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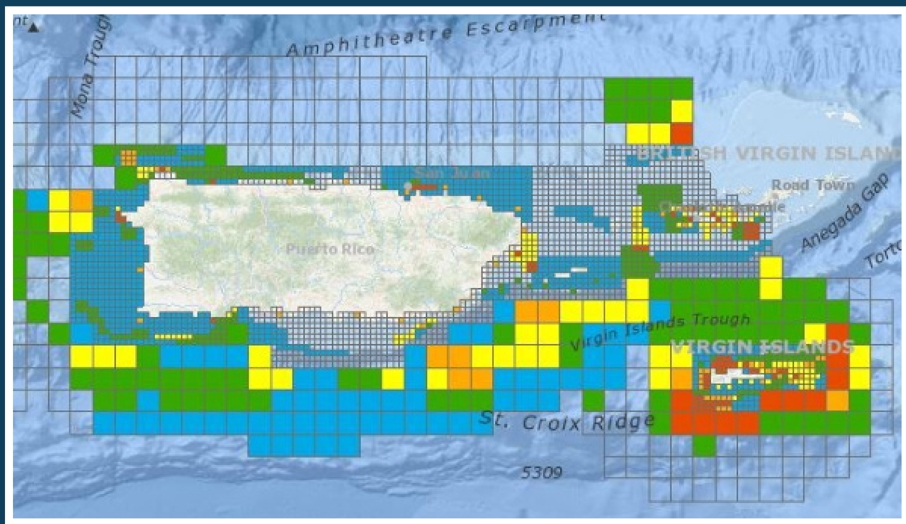
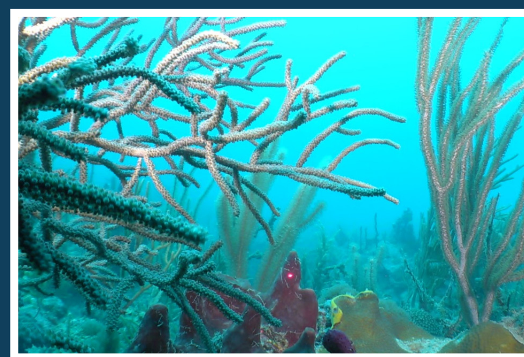
Prioritizing Areas for Future Seafloor Mapping and Exploration in the U.S. Caribbean





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Prioritizing Areas for Future Seafloor Mapping and Exploration in the U.S. Caribbean

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NOAA NOS NCCOS TECHNICAL MEMORANDUM 286

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Executive Summary

Spatial information about the seafloor is critical for decision-making by marine research and management organizations. These organizations are tasked with ensuring safe navigation, sustainable fisheries, smart renewable energy, and sound ecological stewardship in U.S. coastal and marine waters. Coordination among these research and management organizations can help them efficiently leverage resources to map and explore unknown seafloor areas in support of their individual objectives, mandates, and missions. Effective coordination requires that these organizations understand where and when their priorities overlap with others operating in the same regions.

This project works with local participants to identify priority areas for future mapping, sampling, and visual surveys. To build the framework for the online prioritization application, the U.S. Caribbean territories of Puerto Rico and the U.S. Virgin Islands (USVI) were divided into offshore and nearshore sub regions. Offshore regions were further divided into 10 x 10 km grid cells, and nearshore regions divided into 2.5 x 2.5 km grid cells. In addition to this spatial grid, existing relevant spatial datasets (e.g., bathymetry, remotely operated vehicle, dive locations, etc.) were compiled to help participants understand information and data gaps and to identify areas to prioritize for future data collections. An online application was developed using Esri's Web AppBuilder to display the spatial grids and datasets. Fifteen participants from federal, territory, and academic organizations entered their priorities in this online application by placing virtual coins in grid cells. Grid cells with more coins were higher priority than cells with fewer coins. Participants also reported why these locations were important and what data types were needed. Results were pooled, analyzed, and mapped to identify relationships between priorities, rationale, and data needs.

A total of 15 respondents provided their mapping priorities. This input resulted in fifteen high priority locations that were broadly identified for future mapping and visual surveys. These priority locations were broadly distributed throughout the project area, except for southwest Puerto Rico. These locations include: a coastal and offshore location in northwest Puerto Rico (Punta Jacinto to Punta Agujereada), coastal Rincon, San Juan, Punta Arenas (west of Vieques Island), southwest Vieques, Grappler Seamount, southern Virgin Passage, north St. Thomas, east St. Thomas, south St. John, and the entire coast of St. Croix. Participants consistently selected (1) *Biota/Important Natural Area*, (2) *Commercial Fishing* and (3) *Research* as their top reasons (i.e., justifications) for prioritizing locations. Participants also consistently selected (1) *Benthic Habitat Map* and (2) *Photos/Videos* as their top data needs.

In addition to this analysis, recommendations on future mapping missions are given based on participant feedback in areas of high priority. These recommendations will help support collaborative efforts across all federal, territory, and academic institutions in the U.S. Caribbean. The resulting map layers developed for this project have been published to NOAA's U.S. Mapping Coordination website. This website allows users to upload their latest data collections and collectively track their overall progress towards mapping key priority areas identified in this effort. Data was also uploaded to NOAA's Zenodo archive and published as an ArcGIS map service, which can be viewed using an application on ArcGIS online (NOAA NCCOS, 2019). Together these tools and information will enable stakeholders to efficiently leverage resources and coordinate the mapping of high priority locations across the U.S. Caribbean.

NOAA's Coral Reef Conservation Program (CRCP) supported this project. Their mission is to study and provide scientific information needed to conserve and manage coral reef ecosystems, like the one pictured above. Credit: NOAA NCCOS

Results from this effort can be used to drive various mapping efforts, including the annual Essential Fish Habitat mapping cruise aboard the NOAA Ship Nancy Foster (scientists from mapping cruise pictured above). Photo Credit: NOAA/NCCOS

Chapter 1 Introduction

1.1 Background

Spatial information about the seafloor is critical for environmental decision-making by academic, marine science, and coastal management organizations. These organizations serve a variety of mandates and are tasked with ensuring safe navigation, promoting sustainable fisheries, understanding marine hazards, and exploring unknown locations. While these organizations are responsible for ensuring sound ecological stewardship and conservation in U.S. coastal and marine waters, collecting spatial information about the seafloor is expensive, logistically intensive, and time consuming. Collection often requires research vessels and expensive seafloor mapping equipment including sonar (sound navigation and ranging) and remotely operated vehicles (ROVs), making the collection of seafloor data challenging for individual organizations to execute. To overcome these challenges, developing a network of partners and coordinating their data needs can help multiple organizations leverage collective resources and acquire seafloor data that can be used to support a wide range of organizational objectives, mandates, and missions. In the U.S. Caribbean, almost 270,000 km^2 has been mapped using various acoustic and lidar (light detection and ranging) methods. However, much of this data is outdated and in poor quality. Thus, there is a need to assess data availability, quality, and specific organizational needs to prioritize where future mapping efforts should take place.

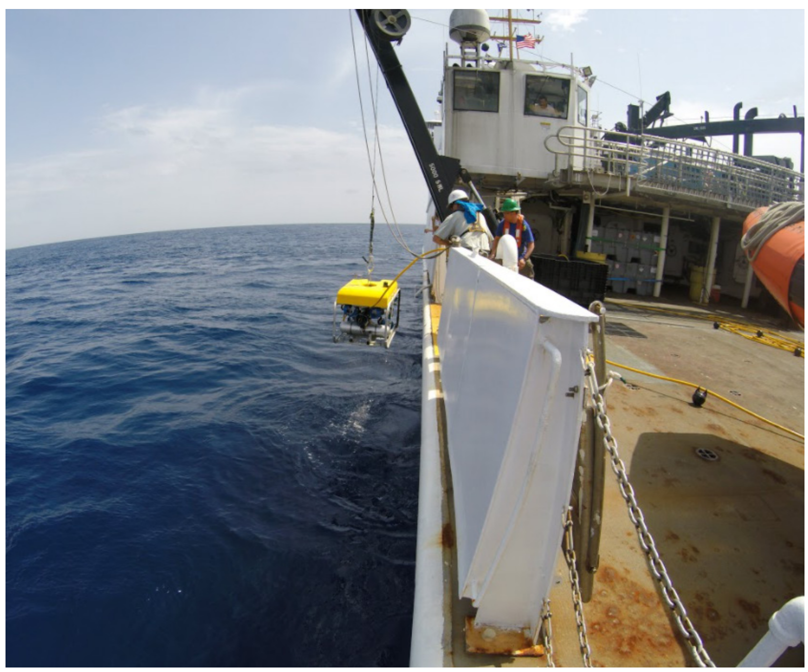
The work described in this report provides the U.S. Caribbean community, resource agencies, and other participating organizations, with information needed to: (1) help organizations better understand how their priorities align with other U.S. Caribbean partner needs; (2) better position participating organizations to more efficiently coordinate across projects; and (3) enable partners to leverage assets and resources to fill their most pressing data gaps.

1.2 Spatial Prioritization Process

To help fill these information gaps and promote coordination across organizations, National Oceanic and Atmospheric Administration (NOAA)'s National Centers for Coastal Ocean Science (NCCOS) developed a spatial framework and online tool to identify common research priorities across partner organizations. This utilizes a graphical user interface where participants enter their priorities using a customized suite of selected tools and pull-down menus to record their organizational needs and priorities. This tool provides a framework to collect and summarize answers to questions that are critical for mission planning, including:

- Where are these important locations?
- Why are these locations important?
- How quickly are data needed?
- What types of data products are needed?
- Who are potential project partners?

The method for this approach contains six main steps that are taken from several similar efforts done by NCCOS (Battista and O'Brien, 2015; Battista and Christensen, 2017; Kendall et al., 2018; Costa et al., 2019). These steps are described in detail in Chapter 2 of this report. This approach has been successfully applied in several regions throughout the U.S., including: West Continental U.S. Coast (WCC; Costa et al., 2019), Lake Michigan (Kendall et al., 2018), Thunder Bay (Kendall et al., 2020), southern California (Freedman et al., 2016), Washington state (Battista et al., 2017), and Long Island Sound, New York (Battista and O'Brien, 2015).



Missions to collect mapping, sampling, and visual surveys are conducted by several ships and organizations. Since 2005, NCCOS has been collecting acoustic bathymetry and backscatter data and deploying an ROV to collect ground truthing data aboard the NOAA Ship Nancy Foster. *Photo credit: NOAA*

1.3 Spatial Prioritization for the U.S. Caribbean

In 2019, NCCOS implemented this well-established spatial prioritization process in the U.S. Caribbean territories of Puerto Rico and U.S. Virgin Islands (USVI; Figure 1.1). The goal was to identify and summarize spatial priorities for seafloor mapping, sampling, and visual surveys in coastal and offshore waters in the U.S. Caribbean (out to the 24 nm contiguous zone). Seafloor mapping was defined as using acoustic, satellite, or lidar data to make maps of the surficial seabed and/or sub-bottom features. Biological and physical sampling included using ROVs, cores and bottom grabs to collect materials from the seafloor. Visual surveys included collecting underwater videos and/or photographs using drop cameras, towed camera sleds, ROVs and autonomous underwater vehicles (AUVs), or other camera platforms.

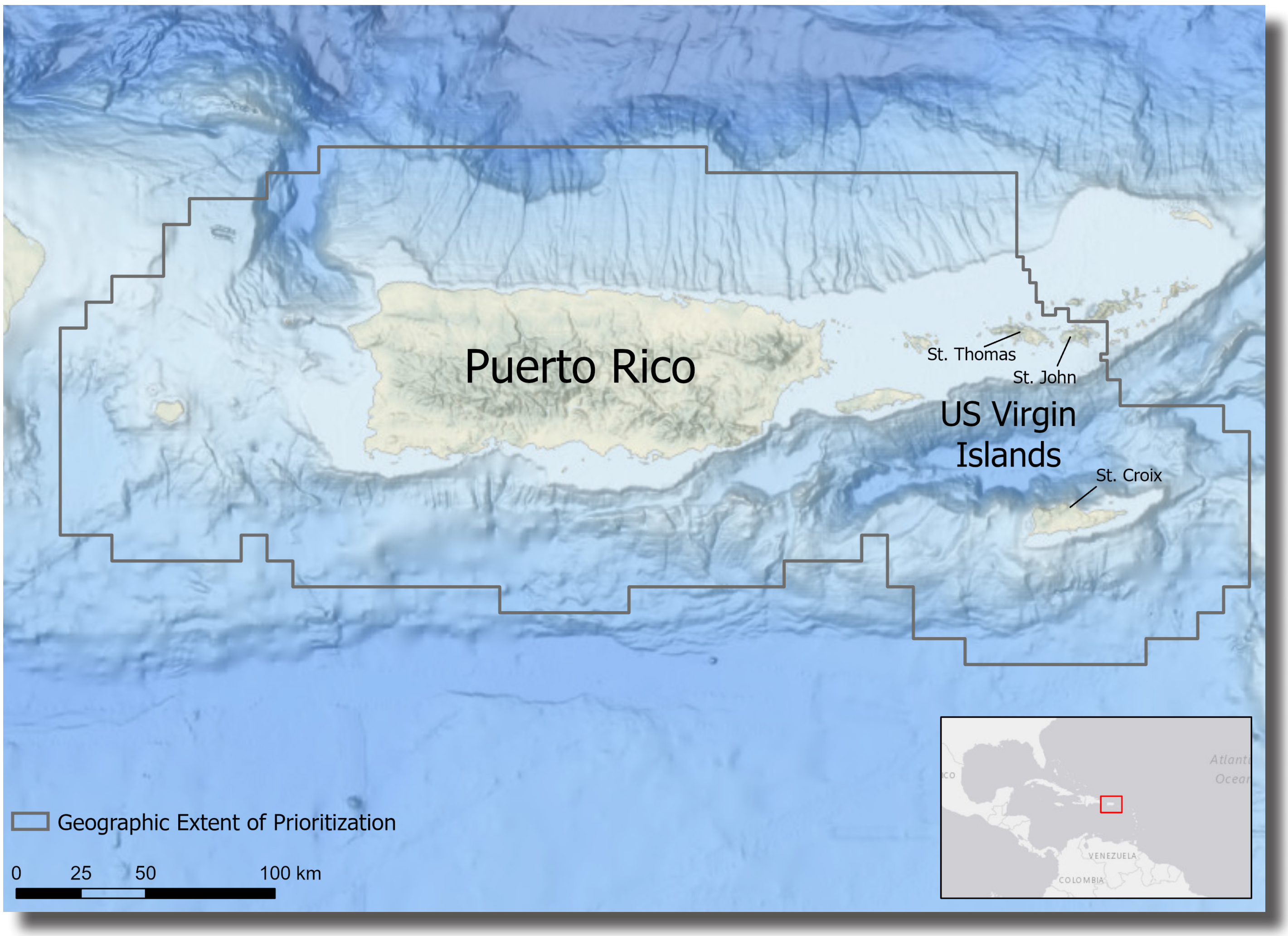


Figure 1.1. ***Geographic extent of U.S. Caribbean Prioritization.*** Map of the U.S. Caribbean spatial prioritization extent, which includes Puerto Rico and U.S. Virgin Islands (USVI). The black polygon shows the geographic extent of the prioritization effort.

Chapter 2 Methods

This chapter discusses each of the six steps developed by previous prioritization efforts and were applied to the U.S. Caribbean.

2.1 Step 1: Select Participants

The first step in this process was to identify the technical advisory team and participants for the prioritization effort. The technical advisory team consisted of four regional liasons of CRCP who equally represented Puerto Rico and the USVI. An initial draft list of participants was generated by NCCOS, which included federal, territory, and local jurisdictional partners who had a direct stake in mapping in the U.S. Caribbean. This initial list was reviewed and refined by the advisory team to select one participant from each NOAA programmatic office or external organization. The advisory team also made recommendations on additional local organizations to participate in the project. In total, 23 participants were invited to represent their organization and provide their seafloor mapping and visual survey priorities online (Appendix, Table A.1). These participants had various levels of expertise in geology, coastal hazards and mitigation, coral reef conservation, coastal restoration and resilience, fisheries management, coast survey, and local jurisdictional mandates.

2.2 Step 2: Develop Framework, Compile Data, and Create Online Application

2.2.1 Develop Framework

In order to develop the spatial framework, the project's geographic area (Figure 1.1) was divided into four subregions. The project area was first divided geographically between the two island groups, Puerto Rico and USVI along their officially recognized boundary. Each of these areas were further divided into nearshore and offshore zones, with the nearshore boundary at the 100 m isobath (along the insular shelf), and the offshore boundary set to the 24 nm contiguous zone (Figure 2.1a). Some participants may not be interested in the entire U.S. Caribbean, so dividing the project area allowed for flexibility in choosing their regions of interest while minimizing the burden on participants when entering their priorities online. These zones were further divided into square grid cells, 2.5 x 2.5 km nearshore and 10 x 10 km offshore. The size of these grid cells were chosen to give participants the smallest spatial unit possible to indicate their priorities, while keeping a manageable number of total cells to choose from.

2.2.2 Compile Data

Existing seafloor mapping data were compiled to help participants understand the extent of mapping information, locate data gaps, and to identify areas to prioritize for future data collections. These spatial layers included a wide range of information about the marine environment in the U.S. Caribbean. An inventory of existing seafloor mapping surveys and benthic habitat maps was provided, so users could see the coverage, sensor type, and derived products (i.e., habitat maps) available (Figure 2.2). Also included were existing political and administrative boundaries such as marine protected areas (MPAs). In situ datasets included U.S. Geological Survey (USGS) core samples, coral reef monitoring sites, and optical validation sites (ROV dives, drop camera sites). The technical advisory team reviewed and approved of these datasets and made any necessary additions or recommendations. These final datasets and web mapping services were subsequently published in an online application (see Section 4.3).

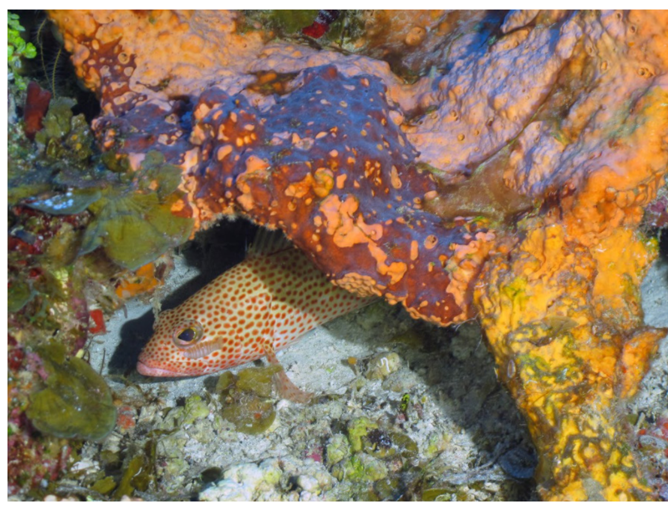


Photo credit: NOAA NCCOS

2.2.3. Create Online Application

The online application used by participants to identify their priority areas was created using Esri's Web AppBuilder (Esri, Redlands, CA). An application was created for each subregion and was designed to enable participants to view and interact with existing spatial data and to enter their data priorities. Each application consisted of two main components: (1) a data viewer (described in Section 2.2.2), and (2) the spatial prioritization widget (Figure 2.3). The widget is the online graphical user interface where participants enter their priorities using a customized suite of selected tools and pull-down menus to record their organizational needs and priorities.

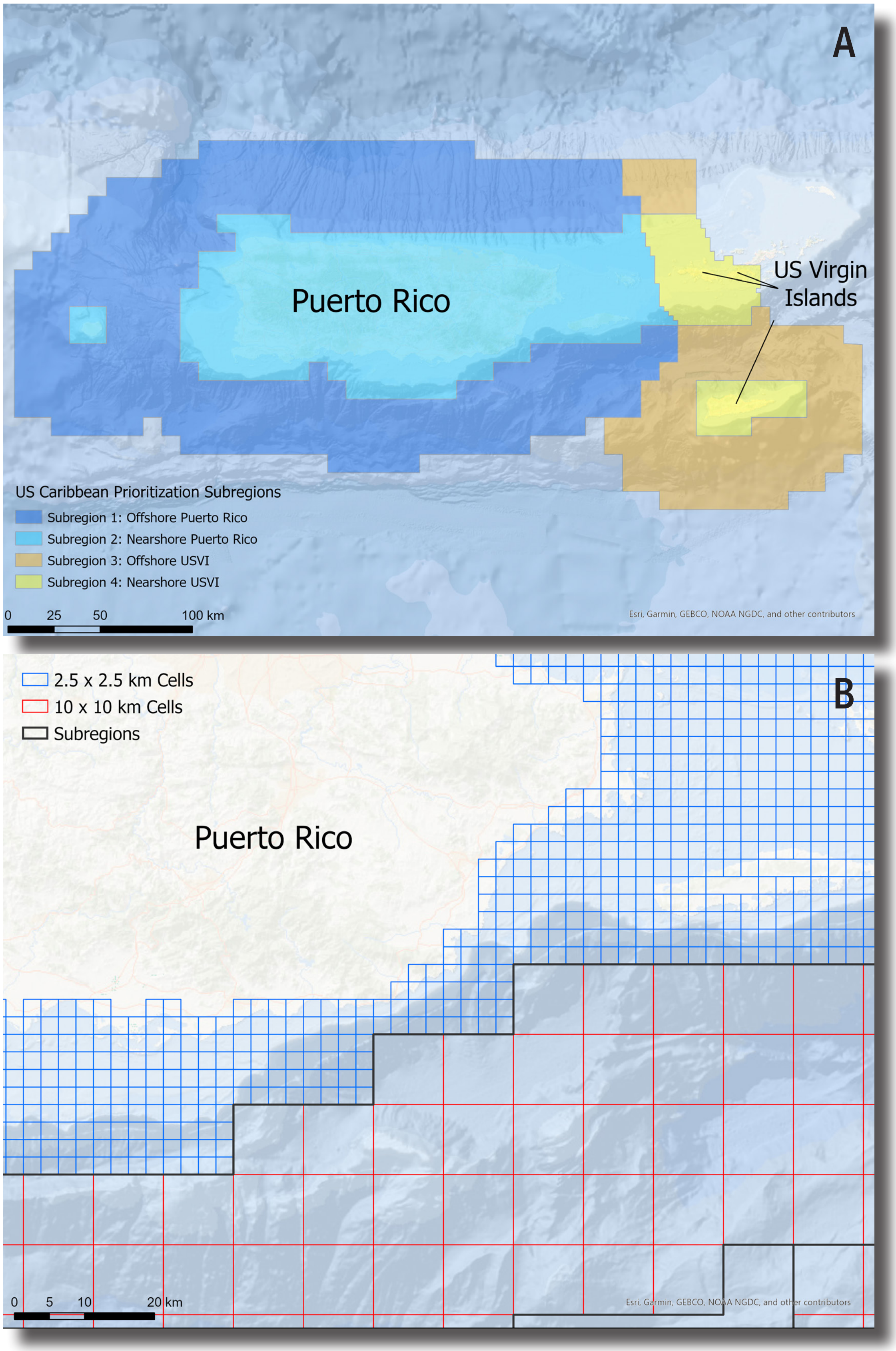


Figure 2.1. (A) Four subregions of the U.S. Caribbean: nearshore/offshore Puerto Rico and nearshore/offshore USVI. (B) Close up of the nearshore (2.5 x 2.5 km) and offshore (10 x 10 km) grid cells.

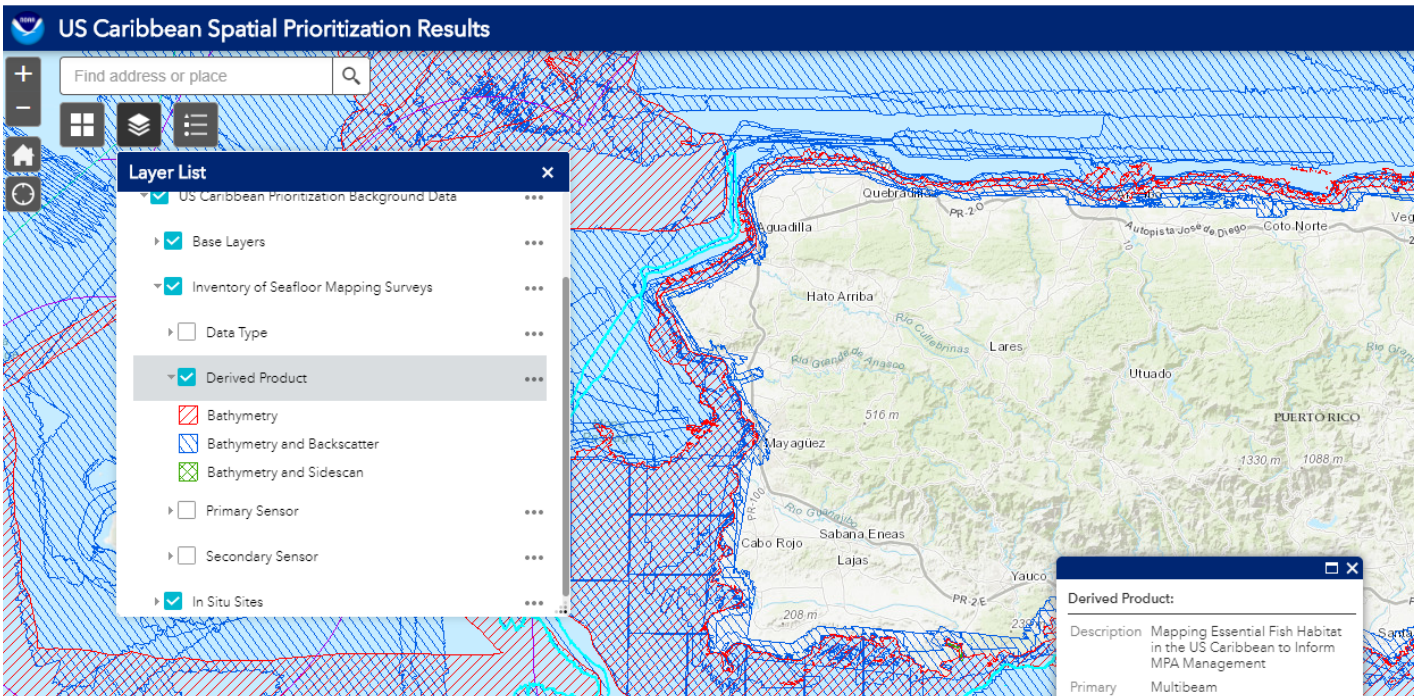


Figure 2.2. Relevant spatial data compiled to help understand available information and data gaps. This map shows a footprint of all available data collected in the U.S. Caribbean by NOAA and other agencies. When a polygon is selected, a pop-up appears with a detailed description of that dataset.

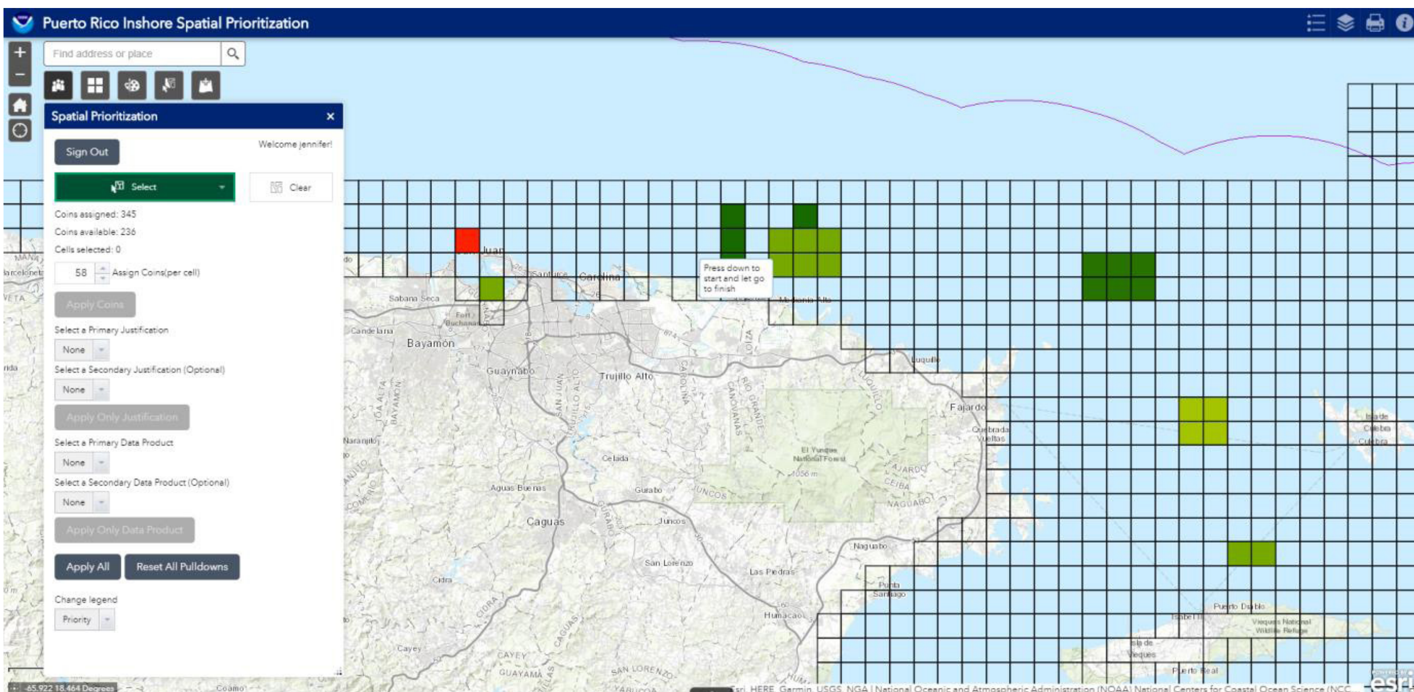


Figure 2.3. The ArcGIS online data viewer with the spatial prioritization widget (left side of image). This example shows the nearshore Puerto Rico subregion.

2.3 Step 3: Participants Enter Priorities Online

Participants were provided a training webinar in June 2019. After receiving a web link and unique login information, participants entered their data needs and priorities at their convenience from any internet-connected computer. Participants were given two weeks (June 28–July 12, 2019) to enter their seafloor mapping and visual survey data needs within the identified regions of the U.S. Caribbean.

2.3.1 Allocation of Coins

Each participant entered their data needs and priorities in the online application for each subregion. Participants were sent a web link and unique login ID, which let participants enter their priorities at their convenience from any computer with internet connection. A separate online application was created for each of the four subregions, however they were not required to input in all subregions. Each participant was given a set number of virtual coins to indicate their priorities, which equaled approximately one third of the cells in the subregion. The maximum number of coins differed by subregion due to the difference in size and subsequent number of cells (Table 2.1). While there were no restrictions on where coins could be placed within each subregion, participants were restricted to placing a maximum of 10% of their coins in a single grid cell. The restrictions on coin loading were specifically designed to ensure that participants' needs were comparable (i.e., everyone spent the same number of coins) and to distribute their priorities more broadly than one or two focus areas (i.e., increasing the chance of overlap among participant needs).

Table 2.1. *Cells and Coins by Subregion.* Table showing the number of grid cells, virtual coins and maximum number of coins that could be allocated to a single cell in each subregion.

Subregion	*Total # Cells*	*Total # Coins*	*Max # Coins per Cell*
1 – Offshore Puerto Rico	329	109	11
2 – Nearshore Puerto Rico	1744	581	58
3 – Offshore USVI	109	36	4
4 – Nearshore USVI	643	214	21
Total	2825	940	-

2.3.2 Selection of Priority Areas

Participants allocated their coins to grid cells they selected using the prioritization widget (Figure 2.3). The widget allowed participants to assign, edit and move their selections (coin placement) as often as they liked until the prioritization deadline. Guidance was provided to participants on how their placement of coins translated into levels of priority importance. Specifically, cells with 8–10% of their coins indicated an immediate need for spatial data, 4–7% of coins indicated a need in the next 2–4 years, 1–3% of coins indicated a need in the next 5–10 years, and 0 coins indicated data was not needed for more than 10 years. By assigning more coins to a cell (up to the 10% limit), participants could indicate the priority level and how quickly they need data. Once coins were assigned to a cell, the prioritization widget displayed the number of coins participants had remaining.

2.3.3 Justification and Product Needs of Priority Selection

In addition to choosing how many coins to allocate, participants were also asked to justify why these areas were of interest to them and their organization. Participants could choose from a list of 12 pre-defined **Justifications** (Table 2.2), which were customized by the technical advisory team. They could choose up to two (primary and secondary) justifications using pull-down menus in the prioritization widget. The default justification was set to *None*, which indicated that no justification was selected. The justification *Other* was also available, if the reason for a data need was not adequately described by this list. Participants who chose *Other* were asked to explain their data needs via email.

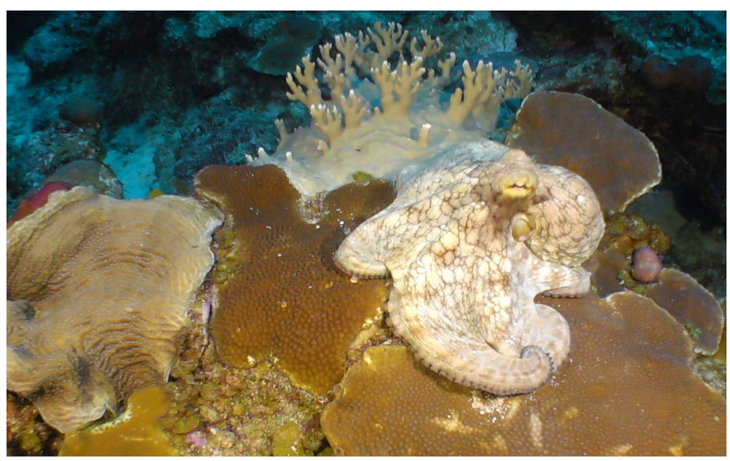


Photo credit: NOAA NCCOS

Lastly, participants were asked to describe what type of seafloor information and datasets were needed in their areas of interest. These datasets were referred to as **Products**. Participants could choose from a list of five products (Figure 2.3, Table 2.3), which were also customized by the technical advisory team. They could choose up to two (primary and secondary) products using the prioritization widget. The default product was also set to *None*, which also indicated that no product was selected. The option *Other* was also an available product, if a need was not adequately described by this list.

Table 2.2. *Justifications.* The list of justifications that participants could select when entering their priorities online.

Justification	*Definition*
1. *Exploration*	Knowledge gap or general lack of seafloor information
2. *Biota/Important Natural Area*	Spawning/nursery area, feeding grounds, key benthic habitats and other ecologically important areas
3. *Coastal/Marine Hazards*	Tsunamis, storm surges, sea level rise, faults, landslides and other hazards
4. *Cultural Heritage & Historical Maritime Resources*	Shipwrecks and other cultural/historic resources
5. *Energy*	Existing or potential energy development and infrastructure (e.g. cable, pipeline, or wind turbine)
6. *Commercial Fishing*	High bycatch areas, popular commercial or charter fishing destinations
7. *Recreational Fishing*	Popular recreational fishing destinations
8. *Geology*	Erosion, deposition, sediment physical properties and critical mineral deposits
9. *Marine Managed Areas*	Marine protected areas, essential fish habitat, other managed areas and permitting needs
10. *Non-Consumptive Human Use*	Diving, boating, swimming and other recreational activities
11. *Nautical Charting*	Ensuring safe navigability of shipping lanes, ferry routes, port facilities and marinas
12. *Research*	Scientific research and monitoring
13. *Other*	Other justifications
14. *None*	No justification selected, default

Table 2.3. *Products.* Participants were asked to choose from five desired data products, describing what specific data and information they needed in their selected grid cells.

Product	*Definition*
1. *Benthic Habitat Map*	Synthesized using bathymetry, backscatter, and underwater photographs/videos
2. *Shoreline characterization*	Description of the land water interface, such as habitat and soil erosion/accretion
3. *Biological or Physical Samples*	Collected using ROVs, cores, grabs
4. *Sub-bottom Profiles*	Collected using sub-bottom profiling sonar
5. *Underwater Photographs/Videos*	Collected using ROVs AUVs or other camera platforms
6. *Other*	Other data products not listed
7. *None*	No product selected, default

2.4 Step 4: Summarize Priorities and Conduct Spatial Analysis

As participants entered and edited their selections, their responses were continuously saved to an online database. At the end of the data entry period, this information was downloaded, quality controlled, summarized, and analyzed (as described below) to identify collective priorities in the U.S. Caribbean.

Photo credit: NOAA NCCOS

2.4.1. Data Compilation and Quality Control

All quality control and data summarizations were performed in R (version 3.6.1, R Core Team, 2019). This quality assurance process confirmed each participant allocated all of their coins for each subregion of interest (not all subregions were prioritized by each participant) and that no participant allocated more than 10% of their coins in a single cell. Once coin values were confirmed, cells with zero coins were examined to ensure no justifications and/or products were selected. If any cells with zero coins included justifications and/or products, they were reset to *None* (default). Lastly, it was confirmed that no participant selected the same justification or product at multiple levels for a single cell. If this occurred, the repeated justification or product was replaced with *None*.

2.4.2. Summarize Justifications and Products

To determine which justifications and products were most commonly selected, the total number of coins were summed separately for each justification (at any priority level) within each subregion, and across the Caribbean region overall. For example, coins in the USVI nearshore subregion were counted towards 'Recreational Fishing' if that justification were chosen at the primary or secondary level. Additionally, coins were tallied for each justification and map product across the entire U.S. Caribbean. Coins from cells with no selected justification and/or product were not included in these totals. The relative proportions of coins allocated under each justification and product option were visualized using stacked bar plots.

2.4.3 Identify Cells of Highest Priority for Future Mapping

Data were summarized in several ways to understand how coins were allocated overall, within different sub-groups of participants, and within justifications and products (Kendall et al., 2018; Costa et al., 2019). The simple sum of all coins (from all participants) was calculated in each grid cell. Tallies were also produced for the number of participants allocating at least one coin in each grid cell, the number of different justifications, and the number of products that occurred in each cell. Coins were also tallied under each justification and product, within each grid cell, and across participants. The data were also partitioned into subsets to measure priorities within different groups of participants. These groupings included: federal, non-federal, Department of Interior, NOAA, NOAA's National Ocean Service (NOS) and National Marine Fisheries Service (NMFS). Coins from within these subsets were summed for each grid cell.

Next, coin values were standardized within each subregion and used to identify spatial patterns across the entire project's geographic area. The number of coins were standardized within these groups for multiple reasons. First, the nearshore and offshore grid cells were different sizes. Second, because the subregions were different sizes, they also had a different number of grid cells and available coins. Lastly, different numbers of participants provided input in each subregion. To account for these differences, the number of coins within a grid cell were divided by the total coins within the subregion to calculate a relative percent. This process was repeated for coins under each justification and product within the subregion. Coins allocated within groups of participants were standardized the same way. The number of participants allocating coins to a single cell were also standardized by dividing by the total number of participants within the subregion.The top five and ten percent of cells with coins were identified and highlighted using the *quantile()* function in R. Maps were created for each group of participants (n=8; Appendix), justification (n=11) and product (n=5) showing their standardized coins values and their associated spatial priorities.

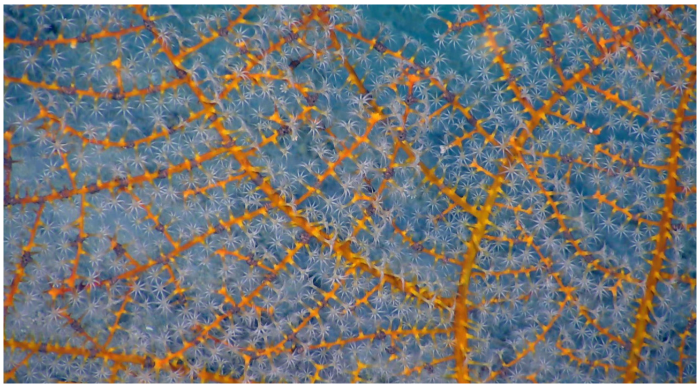


Photo credit: NOAA NCCOS

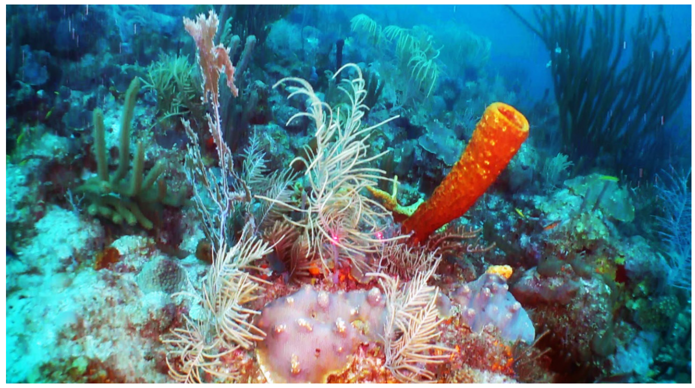


Photo credit: NOAA NCCOS

2.4.4 Identify High Priority Locations

Using the standardized number of coins, high priority locations were determined by the highest number (top 10% and 5%) of coins by participants. To further refine the discussion, clusters of high priority cells were identified as groups of three or more nearshore cells and two or more offshore cells. In some locations (i.e., St. Croix), high value nearshore and offshore cells were adjacent to each other and therefore combined into one high priority location.

2.5 Step 5: Participants Review and Finalize Priorities

Preliminary maps and results were distributed to all participants to request any initial thoughts and feedback. A webinar was also held with participants and anyone interested in viewing the results, during which maps were presented with an open discussion with viewers. Once all initial feedback was received, the results were finalized and published online (see Section 2.6). A meeting was then scheduled with each individual respondent to discuss their input and gather more detailed feedback on their specific spatial needs (Section 4.1).

2.6 Step 6: Publish Results Online

Final maps and results were published online in a few different ways, ensuring results are more easily accessible. Map layers were published as a map service on the NOAA National Centers for Environmental Information (NCEI) server, which can be ingested by other online mapping portals (NOAA NCCOS, 2020). The resulting maps and data were submitted to Zenodo, an online data repository approved by NOAA for this type of dataset, for long-term preservation and public access. Finally, the resulting map services were ingested by and published in NOAA's Integrated Ocean and Coastal Mapping (IOCM) U.S. Mapping Coordination website (NOAA IOCM, 2020). IOCM's website also provides the ability to track progress towards addressing the priorities identified here.

Chapter 3 Results

Fifteen participants entered priorities into the online application, allocating a combined total of 10,519 coins across the U.S. Caribbean. Twelve participants submitted priorities in Puerto Rico (12 in nearshore zone, seven in offshore zone), and twelve responded in the USVI (12 in nearshore zone, six in offshore zone). Some participants made selections entirely on their own, whereas others consulted with their colleagues to make selections. It is unknown how many, and to what extent, participants used specific data layers in the data viewer or independent datasets to assist with their selections.

3.1 Spatial Patterns of Summarized Coins

The summarized number of coins per cell were plotted for nearshore (Figure 3.1a) and offshore (Figure 3.1b) Puerto Rico and USVI. For the Puerto Rico nearshore subregion, three small groups of high value (top 5%) coins were located along the northern coastline, one group off the west coast, two groups off the east coast, and one cell off the south coast. High value cells were broadly distributed around St. Thomas and St John, with a larger concentration of cells around St. Croix. For the offshore zone, only a few clusters of cells with the top 10% were located around Puerto Rico. This is likely due to standardizing the coin values between Puerto Rico and USVI. The majority of the top 10% and 5% were located around St. Croix, with one high value cell north of St. John.

3.2 Spatial Patterns of Participating Organizations

Participants independently identified many of the same locations for future mapping, sampling, and visual surveys. For the nearshore zone, the largest number of participants (top 5%) most commonly chose cells in these locations: northwest offshore Puerto Rico (coastal and offshore Punta Agujereada), Rincon, San Juan, along the deep sea ridge both off western and south-southwest Puerto Rico, and various locations around St. Thomas and St. Croix (Figure 3.2a). For the offshore zone, the largest number of participants (top 5%) were only observed around the west, south, and eastern sides of St. Croix (Figure 3.2b). For maps showing the number of coins allocated by participants refer to the US Caribbean Spatial Prioritization Results Application (NOAA NCCOS, 2020).

Individual discussions were conducted with each organization's respondent to obtain a more detailed narrative on their specific spatial needs. Feedback results are detailed in the Discussion (Section 4.1).

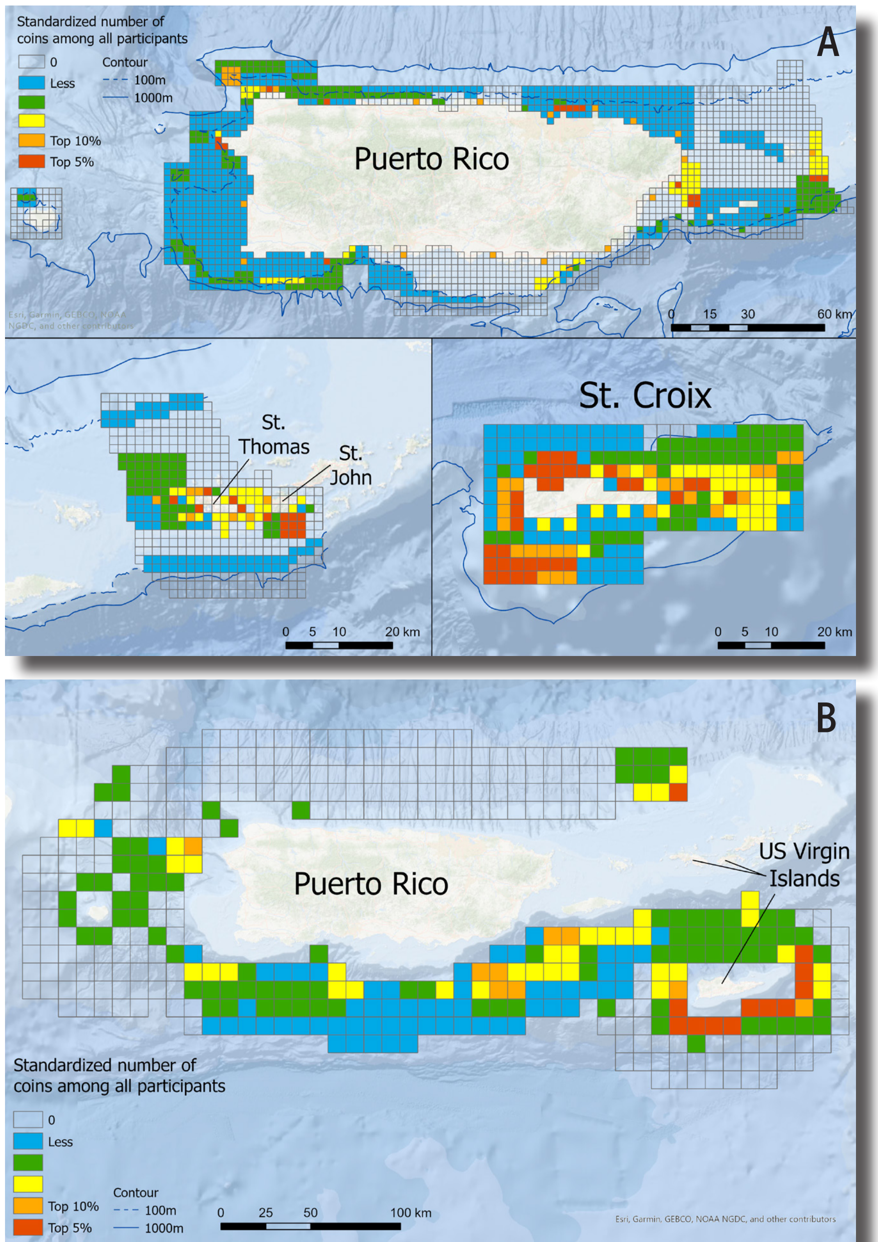


Figure 3.1. Map showing the standardized number of coins allocated in each grid cell for the (A) nearshore and (B) offshore subregions. Cells with the top 5% (red) and 10% (orange) of coins denote the highest priority for participants.

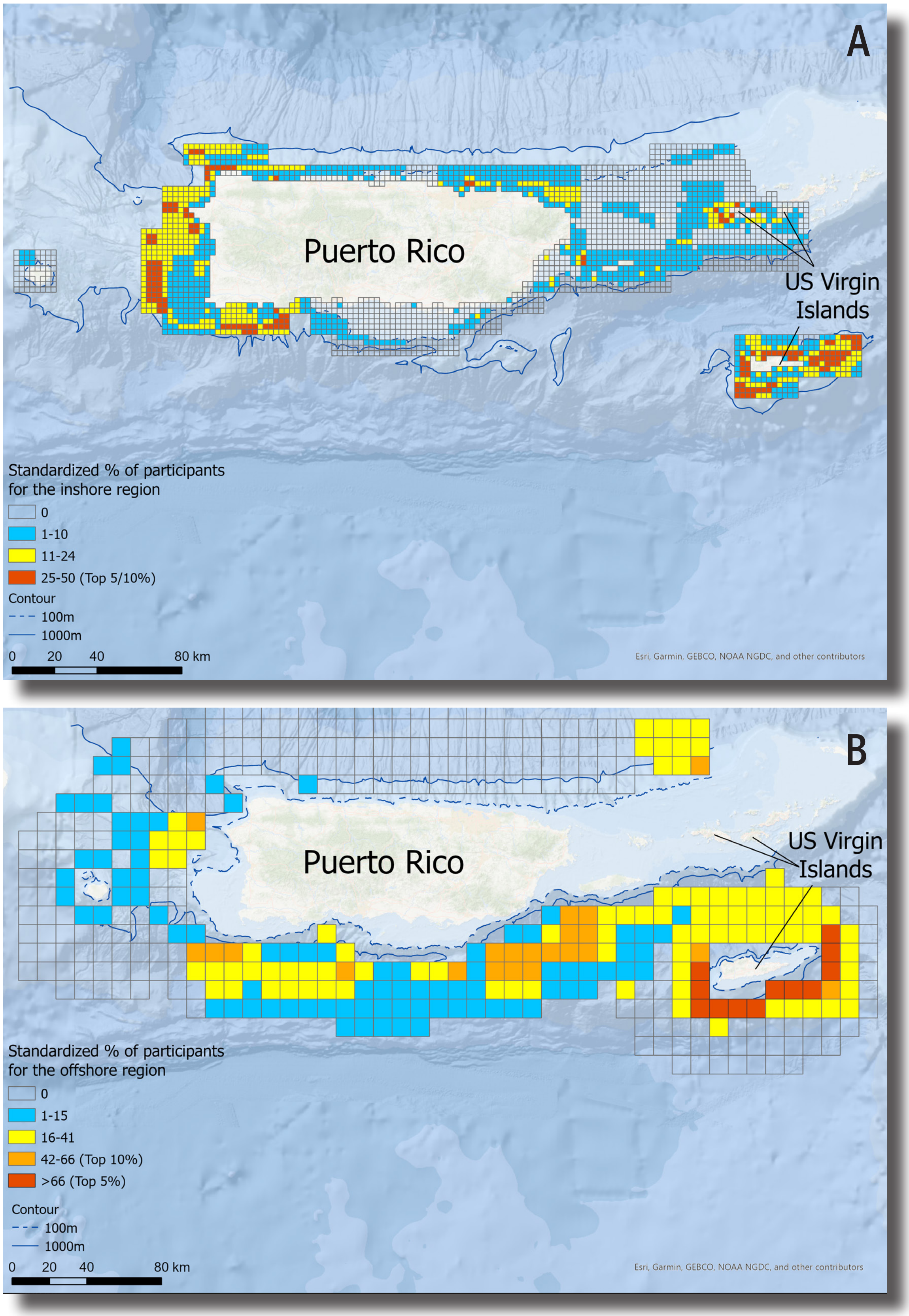


Figure 3.2. ***Percent Participants.*** Standardized percent of participants that allocated coins in the same grid cells for the (A) nearshore and (B) offshore zones.

3.3 Justifications and Products Most Commonly Selected

Participants consistently selected three justifications as their top reasons for prioritizing grid cells: *Biota/Important Natural Area*, *Commercial Fishing,* and *Coastal/Marine Hazards*. These three made up 64% of justifications listed across the entire U.S. Caribbean study area (Figure 3.3). Other commonly selected justifications were *Exploration*, *Research*, and *Marine Managed Areas*, which made up 26.5% of the justifications selected (Figure 3.3). *Recreational Fishing*, *Geology*, *Energy*, *Non-Consumptive Human Uses*, and *Other* were the most infrequently chosen across the U.S. Caribbean, making up the remaining 9.5% of justifications (Figure 3.3). *Nautical Charting* and *Cultural Heritage & Maritime Resources* were not selected as a justification by any participants. Other justifications not on the standard list of options, but noted by respondents, were the threat of coastal development and freshwater springs. Justifications within each sub-region showed similar patterns, with *Biota/Important Natural Area*, *Commercial Fishing*, and *Coastal/Marine Hazards* making up the majority of justifications (Figure 3.3). No justification (i.e., default *None*) was selected for 18% of cells with assigned coins, thus these cells were not included in the final summary of justifications.

For the entire U.S. Caribbean region, participants selected two products as their top data needs: *Benthic Habitat Map* and *Sub-bottom Profile*. With the exception of nearshore USVI, these data types were the two most commonly selected products, making up 72% (Figure 3.4). For the USVI nearshore subregion, *Underwater Photography/Videos* was the second most commonly selected. Overall, *Underwater Photography/Videos* was the third most frequently selected, making up 18% of the selected products (Figure 3.4). *Biological or Physical Samples* was the most infrequently chosen, making up 10% of products (Figure 3.4). No product was selected (i.e., default *None*) for 21% of the cells with assigned coins, thus these cells were not included in the final summary of products. Lastly, 3.5% of the cells with coins allocated did not have both a justification ***and*** product selected.

3.4 Spatial Patterns of Justifications Selected

Several of the same locations were selected by multiple participants, albeit for different reasons and with different data needs in mind (Figure 3.5). In particular, justifications were the most diverse along western nearshore Puerto Rico, coastal San Juan, south of Punta Puerca, Grappler Seamount, various nearshore and offshore locations around St. Croix, south end of the Virgin Island Passage, and various nearshore locations around St. Thomas. However, when looking at grid cells for the three most common justifications (*Biota/Important Natural Area*, *Commercial Fishin*g, and *Coastal/Marine Hazards*), different patterns are displayed. Priority cells (top 10% and 5%) for *Biota/Important Natural Area* (*Biota*) were located in Puerto Rico off Rincon, San Juan, Punta Puerca, south of Vieques Island, and along the 100 m contour south of Arroyo.

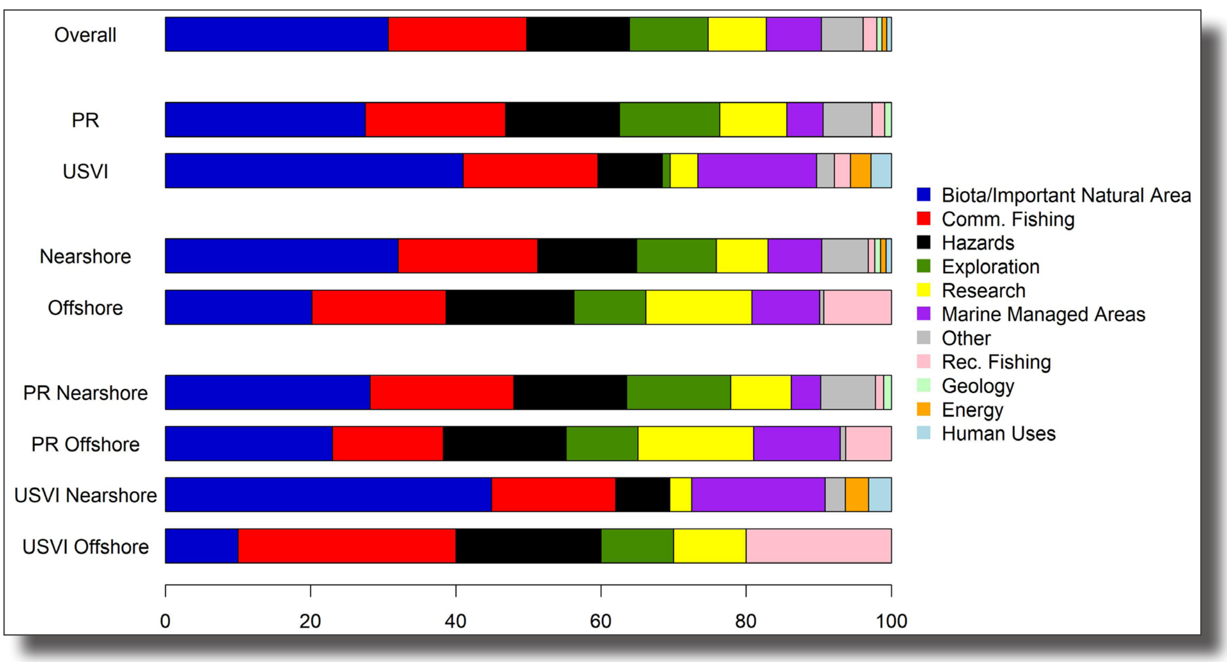


Figure 3.3. *Frequency of Justifications.* Bar graphs showing the frequency in which justifications were selected within each subregion, nearshore/offshore zone, island group, and across the entire U.S. Caribbean. PR - Puerto Rico, USVI - U.S. Virgin Islands

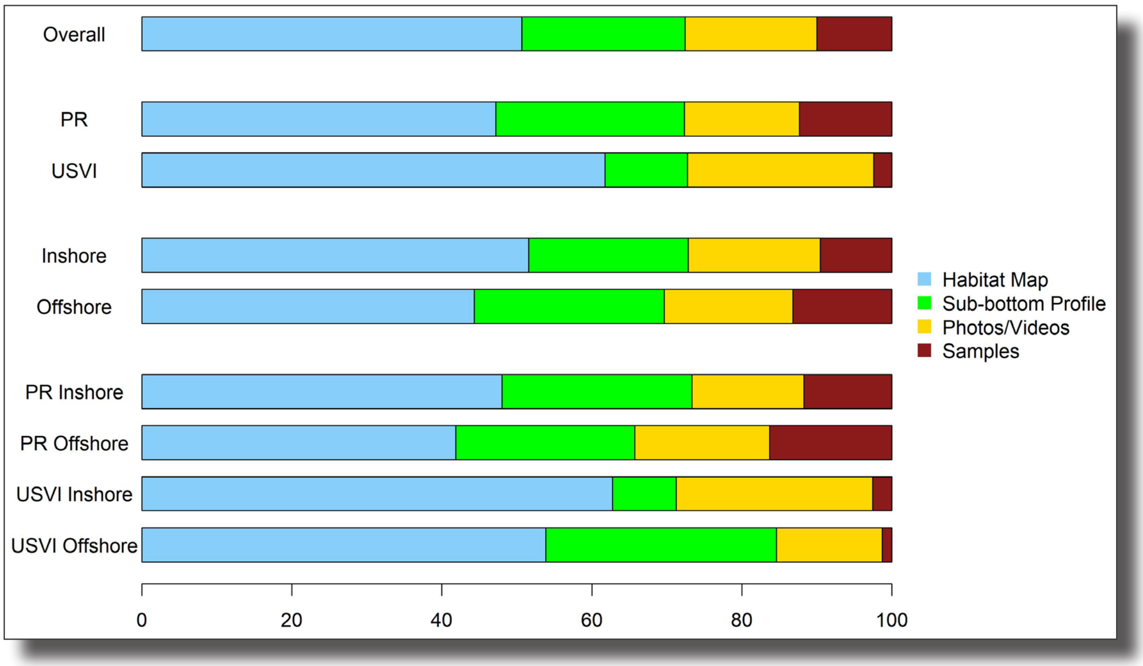


Figure 3.4. *Frequency of Products.* Bar graphs showing the frequency with which products were selected for each subregion, nearshore/offshore zone, island group, and across the entire U.S. Caribbean.

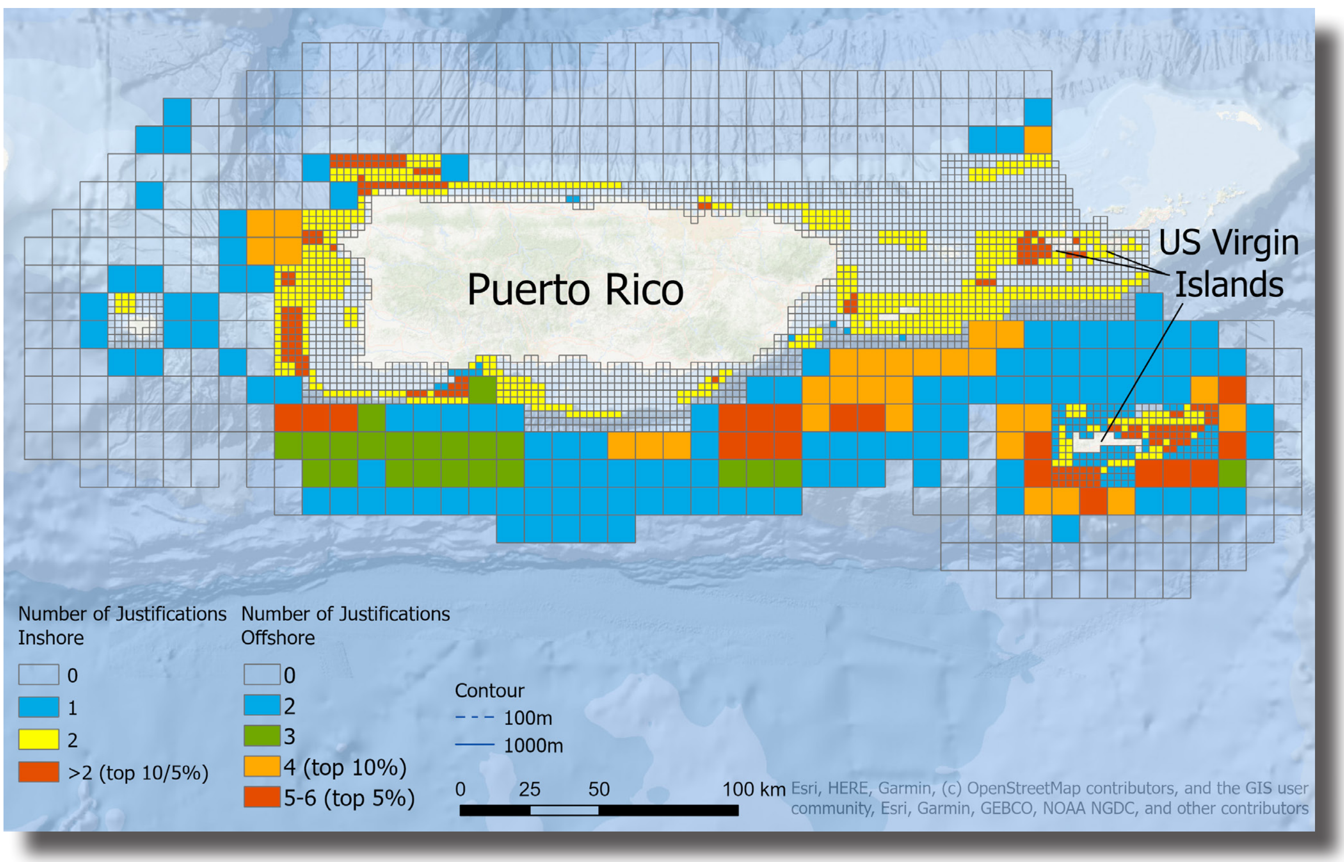


Figure 3.5. *Justification richness.* Map showing the total number of justifications selected within each grid cell.

In the USVI, there are a few high priority cells for Biota along the north coast of St. Thomas, north and east St. Croix (Figure 3.6a). Priority cells for *Commercial Fishing* were located in Virgin Passage, off the Southwest Cape in St. Croix, and over Grappler Seamount (Figure 3.6b). Priority cells for *Coastal/Marine Hazards* (*Hazards*) had large groups of offshore cells southwest of Puerto Rico, over Grappler Seamount, east St. Croix, and north of St. Thomas. A few groups of nearshore cells were high priority for *Hazards*, located off the coast of San Juan, west Vieques Island, and east St Croix extending to Lang Bank (Figure 3.6c).

For maps showing the number of coins allocated by each justification, refer to the U.S. Caribbean Spatial Prioritization Results Application (NOAA NCCOS, 2020).

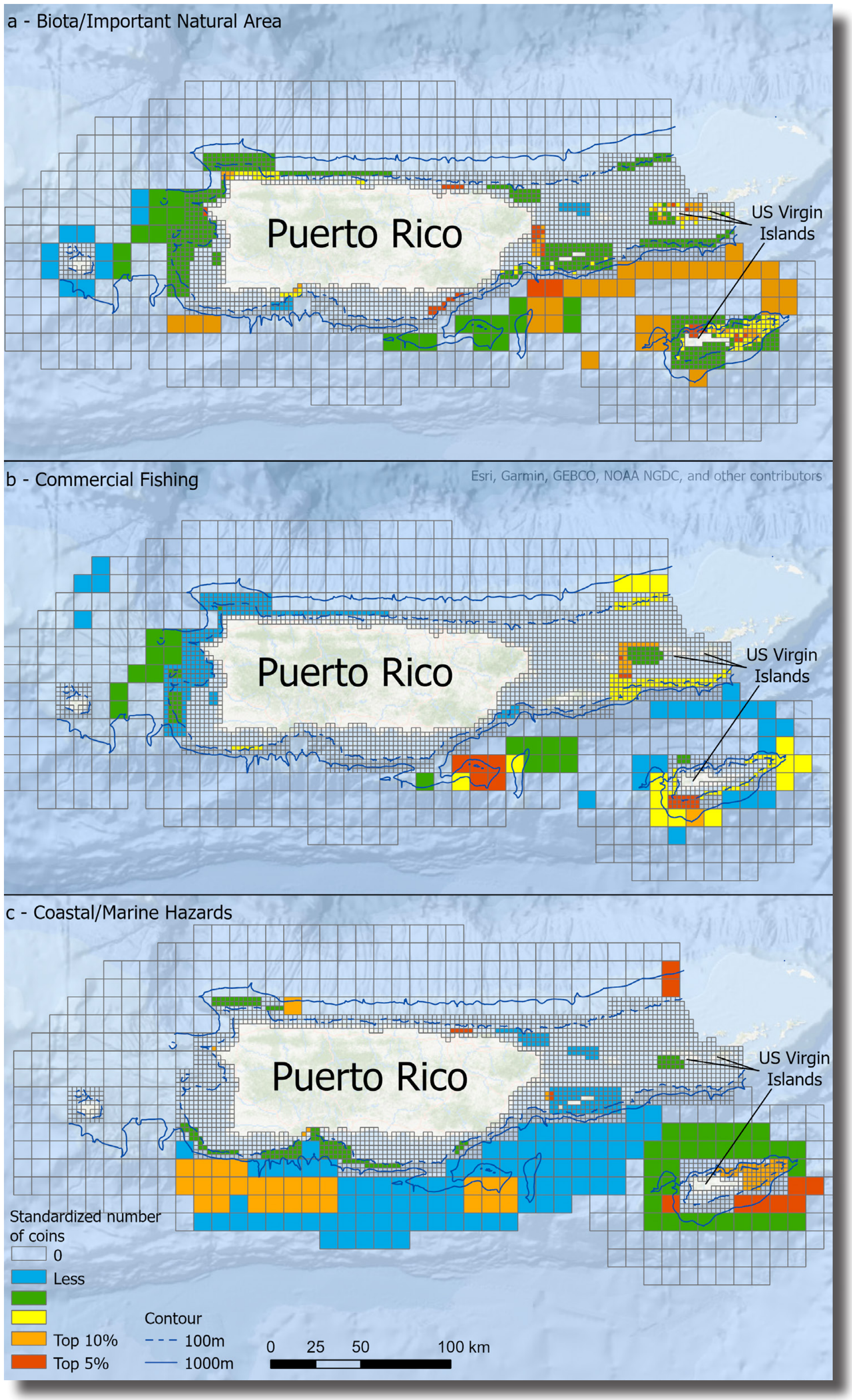


Figure 3.6.. Maps showing the standardized number of coins for the justifications (a) Biota/ Important Natural Area, (b) Commercial Fishing, and (c) Coastal/Marine Hazards.

3.5 Spatial Patterns of Products Selected

As with justifications, similar locations were selected by many participants, albeit with different product needs in mind. Figure 3.7 shows the number of different products assigned to a grid cell. Product needs were widely distributed throughout the project area, however there were five notable areas that had the most diverse product needs. These areas include (1) west Puerto Rico south of Rincon and around Isla Desecheo, (2) along the deep sea ridge in southeast Puerto Rico, from Grappler's Seamount to east of Vieques Island, (3) south Virgin Passage, (4) western St. Thomas and (5) various locations around St. Croix.

Priority grid cells (i.e., top 5%) for *Benthic Habitat Map* requests were primarily made around St. Croix and St. Thomas, including the Virgin Passage. In Puerto Rico, *Benthic Habitat Map* was selected mainly off San Juan and along the nearshore ridge in the southeast about 8 km off Punta Barrancas (Figure 3.8a). The product *Sub-bottom Profiles* had high priority cells off Rincon, southeast of Guayama, San Juan, offshore St. Croix, and north of Barracouta Banks (Figure 3.8b).

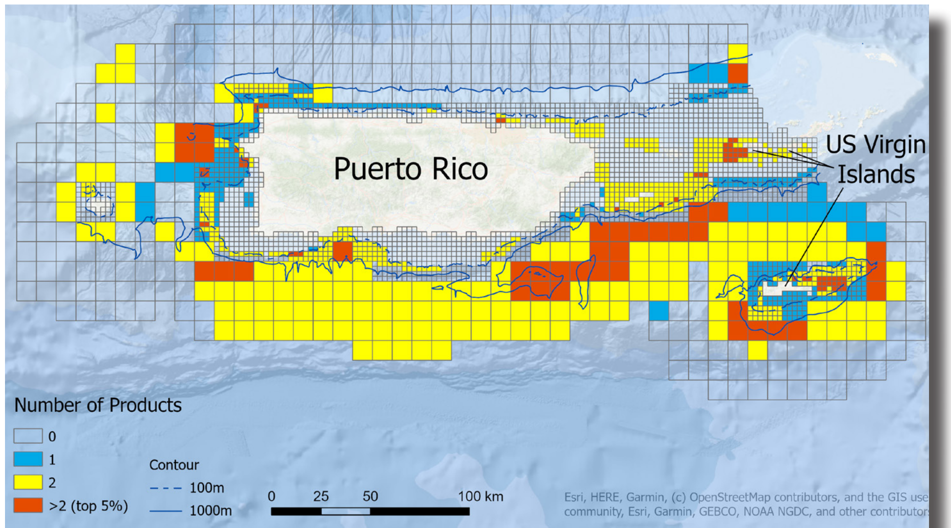


Figure 3.7. *Product richness.* Map showing the total number of products selected within each grid cell.

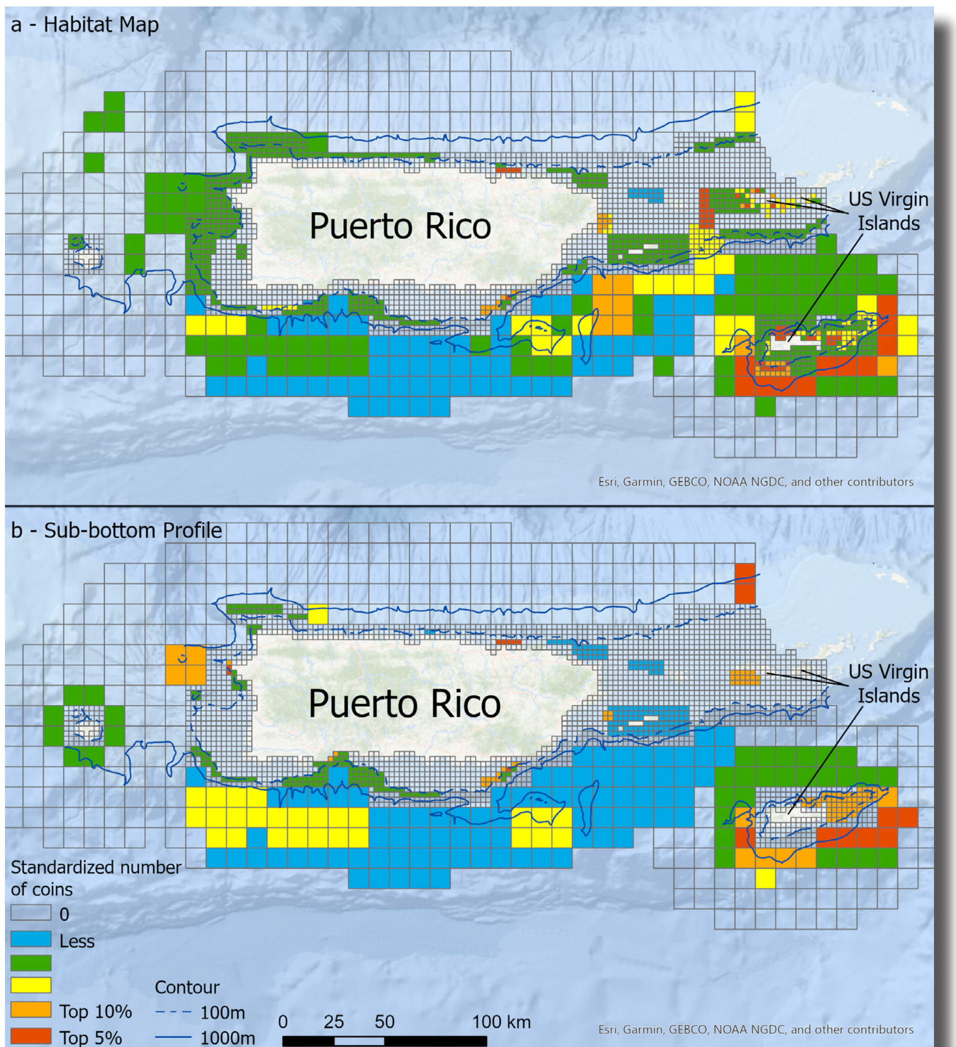


Figure 3.8.. Maps showing the standardized number of coins for the products (A) *Benthic Habitat Map*, and (B) *Sub-bottom Profiles.*

3.6 Highest Priority Locations for Future Mapping

Fifteen high priority locations were identified for future mapping, sampling and visual surveys, based on the standardized total number of coins (Figure 3.9). These priority locations were broadly distributed throughout the project area, except for southwest Puerto Rico. These locations include: a coastal and offshore location in northwest Puerto Rico (Punta Jacinto to Punta Agujereada), coastal Rincon, San Juan, Punta Arenas (west of Vieques Island), southwest Vieques, Grappler Seamount, southern Virgin Passage, north St. Thomas, east St. Thomas, south St. John, and the entire coast of St. Croix (Figure 1.1). The standardized map is an accurate representation of spatial priorities across the U.S. Caribbean because it accounts for differences in number of grid cells, coins, and participants between nearshore and offshore regions. The focus for the remainder of the report is on the spatial patterns seen using the standardized coin values.

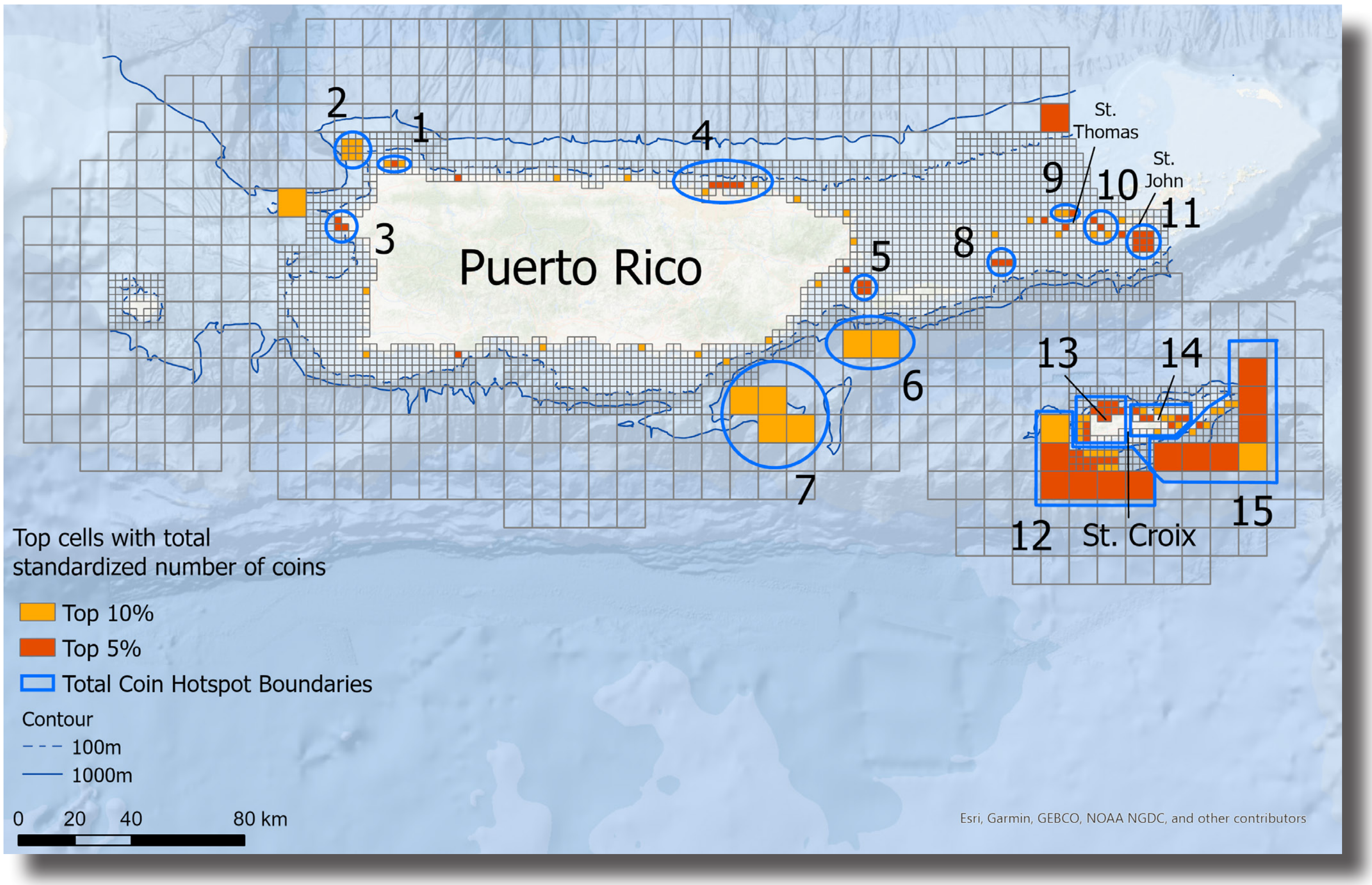


Figure 3.9. Map showing the cells with the top 5% and 10% of coins to denote the highest priority for participants. The 15 groups of cells designated as top priority areas (or hotspots) are circled in blue and labeled # 1-15.

3.7 Online Accessibility of Results

Datasets, data web services, and metadata were made accessbile using methods described in Section 2.6 of the previous chapter. Below is a list of points of accessibilty for project results:

2020: NCCOS Assessment: Spatial Prioritization in the U.S. Caribbean for Future Seafloor Mapping and Exploration from 2019-06-28 to 2019-07-28
Zenodo Accession https://doi.org/10.5281/zenodo.3909729

2019: US Caribbean Prioritization Results (MapServer Data Service)
https://gis.ngdc.noaa.gov/arcgis/rest/services/nccos/BiogeographicAssessments_USCaribbeanPrioritizationResults/MapServer

2019: US Caribbean Prioritization Framework (MapServer Data Service)
https://gis.ngdc.noaa.gov/arcgis/rest/services/nccos/BiogeographicAssessments_USCaribbeanPrioritization/MapServer

Chapter 4 Discussion

Spatial information about the seafloor is critical for decision-making in the marine environment. The spatial prioritization framework and online application described here was designed to identify common data collection priorities across partner organizations in the U.S. Caribbean. The information presented here is intended to provide discussion material for partner organizations to focus their combined interests on discrete locations and to facilitate their discussions on what to map, sample, or survey next. Those combined decisions will be made through continued discussions between and among partner organizations. Final decisions will likely depend on a range of logistical considerations, availability of funding, and allocation of ships and other assets. It is also important to note that due to a small number of participants, spatial and organizational biases are likely drivers of some of the patterns in high value cells. For example, if one organization inputs the maximum allowed number of coins into a small number of cells, those cells might display in the top 5%. However, it is still important to discuss these high priority cells as it can still lead to collaboration and interest from other organizations.

NOAA Ship Nancy Foster. *Photo credit: NOAA*

4.1 Highest priority locations for future data collections in the U.S. Caribbean

The purpose of this discussion is to help incorporate broader spatial needs into localized high priority areas that are also of interest to other organizations. In total, 15 participants entered priorities in the spatial prioritization application for the U.S. Caribbean, allocating a total of 10,519 coins in 1,594 unique grid cells. From this information, 15 high priority locations were identified for future mapping, sampling, and visual surveys. These locations include: (1) northern coastline of Aguadilla, Puerto Rico, (2) approximately 11 km offshore of northwest Aguadilla, (3) coastal Rincon, (4) San Juan, (5) Punta Arenas (west of Vieques Island), (6) southwest Vieques, (7) Grappler Seamount, (8) southern Virgin Passage, (9) north St. Thomas, (10) east St. Thomas, (11) south St. John, (12) west offshore St. Croix, (13) west nearshore St. Croix, (14) east nearshore St. Croix, and (15) east offshore St. Croix (Figure 3.9). Although this does not include several high priority cells (top 10% and 5%) that did not meet the 2–3 cell grouping criteria, these locations were discussed at some length. Often these locations were near or directly related to a high priority location, and thus were still included in some discussions.

To better understand the reasons behind these spatial patterns, individual discussions were conducted with each organization's respondent. During these discussions, participants were asked to provide a detailed narrative on their spatial needs within the 15 high priority locations. They were also asked to provide any mandates, regulatory actions, or laws that acted as drivers for their input. Spatial needs ranged from geographically broad to locally specific, however the more broad regions of interest were difficult to capture in these high priority locations. For example, the National Geodetic Survey (NGS) is mandated to collect baseline pre-hurricane imagery to support programs such as NOAA's Emergency Response Division and NOAA's Marine Charting Division, and thus are interested in entire coastlines. Additionally, the USGS also has a wide region of interest in the southern offshore regions of Puerto Rico and USVI. Their main focus is on the entire southern ridge to conduct tsunami and hurricane impact modeling, following the National Geologic Mapping Act of 1992 (Public Law 102-285) and the Organic Act of March 3, 1879 (20 Stat. 394, 43 U.S.C. 31). And finally, NOAA's Office of Exploration and Research (OER) has a general interest in filling any gaps in bathymetry in order to map and characterize bathymetry greater than 200 m, following the Presidential Memorandum issued on November 2019 for Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska (84 FR 64699). Although it's difficult to capture broader interests with a limited number of coins, this method does force the respondent to prioritize their more immediate data needs.

To facilitate a more region specific discussion, the project area was divided into four geographical regions: east Puerto Rico, west Puerto Rico, St. Thomas and St. John, and St. Croix. For each discussion section, we summarized the feedback given by all respondents across participating organizations in order to make recommendations on future efforts in mapping, exploration, and visual surveys.

4.1.1 Western Puerto Rico

Three high priority spots are located in western Puerto Rico: (#1) north coast of Aguadilla, (#2) northwest offshore Aguadilla, and (#3) coastal Rincon.

The two high priority locations off the northwest corner of Puerto Rico, in the Aguadilla region, include: (#1) a coastal location made up of three nearshore cells between Punta Jacinto and Punta Agujereada and (#2) a region approximately 11 km off Punta Agujereada made up of nine nearshore cells (Figure 4.1). Six organizations showed interest in these two areas, including the U.S. Fish and Wildlife Service (USFW), NOAA NMFS's Southeast Fisheries Science Center (NMFS-SEFSC), NOAA's Office of Protected Resources (OPR), NOAA's National Geodetic Survey (NGS), the Caribbean Regional Association for Coastal Ocean Observing (CARICOOS), and NOAA's OER. These two locations had a high number of justifications (n = 3–4) which varied between organizations (Figure 3.5). Gaps in bathymetric data, or existing low quality data, was the primary driver for several organizations interested in reef habitat (OPR and NMFS-SEFSC), impacts of coastal development (OPR), detecting offshore freshwater springs (USFW), and exploring deep water pelagic fisheries (NMFS-SEFSC and CARICOOS). Collecting high resolution bathymetry and developing habitat maps will support this broad range of user needs and applications.

The third high priority location in western Puerto Rico is located along the shoreline of Rincon, south of Punta Higuero (#3, Figure 4.1). This location has high value cells (top 5%) for *Biota/ Important Natural Area* (Figure 3.6a), *Sub-bottom Profile*, and *Samples*. While there was a broad interest in filling data gaps by NGS and NMFS-SEFSC, more specific interests were highlighted such as fisheries research, beach erosion and renourishment, and ecotourism. Due to a steep near-coastal shelf, this region supports a high potential for coral reef and fisheries research by organizations such as CARICOOS and the University of Puerto Rico (UPR). Much of the interest in this region is connected to Tres Palmas Marine Reserve (Table 4.1), one of the most popular ecotourism locations in Puerto Rico. High resolution bathymetry and habitat information (i.e. biological samples, sediment grabs) can help organizations such as the NOAA Office of Science and Technology (OST) understand the impacts of tourism and coastal development in Tres Palmas Marine Reserve. Additionally, due to the pressures of development and an increase in storm surges, these data products can be applied to restoration efforts in this region. Overall, this location has a wide variety of justifications and products that support the conservation of Tres Palmas Marine Reserve, monitor spawning aggregations, and help further research on human impacts and development.

Table 4.1. ***Marine protected areas and reserves.*** Table showing the reserves mentioned in this report by area, geographic region, and cooresponding reference figure.

Reserve	*Area (km²)*	*Geographic Region*	*Figure*
Tres Palmas Marine Reserve	0.83	Rincon, West PR	4.1
Punta Yegüas Natural Reserve	263.64	Yabucoa, Southeast PR	4.4
Vieques Bioluminescent Bay Natural Reserve	85.15	South Vieques Island, PR	4.4
St. Thomas East End Reserve	9.29	Southeast St. Thomas	4.6
Virgin Islands Coral Reef National Monument	51.49	South St. John	4.7
Mutton Snapper Spawning Aggregation Area	8.81	Southwest St. Croix	4.8
St. Criox East End Marine Park	149.5	Eastern St. Croix	4.9
Buck Island Reef National Monument	76.84	Northeast St. Croix	4.9
Red Hind Spawning Aggregation Area – Lang Bank	11.64	Eastern St. Croix	4.9

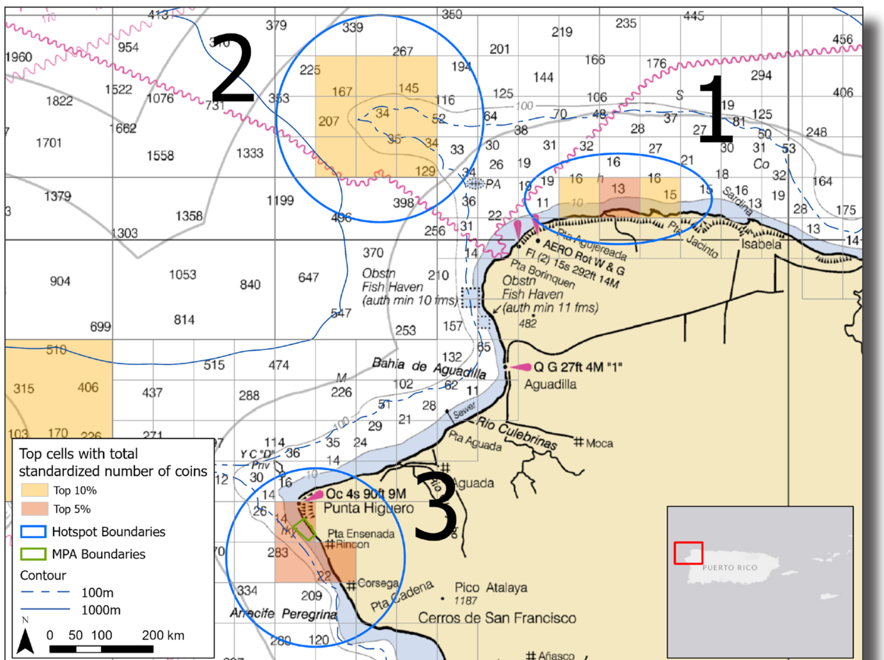


Figure 4.1. Map showing high priority areas #1-3 in western Puerto Rico.

4.1.2 Eastern Puerto Rico

Four high priority spots are located in eastern Puerto Rico: (#4) San Juan, (#5) Punta Arenas (west of Vieques Island), (#6) southwest Vieques, (#7) and Grappler Seamount.

Seven cells were selected as high priority along the coast of San Juan (Figure 4.2) by UPR, OST, NGS, and the Puerto Rico Department of Natural and Environmental Resources (DNER). The top data products selected for these cells were *Benthic Habitat Map*, and *Sub-bottom Profile* (Figure 3.8a-b). The justifications *Biota/ Important Natural Area* and *Coastal/Marine Hazards* (Figure 3.6a,c) were most commonly selected due to the offshore reefs acting as a natural barrier to storm surges. Acquiring high resolution bathymetric data over these offshore reefs can provide partnering organizations with the resources necessary to study offshore barriers, the impacts of development, human uses, and assess hurricane damage. Not only would more comprehensive bathymetric data satisfy US federal directives of efficient spending, but it could also be used to potentially mitigate hazards to public infrastructure (FEMA Section 428, proposal 404), and support Puerto Rico's coral reef conservation efforts (Puerto Rican Law 147). Additionally, these data would support documenting and managing resources in Isla Verde Marine Reserve, which recognizes the ecological sensitivity of the San Juan Metropolitan Area. And finally, although NGS has a general interest in the entire coastline of Puerto Rico, the ports in San Juan require updated bathymetric data following NOAA's Coast and Shoreline Change Analysis Program (C-CAP; NOAA CSC, 2014).

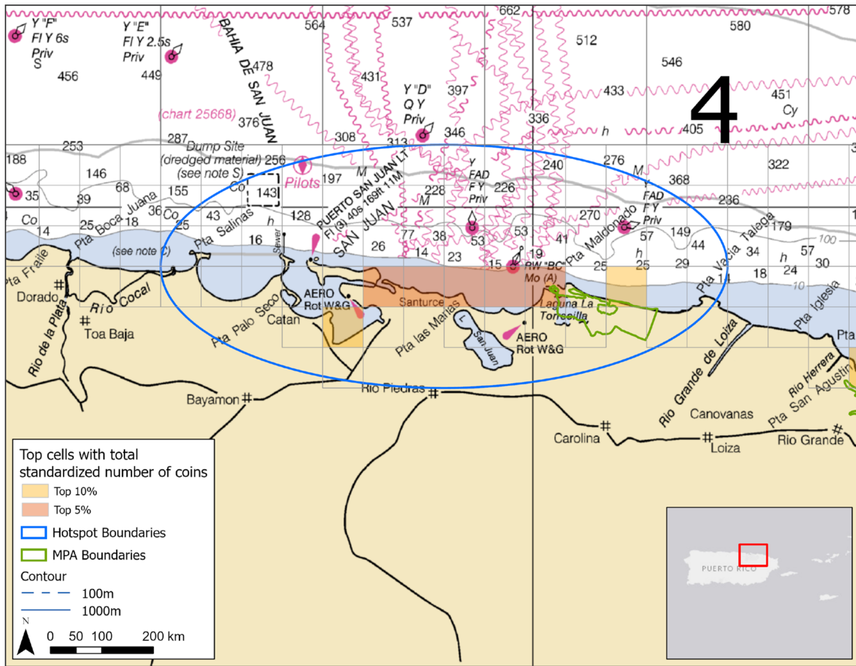


Figure 4.2. Map showing high priority area #4 off the coast of San Juan, Puerto Rico.

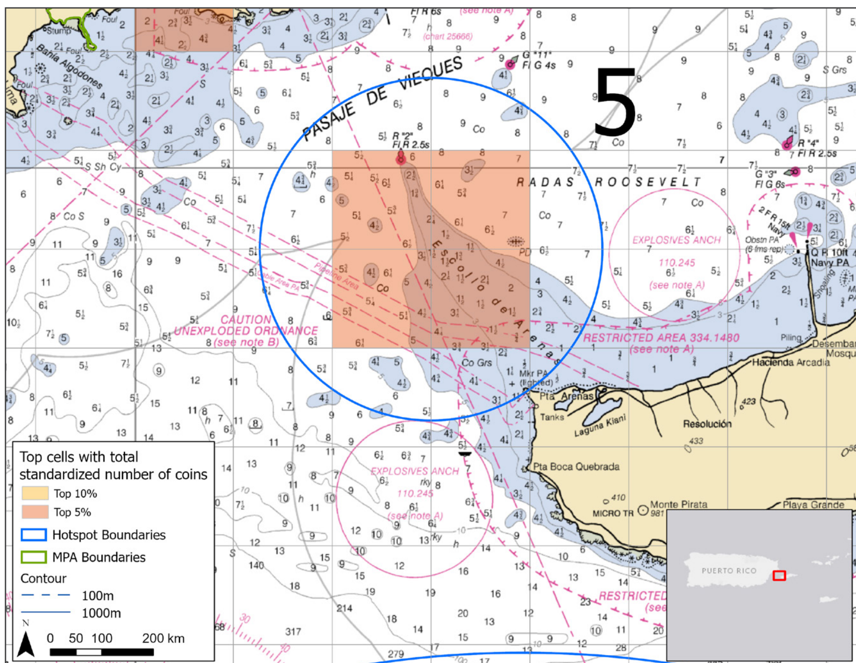


Figure 4.3. Map showing high priority area #5 over Escollo de Arenas off Punta Arenas, Vieques Island, Puerto Rico

Four nearshore cells were selected as high priority off Punta Arenas, west Vieques Island (#5, Figure 4.3). Analysis indicated the justifications *Biota/Important Natural Area* and *Coastal/Marine Hazards* (Figure 3.6a,c) were most commonly selected, with *Sub-bottom Profile* (Figure 3.8b) as the primary data product. These cells are located over Puerto Rico's largest sand deposit, Escollo de Arenas, which covers over 900,000 km^2 (Rodriguez and Trias, 1989). This sand deposit is a potential site for pipeline construction, as well as providing suitable sand for construction and beach renourishment. *Sub-bottom Profiles* will provide key information on sub-surface marine features, which will support characterizing benthic habitats and defining substrate layers. Currently, there is insufficient bathymetric and ground truth data over Escollo de Arenas to support ecological and geologic research. Collecting these key datasets will support deep coral research (OPR), exploration of shallow water habitat such as sand and seagrass (CARICOOS), and improve hurricane relief models (USGS).

Two high priority cells were located south of Vieques Island, over an offshore ridge in approximately 1,000–2,000 m depth (#6, Figure 4.4). Analysis showed these cells were justified as *Biota/Important Natural Area* (Figure 3.6a), with a variety of product needs (Figure 3.7). Four of the five data products available in the web application were chosen in these cells, including *Benthic Habitat Map*, *Underwater Photo/Video*, *Sub-bottom Profile*, and *Samples*. Developing these data products will allow OPR and DNER to monitor the marine resources within this region. Additionally, these cells are located between Punta Yegüas Natural Reserve and Vieques Bioluminescent Bay Natural Reserve (Table 4.1), and may serve as a potentially important natural area.

Additionally, two high priority locations were identified offshore of southeast Puerto Rico. Four cells were selected over Grappler Seamount (#7, Figure 4.4), and chosen as high priority (top 10% and 5%) for the justification *Commercial Fishing* (Figure 3.6b). Seamounts accelerate ocean currents and increase upwellings, providing key nutrients to support diverse flora and fauna. Organizations such as NMFS-SEFSC, OER, CARICOOS, and UPR all share a need for contemporary, high quality bathymetry and detailed habitat data (i.e., *Samples*, *Underwater Photo/Video*) to explore the use of this seamount by commercially important species and reef fishes. Bathymetry data was collected over Grappler Seamount by NOAA NCCOS in 2013 (4 m resolution; NOAA NCCOS, 2015) using an EM1002 multibeam echosounder. Additional ground truth data will help to explore habitat characteristics at this location, and enable stakeholders to develop fisheries management strategies.

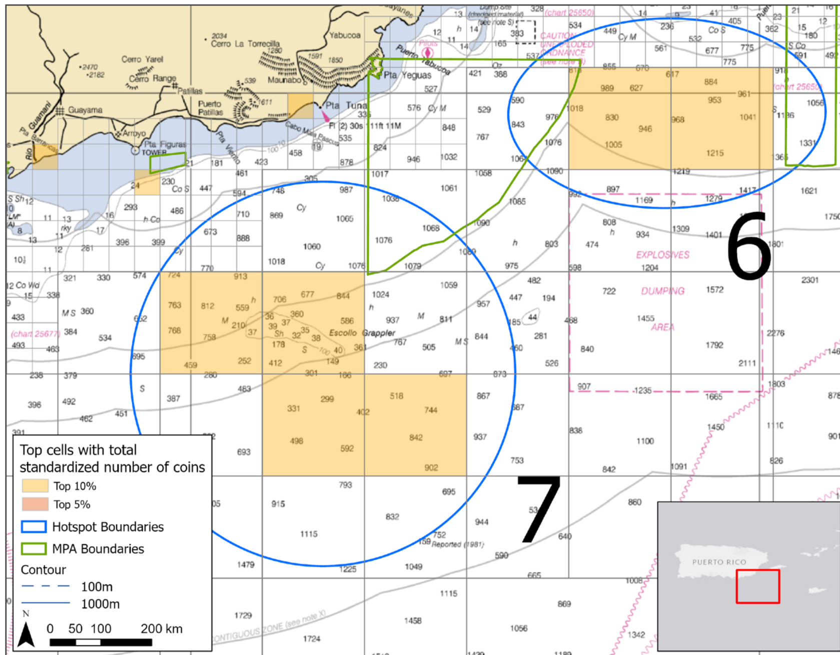


Figure 4.4. Map showing high priority areas #6 and #7 in southeast Puerto Rico.

4.1.3 North USVI: St. Thomas and St. John

Four high priority locations were identified in the north USVI: (#8) south Virgin Passage, (#9) north St. Thomas, (#10) east St. Thomas, and (#11) south St. John.

Three cells were identified as high priority in the southern reach of Virgin Passage by NOAA NMFS's Southeast Regional Office (NMFS-SERO) and the Caribbean Fisheries Management Council (CFMC; #8, Figure 4.5). These cells were selected as high priority (top 10% and 5%) for the justification *Commercial Fishing* (Figure 3.6b), and the data product *Benthic Habitat Map* (Figure 3.8a). Both NMFS-SERO and CMFC identified this region as a potential aggregation site for goliath grouper. Collecting high quality bathymetry data and producing a habitat map will help document the seafloor characteristics used by important species, as well as the expansive coral reef system located in this area.

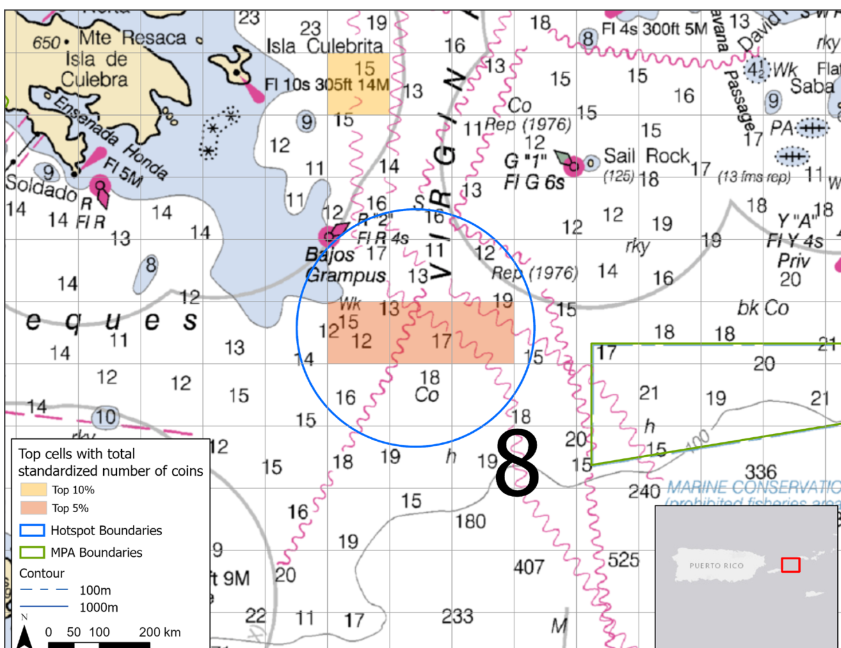


Figure 4.5. Map showing high priority area #8 in southern Virgin Passage.

Additionally, this area connects the shelf edge to shallower waters, and thus can provide key information on the distribution of shallow and pelagic fish species for the management of Essential Fish Habitat (EFH; Magnuson-Stevens Fisheries Conservation and Management Act (US 90 Stat. 331).

Three nearshore cells were selected as high priority (top 10% and 5%) along the northern coast of St. Thomas from Vluck Point to Magen's Bay (#9, Figure 4.6). The most selected justification for these cells was *Biota/Important Natural Area* (Figure 3.6a), with the top 5% of coins allocated in Magens Bay. Valuable resources within Magens Bay include fish nursery habitat, ESA listed coral species, and mangrove forests. However, Magens Bay (extending west to Inner Brass Island), is also subject to increased environmental stresses due to tourism and rapid development. Thus, contemporary bathymetry and habitat maps will help organizations such as The Nature Conservancy (TNC), OPR, NMFS-SERO, CFMC, and DPNR manage coastal resources and assess the health of these ecosystems.

In eastern St. Thomas, four cells were selected as high priority along the coastline extending from Thatch Cay to Jersey Bay, including Great and Little St. James Islands (#10, Figure 4.6). Many of these cells were in the top 10% and 5% for *Biota/ Important Natural Area* (Figure 3.6a) and *Marine Managed Area*. Among participants, the most frequently chosen data product needed within these cells is a comprehensive *Benthic Habitat Map* (Figure 3.8a). Important resources within these cells, particularly around Thatch Cay, include Endangered Species Act (ESA) listed corals, extensive seagrass beds, and critical sea turtle habitat, which are also facing imminent threats from development. Thatch Cay is a privately owned island, with many proposals to fully develop the island into a tourist destination. Consequently, this poses threats to the extensive reef system located around the cay. Following the coastline south into Redhook Bay, this cell was selected with *Benthic Habitat Map* and *Underwater Photo/Video* as the product needs. Within the St. Thomas East End Reserves (Table 4.1), mangrove forests, salt ponds, reefs, and cays, all support one of the most valuable fish nurseries remaining on St. Thomas. Developing habitat maps within these regions will support management efforts to protect important natural resources.

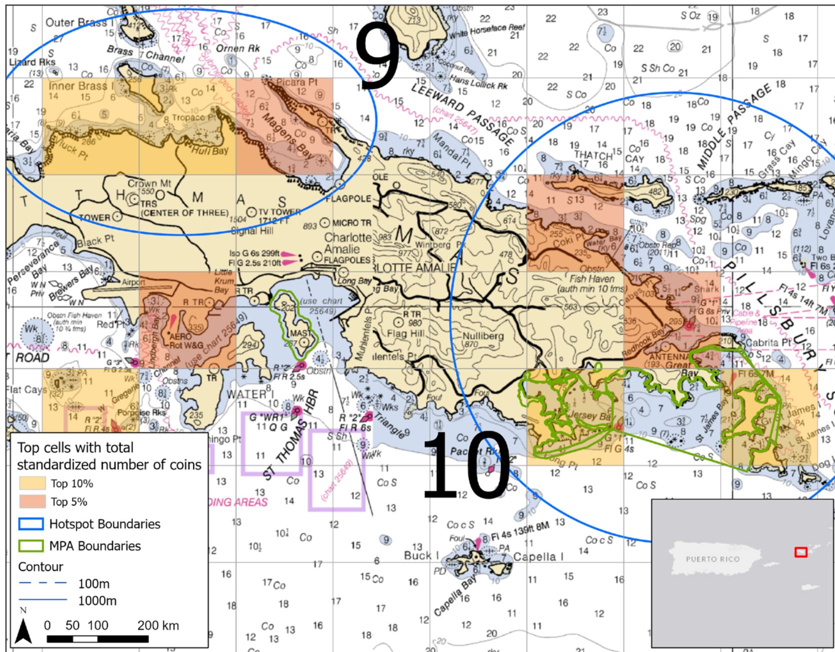


Figure 4.6. Map showing high priority areas #9 and #10 located in St. Thomas.

Nine cells were chosen by USFW in south St. John in the Virgin Islands Coral Reef National Monument (VICR; #11, Figure 4.7; Table 4.1). Possible collaboration between USFW and the National Park Service can extend the VICR to include offshore reef complexes that are not adequately mapped. High quality bathymetry and detailed habitat maps can provide key information on the local reef structures to help manage the boundaries and ecological resources of VICR.

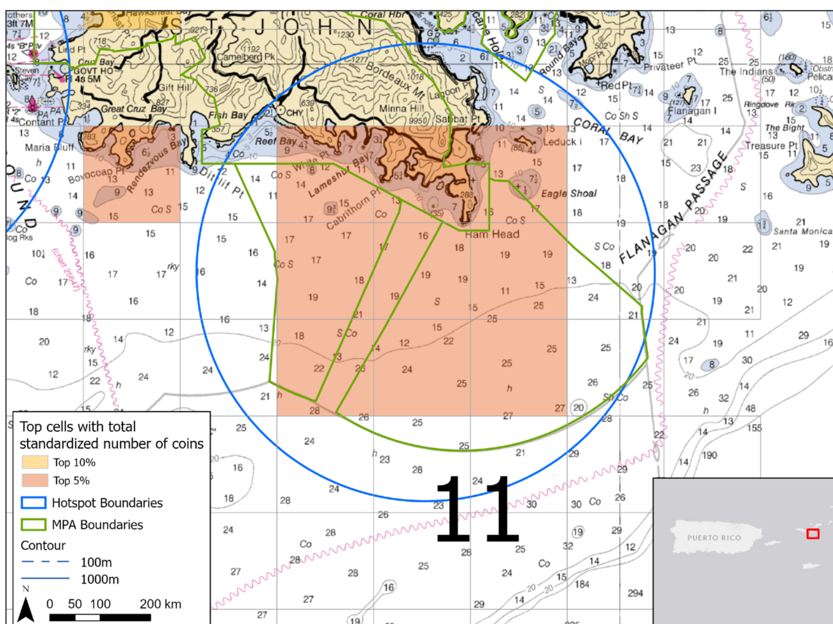


Figure 4.7. Map showing high priority area #11 located in southern St. John.

4.1.4 South USVI: St. Croix

Overall, St. Croix had the most interest among participants, containing 39.8% of the coins allocated in the USVI. For simplicity, cells within the top 10% and 5% were divided into four high priority locations around St. Croix: (#12) southwest offshore St. Croix, (#13) west coast St. Croix, (#15) east offshore St. Croix, and (#15) east coast St. Croix. More general mapping interests around St. Croix include tsunami and hurricane modeling (USGS), and filling gaps in bathymetry (OER, SEFSC). The University of Virgin Islands (UVI) also has a regional interest in depths where corals are most likely found, mainly along the shelf edge in approximately 20–100 m depth.

There were more specific interests in all four of these high priority areas, all with the need for updated bathymetry, backscatter, and habitat maps. The southwest offshore St. Croix high priority area consisted of 21 nearshore cells and 6 offshore cells (#12, Figure 4.8). These cells were selected as high priority (top 10% and 5%) for the justification *Commercial Fishing* (Figure 3.6b) and data products *Benthic Habitat Map* and *Sub-bottom Profiles* (Figure 3.8a-b) by DPNR and CFMC. Located within this high priority area is the Mutton Snapper Spawning Aggregation Area (MSSAA; Table 4.1), which enforces annual seasonal closures on fishing and provides protection for mutton snapper during their spawning season. However, there are currently no closures in the MSSAA, or surrounding regions, for other commercially important species such as snapper, grouper, and wahu. Additionally, this high priority area also includes dynamic bathymetric features such as a double shelf edge and seamounts, which can support a variety of pelagic fish species. Developing a habitat map, paired with high resolution bathymetry, will provide stakeholders with key information to help manage and regulate commercially important species.

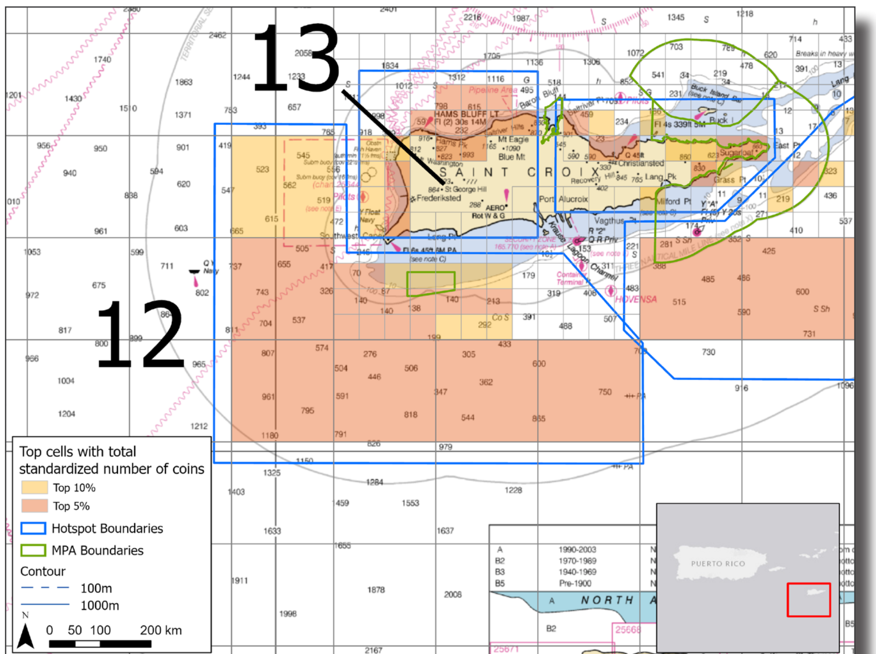


Figure 4.8. Map showing high priority areas #12 and #13 located in western St. Croix.

Eighteen nearshore cells were selected as high priority along the western coastline of St. Croix, stretching from Sandy Point northward to Hams Bluff, and following the coast east to Baron Bluff (#13, Figure 4.8). A majority of the cells were selected for their importance in *Biota/Natural Habitat* (Figure 3.6a) with the need for a *Benthic Habitat Map* (Figure 3.8a). Coin placement in cells along the western shore of St. Croix was mainly driven by coastal vulnerability and human impacts by CFMC and OPR. One specific location of interest is around Frederiksted Pier, a 465 m cruise ship pier that can accommodate several ships with drafts up to 9 m, in addition to anchorages in the outer harbor for larger vessels. Waters around Frederiksted Pier are an important corridor for ESA listed species (i.e., sea turtles) and support extensive reef systems. However, the impacts of high vessel traffic and anchoring are poorly understood due to a lack of contemporary, high quality bathymetric data. Additional pressures of human development along the entire western coast of St. Croix amplifies the need for updated bathymetry. Continuing to the north shore of St. Croix, biodiversity and coral conservation were the main drivers for coin placement among participating organizations. TNC is interested in improving monitoring and resource management for coral nurseries to aid in restoring reefs damaged by hurricanes and coral bleaching. Within this same region, UVI is particularly interested in characterizing habitats in Cane Bay, which contains a steep mesophotic reef important for recreational activities (i.e. diving, fishing), fish recruitment, and supports high biodiversity. Collecting high quality bathymetric data and developing habitat maps in these key locations along St. Croix's northern coastline will support the management of EFH and coral reef conservation efforts.

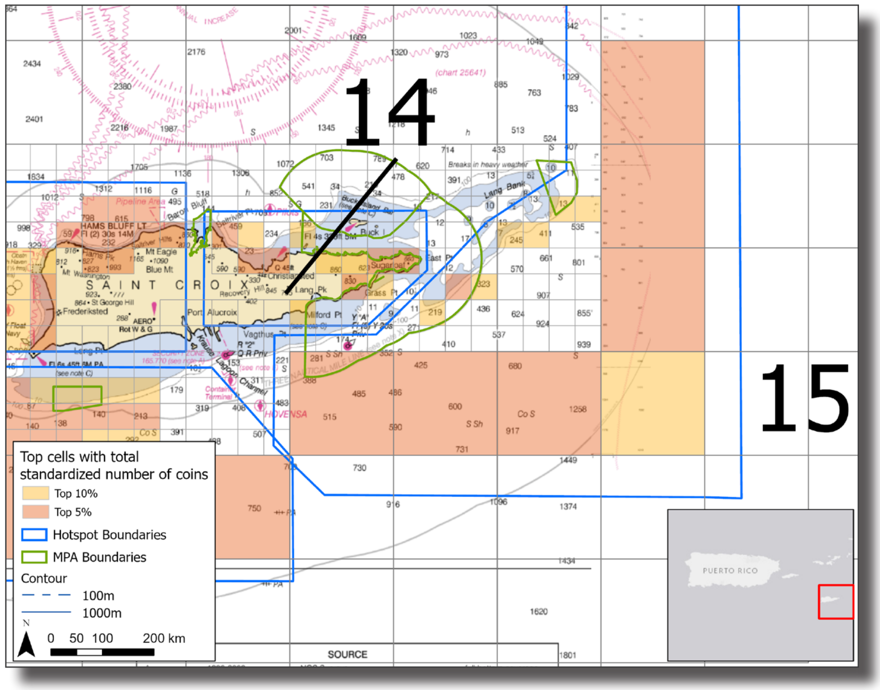


Figure 4.9. Map showing high priority areas #14 and #15 located in east and south St. Croix

Twelve nearshore cells were selected as high priority (top 10% and 5%) along the eastern coast of St. Croix. This high priority area stretches from Salt River Point on the north coast, around East Point, and ends at Milford point on the south coast (#14, Figure 4.9). Majority of these cells were justified under *Biota/Important Natural Area*, *Coastal/Marine Hazards* (Figure 3.6a,c), with some coins allocated for the justification *Marine Managed Area*. Eight of these top priority cells are within the St. Croix East End Marine Park (EEMP; Table 4.1), which includes one of the most extensive reef systems on the Puerto Rican/Virgin Islands shelf. EEMP encompasses nearshore habitats and fish populations which are likely to interact with Buck Island Reef National Monument and Lang Bank (Table 4.1). Although EEMP protects significant marine resources (i.e., mangroves, coral communities, and seagrass beds) within its boundaries, it is still vulnerable to human development, coral bleaching, and land-based pollution. Thus, there is significant interest by TNC, OPR, DPNR, and UVI to study the effects of human impacts and habitat change within EEMP. The remaining four cells in this high priority area reach from Saltriver Point to Christiansted Harbor, a region with dense populations, high boat traffic, and marine debris. Analysis showed cells in this high priority region were selected with the data product needs *Benthic Habitat Map*, *Sub-bottom Profile* (Figure 3.8 a-b), and *Underwater Photo/Video*. TNC is proposing a large scale coral restoration project, and is producing Caribbean-wide benthic habitat maps using satellite-derived hyperspectral data in 2020 (TNC, 2020). Collecting fine resolution acoustic bathymetry and ground truthing data can help verify existing habitat maps, as well as produce more contemporary habitat models that will aide in understanding coral distributions, temporal changes in habitats (USGS, DPNR), and impacts of human development (OPR, DPNR).

Further offshore of eastern St. Croix, seven offshore and seven nearshore cells were selected as top priority (top 10% and 5%; #15, Figure 4.9). The most frequently selected justifications were *Biota/Important Natural Area*, *Commercial Fishing*, and *Coastal/Marine Hazards* (Figure 3.6 a-c), with *Benthic Habitat Map* and *Sub-bottom Profile* (Figure 3.8 a-b) the most frequently selected data products. This wide variety of justification and products encompasses the needs of six organizations: USGS, NMFS-SEFSC, OER, DPNR, CFMC, and UVI. The nearshore cells that received the highest number of total coins (top 10% and 5%) were located along the southern edge of a 25–100 m shelf up to Lang Bank. Along this shelf edge, bathymetry collected in 2014 suggests high rugosity and deep water platforms which may serve as critical habitat for commercially important fish species. However, lack of habitat classifications prevents stakeholders from determining the extent and use of these habitats. Additionally, the offshore cells within this top priority region were selected mainly due to large data gaps or outdated bathymetry (most recent data collected in 2006). Filling in these bathymetric data gaps, and providing a habitat map, will allow organizations to update tsunami and hurricane impact models (USGS), understand the distribution of commercial fish species (CFMC), and fill in data gaps to satisfy NOAA's Integrated Ocean and Coastal Mapping (IOCM) Seabed 2030 Initiative. For more information on Seabed 2030 visit https://iocm.noaa.gov/seabed-2030.html.

4.2 Using priorities for future planning

The spatial priorities described above answer five main questions, which are critical for planning data collections in the field. These questions include:

- Where are these important locations?
- Why are these locations important?
- How quickly are data needed?
- What types of data products are needed?
- Who are potential project partners?

This section describes how answers to these questions are being applied and how users can track the overall progress of new data collections.

4.2.1 Where will NCCOS map next?

Ultimately, the goal of this effort is to assist in coordination of seafloor data collection in the U.S. Caribbean. Mission planning requires, in addition to these results, consideration of vessel capabilities, available technology, and transit time to survey areas. NCCOS used the results from this prioritization effort to plan a field mission (year TBD due to Covid-19) aboard the NOAA Ship *Nancy Foster*, a hydrographic survey vessel equipped with multibeam sonar, split beam sonar, and ROV deployment capabilities. Planning for approximately 15 days of survey, NCCOS selected a 1080 km^2 area of northwest Puerto Rico that includes priority areas #2 and #3 (Figure 4.10). This area does not have any mapping data collected after 2010 and therefore is in need of updated bathymetry. Within the survey area, approximately 200 km^2 were in the top 10% of cells and were highlighted by seven different participants as an area where data is needed (Figure 3.4). These high priority locations also contained a wide variety of justifications (Figure 3.5) indicating broad need for data in this area. Based on the capabilities of the NOAA Ship *Nancy Foster*, bathymetry, backscatter, and visual survey data will be collected.

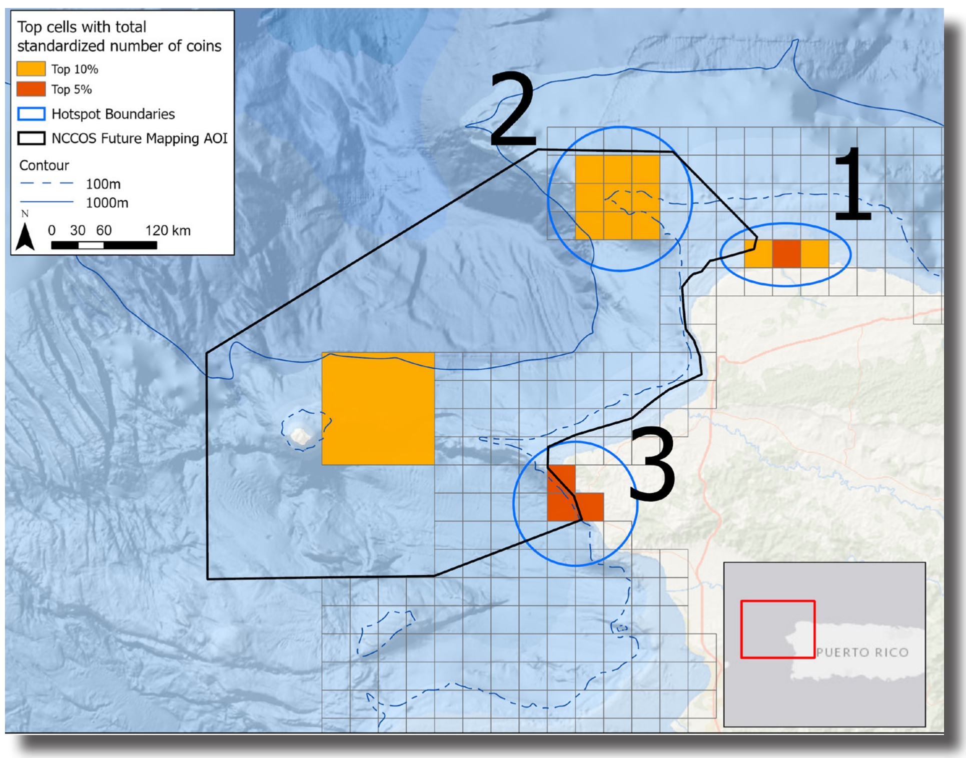


Figure 4.10. NCCOS and CRCP's area of interest (AOI) for the next Essential Fish Habitat (EFH) mapping mission in the U.S. Caribbean. This will be likely planned for the 2021 field season aboard the NOAA Ship *Nancy Foster.*

4.3 Tracking new data collections and overall progress

It is important to note that the data provided in this report represents a snapshot in time of mapping priorities. New areas are continuously being mapped and new data is becoming available. Additionally, natural disasters and other extreme events may alter seafloor characteristics. As such, over time, these results will need to be re-visited. It is critical to keeping organizations up-to-date on which areas have been mapped and what data types are available to avoid duplication. To help keep track of progress towards mapping of high priority areas identified through this effort, the map layers developed here were published in NOAA IOCM's U.S. Mapping Coordination website (Figure 4.11; NOAA IOCM, 2020).

NOAA IOCM's goal is to help federal agencies and their partners collaborate on mapping data requirements and acquisitions to avoid duplicate efforts and "to map once, use many times." This site was designed as a way for agencies to coordinate mapping efforts and mission planning. It is built on SeaSketch (SeaSketch, 2020), which is an online participatory mapping platform that allows users to share their sketches, discuss ideas and post GIS files. Including the results from this prioritization effort will help the data reach a broader audience and promote further coordination of data collections in the U.S. Caribbean. This website will also give prioritization participants, and other mapping collection teams in the region, the ability to track mapping progress toward surveying key priorities identified by this effort. GIS files can be uploaded to this site, showing the geographic extent of new mapping, sampling, or visual surveys, keeping the prioritization results and progress as up-to-date as possible for the U.S. Caribbean mapping community. To view the prioritization layers and upload new data collections, please see https://www.seasketch.org/#projecthomepage/5272840f6ec5f42d210016e4.

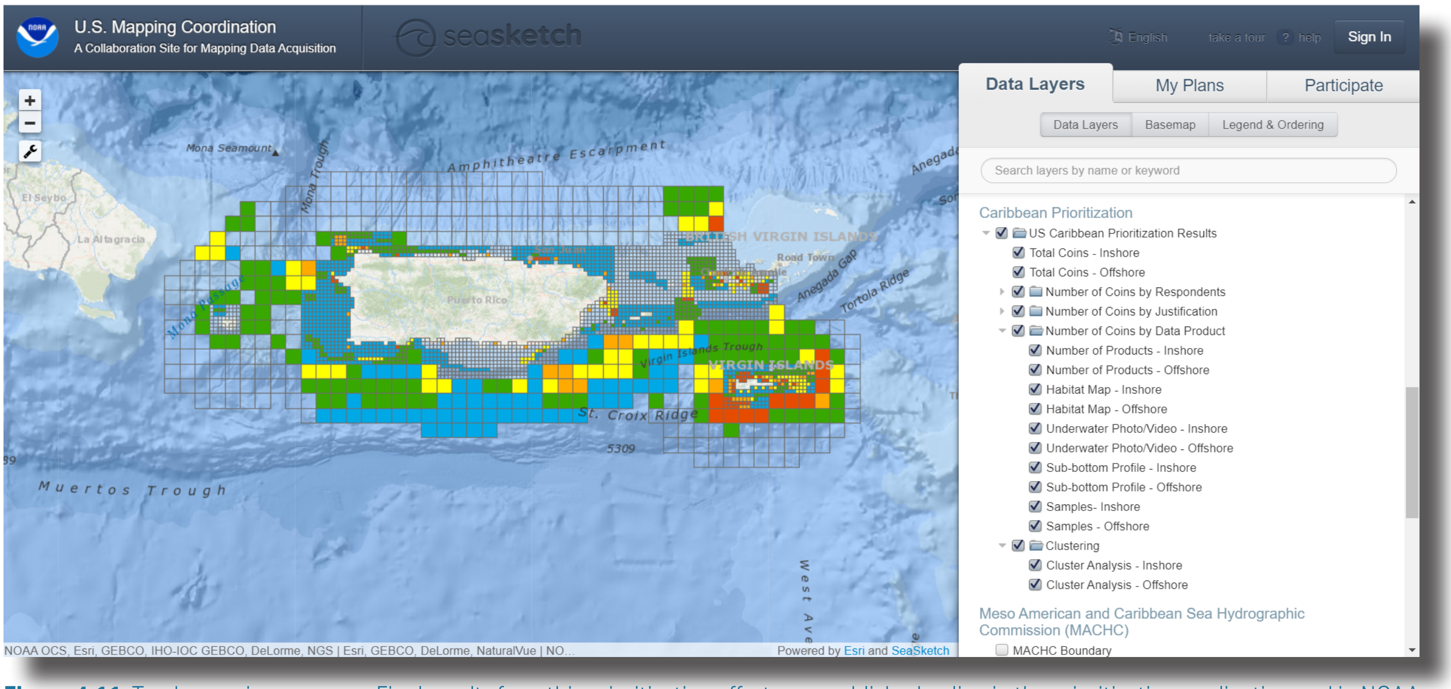


Figure 4.11. Track mapping progress. Final results from this prioritization effort were published online in the prioritization application and in NOAA IOCM mapping coordination website. This will allow users to track their progress as they collect new data in high priority locations identified on this web tool.

References

Battista, T., K. Buja, J. Christensen, J. Hennessey, and K. Lassiter. 2017. Prioritizing seafloor mapping for Washington's Pacific Coast. Sensors 17(4): 701. DOI: 10.3390/s17040701

Battista, T., and K. O'Brien. 2015. Spatially Prioritizing Seafloor Mapping for Coastal and Marine Planning. Coastal Management 43(1): 35-51. DOI: 10.1080/08920753.2014.985177

Costa, B., K. Buja, M. Kendall, B. Williams, and J. Kraus. 2019. NOAA NCCOS Assessment: Prioritizing Areas for Future Seafloor Mapping, Research, and Exploration Offshore of California, Oregon, and Washington from 2019-03-01 to 2019-04-01. Zenodo. Dataset, V1.0. doi:10.5281/zenodo.3533201

Freedman, R., L. Kracker, T. Battista, and C. Caldow. 2016. Seafloor Mapping in Southern California: Identifying the Gaps and Prioritizing Future Efforts. National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries. Marine Sanctuaries Conservation Series ONMS-17-03. Silver Spring, MD. 23 pp.

Kendall, M.S., K. Buja, and C. Menza. 2018. Priorities for Lakebed Mapping in the Proposed Wisconsin-Lake Michigan National Marine Sanctuary. NOAA Technical Memorandum NOS NCCOS 246. Silver Spring, MD. 24 pp. DOI: 0.7289/V5/TM-NOS-NCCOS-246

NOAA CSC. 2014. NOAA's Coastal Change Analysis Program (C-CAP) 1985 to 2010 Regional Land Cover Change Data - Coastal United States (NCEI Accession 0121254). NOAA National Centers for Environmental Information. Available online: https://accession.nodc.noaa.gov/0121254 (Accessed 4 December 2020).

NOAA IOCM. 2020. U.S. Mapping Coordination: A Collaboration Site for Mapping Data Acquisition (website). Available online: https://www.seasketch.org/#projecthomepage/5272840f6ec5f42d210016e4 (Accessed 4 December 2020)

NOAA NCCOS. 2015. Water depth and acoustic backscatter data collected from NOAA Ship Nancy Foster in Caribbean Sea, Northeast Grand Reserve, Puerto Rico from 2013-03-05 to 2013-03-29 (NCEI Accession 0131855). NOAA National Centers for Environmental Information. Dataset. Available online: https://accession.nodc.noaa.gov/0131855. (Accessed 4 December 2020)

NOAA NCCOS. 2020. ArcGIS Online U.S. Caribbean Spatial Prioritization Results App (website). Available online: https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=537dfa0a18334b1c82e0f691b85c2848 (Accessed 4 December 2020)

NOAA OCS. 2019. National Oceanic and Atmospheric Administration's Office of Coast Survey (website). Available online: https://nauticalcharts.noaa.gov/ (Accessed 4 December 2020).

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rodriguez, R.W., and J.L. Trias. 1989. Maps showing characteristics of the Escollo de Arenas sand and gravel deposit, Vieques Island, Puerto Rico. USGS Miscellaneous Field Studies Map 2108. DOI: 10.3133/mf2108

SeaSketch. 2020. SeaSketch Supports Collaborative Planning for our Oceans. University of California, Santa Barbara, Marine Science Institute, McClintok Lab. Available online: https://www.seasketch.org/home.html (Accessed 4 December 2020).

TNC 2020. Mapping Coral: Building high-resolution maps for effefctive coral conservation (website). The Nature Conservancy and partners. Available online: https://storymaps.arcgis.com/stories/88bf705ca7484451ae1f9eb00db089d2 (Accessed 4 December 2020)

Appendix

Appendix: Participant List and Number of Coins by Participants

Table A.1 lists the participants, organizations, and emails of the people who were invited to provide input into the U.S. Caribbean spatial prioritization. This list was compiled by NCCOS to represent local jurisdictional, academic, and management organizations from both Puerto Rico and the USVI. It was vetted by the project's technical advisor team, which included the 4 members of the NOAA's CRCP.

Table A.1. *Prioritization participant list.* Contact information for the participants who were invited to provide input into the U.S. Caribbean spatial prioritization.

#	Organization	Point of Contact	Email	Participated
1	Caribbean Coastal Ocean Observing Systems (CariCOOS)	Miguel Canals	miguelf.canals@upr.edu	✓
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3	Department of Natural and Environmental Resources	Tania Metz	Tmetz@drna.pr.gov	✓
4	Department of Planning and Natural Resources	Pedro Nieves	pedro.nieves@dpnr.vi.gov	✓
5	NOAA/NOS/NGS/Remote Sensing Division	LCDR David Gothan	david.gothan@noaa.gov	✓
6	NOAA/NMFS/Office of Science and Technology	Tony Marshak	Tony.Marshak@noaa.gov	✓
7	NOAA/NMFS/Restoration Center	Michael Nemeth	michael.nemeth@noaa.gov	
8	NOAA/NMFS/Southeast Fisheries Science Center	Kevin McCarthy	kevin.j.mccarthy@noaa.gov	✓
9	National Park Service – Puerto Rico	Felix J. Lopez	felix_j_lopez@nps.gov	
10	NOAA/Office of Coastal Management	Bill O' Beirne	bill.obeirne@noaa.gov	
11	NOAA/Ocean Exploration and Research	Caitlin Adams	caitlin.adams@noaal.gov	✓
12	NOAA/NOS/Office of Response and Restoration	Brad Benggio	Brad.benggio@noaa.gov	
13	NOAA/NMFS/Office of Protected Resources	Lisa Carrubba	lisamarie.carrubba@noaa.gov	✓
14	NOAA/NMFS/Southeast Regional Office	Bill Arnold	bill.arnold@noaa.gov	✓
15	Protectores de Cuencas	Roberto Viqueira	rviqueira@protectoresdecuencasinc.org	
16	Ridge to Reefs	Paul Sturm	paul@ridgetoreefs.org	
17	The Nature Conservancy – Caribbean Division	Steve Schill	sschill@tnc.org	✓
18	University of Puerto Rico	William Hernandez	william.hernandez@upr.edu	✓
19	US Coast Guard	MST3 Crystal Saladino	Crystal.A.Saladino@uscg.mil	
20	US Fish and Wildlife	Felix Lopez	felix_lopez@fws.gov	✓
22	US Geological Survey	Alexandra Fredericks	afredericks@usgs.gov	✓
23	University of Virgin Islands	Tyler Smith	tsmith@live.uvi.edu	✓

U.S. Department of Commerce

Wilbur L. Ross, *Secretary*

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