2020 with the objective of gathering relevant information to address key stakeholder needs in order to guide strategic planning and improve our capacity to support coastal and marine activities in the Caribbean region.

An initial consultation with the [CARICOOS Board of Directors \(CBOD\)](#) provided preliminary feedback that guided this process. This governing body represents the maritime operations, living marine resources, coastal hazards and human threats, climate variability, and stakeholder education and communication sectors. Following the advice provided by the CBOD, formal stakeholder engagement efforts were conducted with various user groups. Moreover, the continuous dialogue that CARICOOS maintains with relevant stakeholders, including the National Weather Service and the U.S. Coast Guard, also had a significant contribution to this assessment.

This document presents a summary of the needs assessment process including a description of the data collection approaches, stakeholders engaged, and an overview of key findings by programmatic area. Appendices A and B include a summary of the surveys and Appendix C outlines the identified needs by focus area.



## 2. METHODS

The CARICOOS needs assessment process took place from February to October 2020 with the participation of 310 stakeholders from different sectors. This systematic process consisted of three phases: 1) planning, 2) data gathering and 3) analysis-reporting. During the planning phase, CARICOOS performed an initial scoping to identify the target population and key people with the knowledge and willingness to share information regarding their sector needs. Qualitative and quantitative data collection approaches to undertake the needs assessment were also identified during this phase. A final phase in the needs assessment process consisted of synthesizing and reporting data to enable evaluation and prioritization by decision makers.

### 2.1 NEEDS ASSESSMENT APPROACHES

The data collection phase employed mixed approaches including surveys, personal interviews, and target group meetings. Table 1 includes a brief description of the data-gathering methods employed.

- **Surveys:** Coastal and ocean users (e.g., recreational, tourism operations, conservation efforts) were consulted through an online questionnaire (Spanish and English) using email, CARICOOS and Ocean and Coastal Observing Virgin Islands (OCОВI) web pages and social media. This assessment tool aided in the evaluation of the reach of CARICOOS data products and services and identified the needs of additional ocean-observing and forecasting tools. The integration of closed-ended questions facilitated quantification of data and categorization of respondents. Telephonic interviews directed to emergency planning officers and environmental managers from coastal municipalities, hotels administrators, fishermen and divers, explored concerns related to sargassum beaching events in the Caribbean coastline.
- **Personal interviews and focal groups:** These qualitative approaches engaged high-priority stakeholders from federal, state and local government, maritime operations, academia, and ecosystem restoration sectors that helped to identify data, information and product needs by focus area. The ecosystem restoration sector is a prominent stakeholder group consulted during this need's assessment. This sector grew significantly after the impact of hurricanes Irma and Maria in 2017.

Table 1. CARICOOS needs assessment data collection methods

Approach	Type of data collected	Description
Surveys	Quantitative	Facilitated collection of specific information from large groups (web-based, telephonic).
Personal Interviews	Qualitative	Provided in-depth direct information about perceptions and opinions based on personal observation and experiences with the CARICOOS products and services.
Focus groups	Qualitative	Allowed discussion of needs and issues affecting specific marine sectors and brainstorming of new and creative ideas to solve them.

## 2.2 STAKEHOLDER ENGAGEMENT

Stakeholders are key for the governance of CARICOOS. Each stakeholder sector is represented in the CBOD. This body informed the needs assessment resulting in a total of 310 stakeholders from six different sectors formally consulted (Figure 3). Table 2 incorporates details of the agencies, programs, organizations and other users (by sector) that participated in the consultation. The tourism and recreational sector were the one with the highest participation (45%). This broad sector includes, hotels administrators, tour operators, fishermen, surfers, and other enthusiasts of water activities.

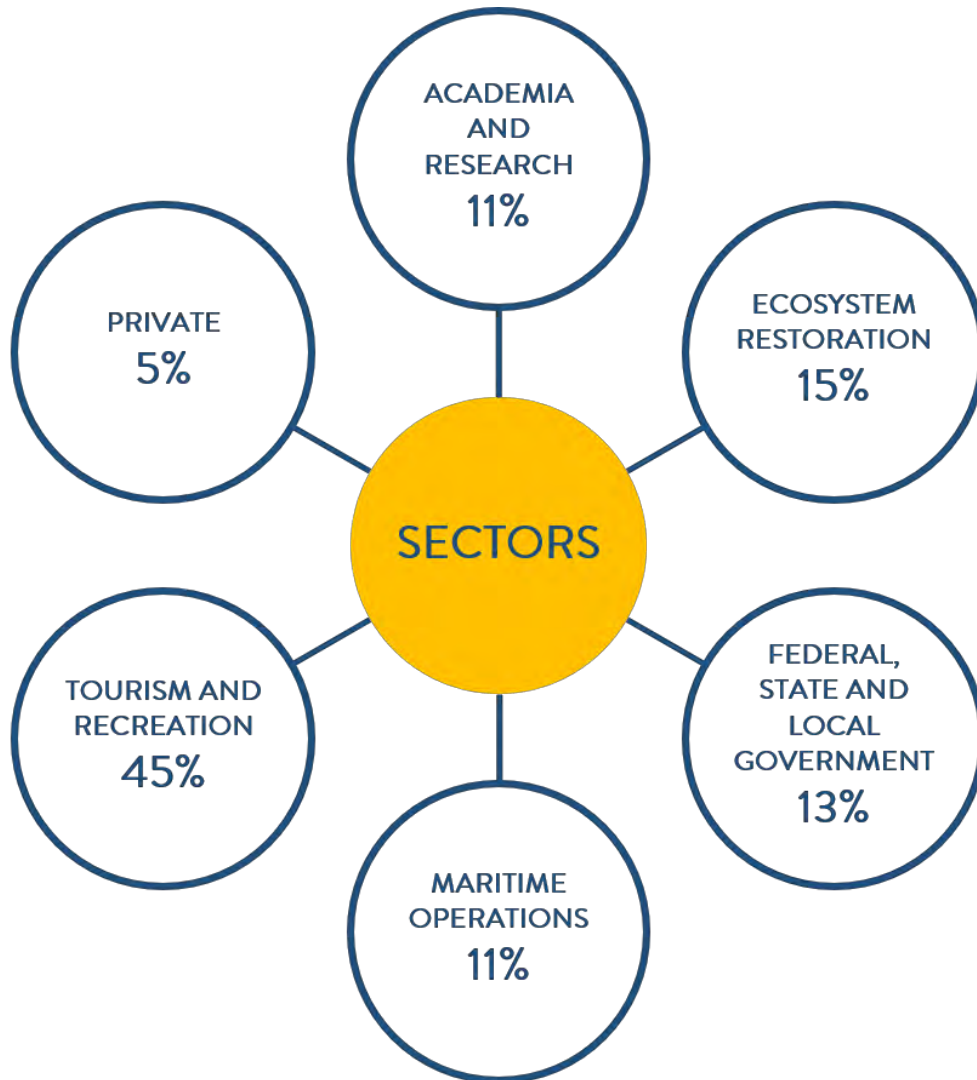


Figure 3 Key stakeholder sectors and percent of participants in the needs assessment process.

Table 2. List of agencies, academic centers, organizations, and groups, by sector, represented in the CARICOOS needs assessment process

Sectors engaged	Number of participants
<b>Federal, state &amp; local government</b> <ul style="list-style-type: none"> <li>● USCG (SJ Commander, RIO Ponce)</li> <li>● NOAA (NWS, CFMC, CRCP, CTWP, Sea Grant)</li> <li>● USDA NRCS</li> <li>● EPA Region 2</li> <li>● DNER CZMP</li> <li>● JOBANERR</li> <li>● Municipalities</li> </ul>	40
<b>Maritime operations</b> <ul style="list-style-type: none"> <li>● Harbor pilots</li> <li>● Port operators</li> <li>● Tugboat operators</li> </ul>	35
<b>Ecosystem restoration (For profit &amp; non-profit organizations)</b> <ul style="list-style-type: none"> <li>● San Juan Bay Estuary Program</li> <li>● Sociedad De Ambiente Marino</li> <li>● Protectores De Cuencas</li> <li>● ISER Caribe</li> <li>● Vida Marina</li> <li>● Reefscaping</li> <li>● Coastal Survey Solutions</li> </ul>	45
<b>Academia / Research</b> <ul style="list-style-type: none"> <li>● Puerto Rico Coastal Research &amp; Planning Institute</li> <li>● Red de Playas del Caribe</li> <li>● Center for Applied Tropical Ecology &amp; Conservation</li> <li>● Puerto Rico Seismic Network</li> </ul>	33
<b>Tourism / Recreation</b> <ul style="list-style-type: none"> <li>● Hotel administrators &amp; tourism operations</li> <li>● Beachgoers &amp; other recreational users</li> </ul>	140
<b>Private (i.e., engineers, consultants, communicators)</b>	17



### 3. SUMMARY OF FINDINGS

The following section includes the goals of the programmatic areas and a general overview of data and information needs identified. The Current Activities section includes initiatives that are currently in-place, while Planned Activities are those that have already received funding and are in the early stages of execution. Potential projects identified during the stakeholder consultation process are included under Opportunities.

#### 3.1 SUPPORT SAFE AND EFFICIENT MARINE OPERATIONS

##### Goals

Provide ocean information and decision support tools to enhance safety and efficiency of the full range of maritime operations (i.e. marine transportation, recreational activities, search and rescue, response to hazardous spills) taking place in the US Caribbean region.

##### Data and Information Needs Overview

Stakeholders in the maritime operations sector expressed the importance and need of real-time metocean data acquisition and transmission, including profiles of current velocity, to help ensure safety of vessel operations around entrances to major seaports in Puerto Rico and the US Virgin Islands. They also emphasized on the importance of improved circulation and wind data and forecasts near ports and harbors and the need of visualization tools, for desktop or mobile devices, of real-time data and forecasts pertinent to maritime and port operations to facilitate understanding and decision making.

There is a need for improved observations and forecasts in support of United States Coast Guard (USCG) Search and Rescue Operations in Puerto Rico and U.S. Virgin Islands waters. The USCG expressed the need to strengthen the high-frequency radar network stations to ensure a continuous operation under a broad range of environmental conditions, in remote areas or during periods of prolonged power outages. The maritime sector communicated the need to expand the high-frequency radar network to provide accurate sea surface current maps for the San Juan-St Thomas sea lane and to improve ocean and coastal circulation models to address issues associated with a range of coastal and nearshore dynamics and environmental emergencies in local ports.

##### Current Activities

CARICOOS currently operates a network of several observing assets and forecast models to improve safety and efficiency of maritime operations, support national defense and homeland security, improve search and rescue operations strategies and emergency responses to hazardous spills.

- Observing assets: oceanographic data buoys, land-based meteorological stations, and high-frequency radars (HFR) for surface currents
- Forecast models: wave, wind, and currents
- [Yabucoa Port Dashboard](#)

##### Planned Activities

- High-resolution nearshore circulation model (FVCOM)
- Expand the HFR network towards the northeastern coast of PR

##### Opportunities

- Surface current maps for the San Juan-St. Thomas sea lane.
- More resilient HFR installations able to withstand a broad range of environmental conditions.
- Reduced HFR downtime due to power outages.

- Improved weather data and circulation forecasts near ports and harbors.
- Real-time metocean data, including profiles of current velocity, to help ensure safe vessel operations around entrances to major seaports in Puerto Rico and the US Virgin Islands.
- Simplified visual representations of data and forecasts pertinent to maritime and port operations.
- Improved ocean and coastal circulation models.

## 3.2 MITIGATE COASTAL HAZARDS AND THREATS TO HUMAN HEALTH

### Goals

Provide coastal information and decision support tools in support of coastal hazard prevention, preparedness, mitigation, and adaptation. Continue to expand, as required, the network of observing and modeling assets and capabilities that provide information on coastal weather, waves, currents, water quality, and storm surge inundation.

### Data and Information Needs Overview

Extreme weather and climate events have increased during recent decades. The governmental, private, ecosystem restoration, and tourism/recreational sectors expressed the need for an integrated data product, combining impacts of storm surge and freshwater inundation estimates on coastal areas. These sectors also emphasized the need to understand the vulnerability of natural coastal barriers at critical locations to extreme events and climate variability (e.g. sea level rise, increase in ocean temperature, pollutants, ocean acidification) and for a risk-based assessment of climate change and extreme events impacts on coastal zones at a regional scale. Given the potential of a tsunami landfall in coastal Caribbean waters and the vulnerability of coastal communities and infrastructure, most sectors communicated the need for an early tsunami detection system for Puerto Rico and the U.S. Virgin Islands.

Given the high incidence of drownings in the Caribbean, stakeholders from the state government, and the tourism/recreational sectors expressed the need for real-time monitoring and/or forecasting of beach conditions that may pose hazards to beachgoers. Real-time data may potentially reduce the alarming drowning rates in the region.

In an effort to protect beachgoers, recreational beaches across the nation are monitored for fecal indicator bacteria (*Enterococcus sp.*). Beach water quality monitoring in Puerto Rico has historically been maintained by the EPA through the PR Environmental Quality Board (within the Department of Natural and Environmental Resources, DNER), Surfrider Foundation and the Blue Flag program. Several water quality monitoring stations are also maintained by the San Juan Bay Estuary program. Federal and state government and tourism/recreational sectors established the need to increase the sampling frequency of already sampled sites and to incorporate new beach sites and beaches in the USVI into the program.

### Current Activities

CARICOOS' current products that address coastal hazards and human threats include:

- [DNER CZMP - CARICOOS Storm Surge Maps](#)
- [CARICOOS Breaker Height Forecasts](#)
- CARICOOS Pa' la Playa Beach App (for beachgoers)
- CARICOOS Boating App (for recreational boaters)
- [Beach Water Quality Map and Nowcasts](#)

### Planned Activities

- Expand the beach water quality monitoring to US Virgin Islands and include data on the CARICOOS website.
- Include San Juan Bay Estuary Program water quality monitoring data into the CARICOOS beach water quality map.
- Continue improvement of nearshore wave models.

### Opportunities

- Real-time observations of beach conditions that may pose hazards to beachgoers.
- Total inundation maps that include both: storm surge and freshwater inundation estimates.
- Long-term time series of beach evolution and shoreline changes in response to normal and extreme events at critical locations.
- Sensors and/or techniques for early tsunami detection.
- Risk-based assessment of climate change and extreme events impacts on coastal zones at a regional scale.
- Increased frequency and extent of beach water quality monitoring.

## **3.3 LIVING MARINE RESOURCES: MONITORING AND MANAGEMENT**

### Goals

Provide data products and services to aid state/federal agencies and NGOs in their mission of supporting Caribbean coastal ecosystems health, living marine resources and water quality.

### Data and Information Needs Overview

The federal and state government and ecosystem restoration sectors expressed the need to assess coastal barriers effectiveness in shoreline protection and vulnerability to climate variability (e.g. sea level rise, increase in ocean temperature, pollutants, ocean acidification). The need to understand emergent coral diseases and their relation to the hydrodynamics of the nearshore was expressed by the federal and state government and ecosystem restoration stakeholders. Most sectors, including federal, state and local government and tourism/recreational sectors, stressed the need to track sargassum accumulations along shorelines and to quantify H<sub>2</sub>S emissions that affect human health and coastal economy. The need for a sargassum arrival early warning product was also emphasized by stakeholders. Ecosystem restoration groups also stressed the need to assess how coastal accumulation of sargassum affect Caribbean nesting beaches and other critical habitats.

Monitoring and assessing marine debris and microplastics in the ocean and coastal Caribbean areas, in order to understand their extent and related impacts, was a need identified by stakeholders from federal and state agencies, academia/research and the ecosystem restoration sectors. Many sectors, including government, academia/research and ecosystem restoration, expressed the need to access high-quality marine biodiversity data sets in a consistent format and to implement ecosystem biomonitoring to document marine biodiversity (i.e. eDNA barcoding, meta barcoding). In addition, these stakeholders stated their need to understand nearshore hydrodynamics and its role in the dispersal of marine organisms, pollutants, and other substances (dissolved and particulate). Assessment of benthic assemblages and structure, fish monitoring, and marine mammal tracking were also expressed needs.

Most federal and state government and academia/research stakeholders discussed the need for vertical assessments of water quality and physical properties at critical sites, including high priority watershed conservation sites. The need for information related to the spatio-temporal variability in water quality parameters

(i.e. water temperature, salinity, optical properties, nutrients, turbidity) affecting the nearshore environment and essential fish habitats was also communicated.

Several environmental organizations, including NGOs, have been actively working on initiatives to evaluate the vulnerability of coastal barriers to hurricanes and climate change, and their role in ecosystem restoration projects (i.e. coral reef, mangrove, sand dunes). This sector can greatly benefit from access to information related to sea state conditions, coastal weather, ocean acidification, nearshore circulation, and water quality.

#### Current Activities

- [Seawater & atmospheric CO<sub>2</sub>](#)
- [Floating Algae Index \(USF\)](#)
- [SST & anomalies](#)
- [IOOS MBON - Puerto Rico Coral Reef Monitoring Program data](#)

#### Planned Activities

- Sargassum beaching/inundation forecast (Rutgers)
- Virtual (satellite-based) water quality buoys (USF)

#### Opportunities

- Bottom water quality and physical properties data collection.
- Monitor and assess marine debris and microplastics in the ocean and coastal areas.
- Assessments of the health and effectiveness of coastal barriers in shoreline protection and their vulnerability to climate variability (e.g., sea level rise, increases in ocean temperature, pollutants, and ocean acidification).
- Identify and emplace additional observational and modeling assets to support ecosystem management and restoration efforts.
- Fish monitoring and/or marine mammal tracking.
- Assessments of benthic assemblages and structure.
- Spatio-temporal assessments of nearshore water quality.
- Tracking and forecasting Sargassum blooms and beaching events.
- Advance IOOS biological observing component through biological data stewardship activities in the US Caribbean region.
- Ecosystem biomonitoring.
- Better understanding of marine organism dispersal patterns.
- Better understanding of emergent coral diseases and their relationship to the dynamics of the coastal environment.
- Monitoring of hotspots and quantification of H<sub>2</sub>S emissions by Sargasso.
- Monitoring the impact of Sargasso on turtle nesting sites and other critical habitats.

### **3.4 CLIMATE VARIABILITY**

#### Goals

The goals of the CARICOOS Climate Variability program are to document and report variations in ocean properties attributable to regional and extra regional climate processes with the potential to impact marine operations and increased coastal hazards.

### Data and Information Needs Overview

Our oceans influence both regional and extra-regional climate and weather processes, and their variability can fundamentally alter many of its properties and patterns, which may impact the sustainable management, conservation and restoration of coastal and marine ecosystems, the diversity and abundance of marine species, and the frequency, intensity and impact of extreme weather events. Changes in frequency and intensity of extreme weather events such as hurricanes, extratropical cyclones, storm surge and floods can be a significant hazard for coastal areas and habitats, which limits their capacity to recover and adapt.

Stakeholders in the coastal management sector have highlighted the need for an improved understanding of the role of climate change in our coastal ocean. CARICOOS proposes to initiate a comprehensive analysis of 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. All sectors also agreed that the continued collection of oceanographic data is vital to obtain long time series of the conditions of our coastal environment. CARICOOS will continue to provide support for a long-term sustained observing network to track ocean, weather, and marine ecosystem changes.

### Current Activities

- [CARICOOS Underwater Glider Program](#)
- [Seawater & atmospheric CO<sub>2</sub> observations in the La Parguera Marine Reserve](#)
- [Sea surface temperature anomaly detection using remote sensing and buoy data](#)

### Planned Activities

- Expansion of CARICOOS Underwater Glider operations.
- Increase in number of buoy assets across the region capable of measuring ocean chemistry and sea state.

### Opportunities

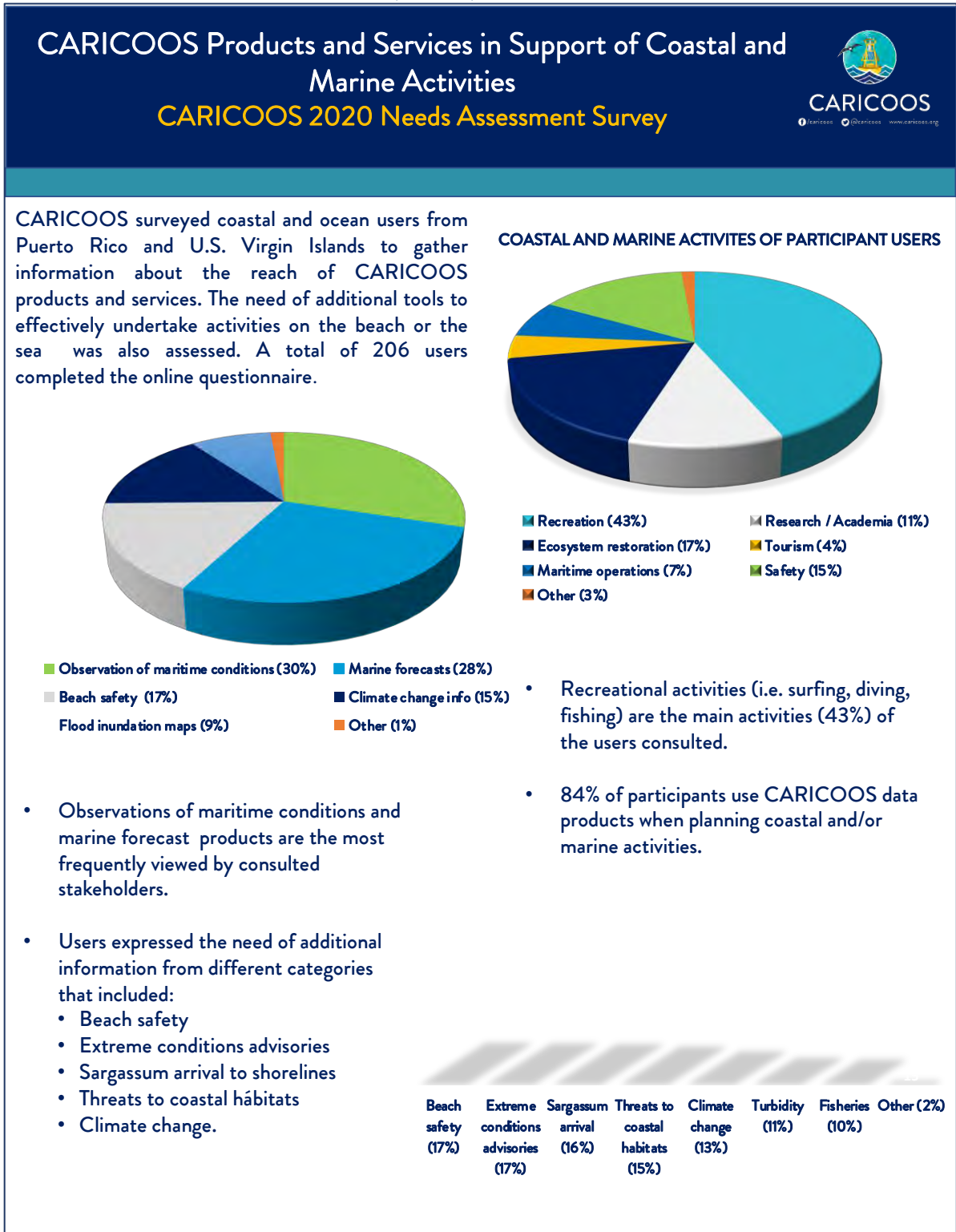
- Expand standard and event-driven underwater glider deployments to increase the range of physical, ocean biogeochemical and biological data being collected.
- Better monitoring techniques to resolve physical and biogeochemical gradients from inshore to offshore waters.
- Identify and assess climate-related risks and extreme events at a local scale.

## **4. CONCLUSIONS**

The needs assessment with stakeholders, representing the diverse sectors of coastal users in the US Caribbean region, has been a useful tool to document information about the use of current CARICOOS tools and needs of the coastal and ocean users in the region. This process facilitated prioritization of needs by programmatic areas and was essential for a transparent and efficient allocation of resources. Moreover, this inclusive and iterative stakeholder consultation process has proven crucial in strengthening users' trust and engagement and to advance the mission of the CARICOOS program.

5. APPENDIXES

A. CARICOOS DATA PRODUCTS AND SERVICES (SURVEY)






B. IMPACTS OF BEACHED SARGASSUM ON COASTAL OPERATIONS (SURVEY)


## Impacts of Beached Sargassum on Coastal Operations

### CARICOOS Needs Assessment Survey

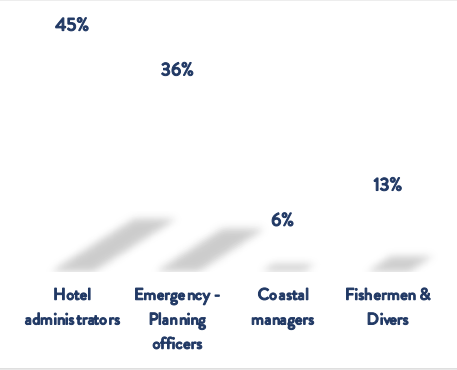



**CARICOOS**  
Facebook Twitter Website

Massive quantities of Sargasso has been arriving to the Caribbean since 2016. A total of 31 government officers, environmental managers, and private sector operators from 17 coastal municipalities in Puerto Rico, were consulted during the CARICOOS 2020 Needs Assessment process. Through these interviews we collected information regarding the impacts of seasonal arrival of Sargasso in coastal activities and the need of a product or tool for early warning of potential beaching events.




- Government (municipalities & coastal managers)
- Hotel Management
- Diving/Fishermen







**87%** of participants are aware of sargassum. Inundation events in the Caribbean.




**65%** of stakeholders expressed their coastal operations and services have been directly impacted by arrival of sargassum.



**84%** of interviewed population considers beached sargassum has detrimental or harmful impacts.

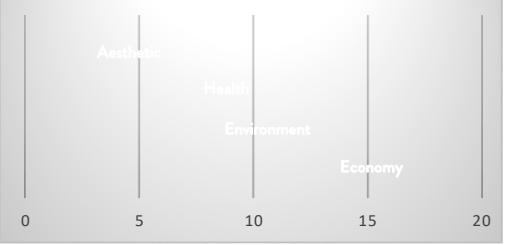


**74%** of survey participants classified accumulated sargassum impacts in moderate to severe.



**97%** of participants expressed the need of a near-real-time product for warning of potential beaching events.

Main impacts of beached sargassum were associated to adverse effects to the economy (i.e. tourism, fisheries, small commercial operations), environment and health.



## C. SUMMARY OF FINDINGS



# CARICOOS | USER NEEDS ASSESSMENT

CARIBBEAN COASTAL OCEAN OBSERVING SYSTEM

Identification and prioritization of stakeholder needs is essential to expand and improve ocean observing and forecasting services in the US Caribbean region as required for meeting stakeholder needs. To this end, the CARICOOS 2021-2026 strategic planning process has incorporated a comprehensive assessment of stakeholder needs yet to be fulfilled. A variety of approaches, including personal interviews, focus groups and surveys, were employed to identify needs of several user sectors. The table below is not exclusive, as we strive to continuously identify additional stakeholder needs.

Focus Area	Goals	User needs	Core Variables/Examples
<b>Safe and Efficient Maritime Operations</b>	Provide ocean information and decision support tools to enhance safety and efficiency of the full range of maritime operations taking place in the region.	<ul style="list-style-type: none"> <li>• Surface current maps for the San Juan-St. Thomas sea lane.</li> <li>• More resilient High-Frequency Radars (HFR) installations able to withstand a broad range of environmental conditions.</li> <li>• Reduced HFR downtime due to power outages.</li> <li>• Improved circulation and weather data and forecast near ports and harbors.</li> <li>• Real-time metocean data, including profiles of current velocity, to help ensure safe vessel operations around entrances to major seaports in Puerto Rico and the US Virgin Islands.</li> <li>• Simplified visual representations of data and forecasts pertinent to maritime and port operations.</li> <li>• Improved ocean and coastal circulation models.</li> </ul>	<p><b>Variables:</b> barometric pressure, bathymetry, currents (speed and direction), salinity, waves (height, period and direction), water levels, water and air temperature, wind speed and direction, optical properties of air and water.</p> <p><b>Examples:</b> solar power systems for HFRs; high-resolution coastal circulation and wind models; data dashboards; among others.</p>
<b>Climate Variability</b>	Document and report variations in ocean properties attributable to regional and extra regional climate processes with the potential to impact marine operations, coastal resources, and increased coastal hazards.	<ul style="list-style-type: none"> <li>• Expand standard and event driven underwater glider deployments to increase the range of physical, ocean biogeochemical and biological data being collected.</li> <li>• Better monitoring techniques to resolve physical and biogeochemical gradients from inshore to offshore waters.</li> <li>• Identify and assess climate-related risks and extreme events at a local scale.</li> </ul>	<p><b>Variables:</b> temperature, salinity, density, pCO<sub>2</sub>, pH, oxygen, DOC, among others.</p> <p><b>Examples:</b> AUV platforms, remote sensing, discrete water sampling and analysis</p>

### Coastal Hazards

Provide coastal information and decision support tools in support of coastal hazard prevention, preparedness, mitigation and adaptation. Continue to expand, as required, the network of observing and modelling assets and capabilities that provide information on coastal weather, waves, currents, water quality, and storm surge inundation.

- Real-time observations of beach conditions that may pose hazards to beachgoers.
- Total inundation maps that include both: storm surge and freshwater inundation estimates.
- Long-term time series of beach evolution and shoreline changes in response to normal and extreme events at critical locations.
- Sensors and/or techniques for tsunami detection.
- Risk-based assessment of climate change and extreme events impacts on coastal zones at a regional scale.

**Variables:** bathymetry, seabed characteristics, currents (speed and direction), heat flux, salinity, waves (height, period and direction), water levels, stream flow, temperature, wind speed/direction, contaminants, dissolved oxygen, ocean color optical properties, total suspended matter, barometric pressure, rainfall.

**Examples:** UAVs for shoreline monitoring, webcams for beach conditions, among others.

### Coastal Resources: Monitoring and Management

Provide data products and services to aid state/federal agencies and NGOs in their mission of supporting Caribbean coastal ecosystems' health, living marine resources, and water quality.

- Bottom water quality and physical properties data collection
- Monitor and assess marine debris and microplastics in the ocean and coastal areas.
- Assessments of the health and effectiveness of coastal barriers in shoreline protection and their vulnerability to climate variability (e.g., sea level rise, increases in ocean temperature, pollutants, and ocean acidification).
- Identify and emplace additional observational and modeling assets to support ecosystem management and restoration efforts.
- Fish monitoring and/or marine mammal tracking
- Assessments of benthic assemblages and structure.
- Spatio-temporal assessments of nearshore water quality.
- Tracking and forecasting Sargassum blooms and beaching events.

**Variables:** bathymetry, seabed characteristics, currents (speed and direction), heat flux, salinity, waves (height, period and direction), water levels, stream flow, temperature, wind speed and direction, ocean acidification, DOC, FIB, pollutants, dissolved nutrients, dissolved oxygen, ocean optical properties, total suspended matter, marine and ecosystem diversity and abundance, phytoplankton species and abundance, soundscape, zooplankton species and abundance.

- Advance IOOS biological observing component through biological data stewardship activities in the US Caribbean region.
- Ecosystem biomonitoring
- Satellite-based water quality virtual buoys
- Better understanding of marine organism dispersal patterns.
- Better understanding of emergent coral diseases and their relationship to the dynamics of the coastal environment.
- Increased frequency and extent of beach water quality monitoring.
- Monitoring of hotspots and quantification of H<sub>2</sub>S emissions by Sargasso
- Monitoring the impact of Sargasso on turtle nesting sites and other critical habitats.

**Examples:** eDNA; water quality buoys or platforms; instrumented FADs; H<sub>2</sub>S sensors; turtle nesting distribution maps; among others.