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National Coral Reef Monitoring Program

Biological Monitoring Summary

U.S. Virgin Islands and Puerto Rico: 2021

2023

NOAA | NOS Coral Reef Conservation Program
NOAA | NOS National Centers for Coastal Ocean Science
NOAA | NMFS Southeast Fisheries Science Center

NOAA Technical Memorandum NOS CRCP 46

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Cover photos were taken by University of the Virgin Islands (top) and HJR Reefscaping, Inc. (bottom).

Disclaimer

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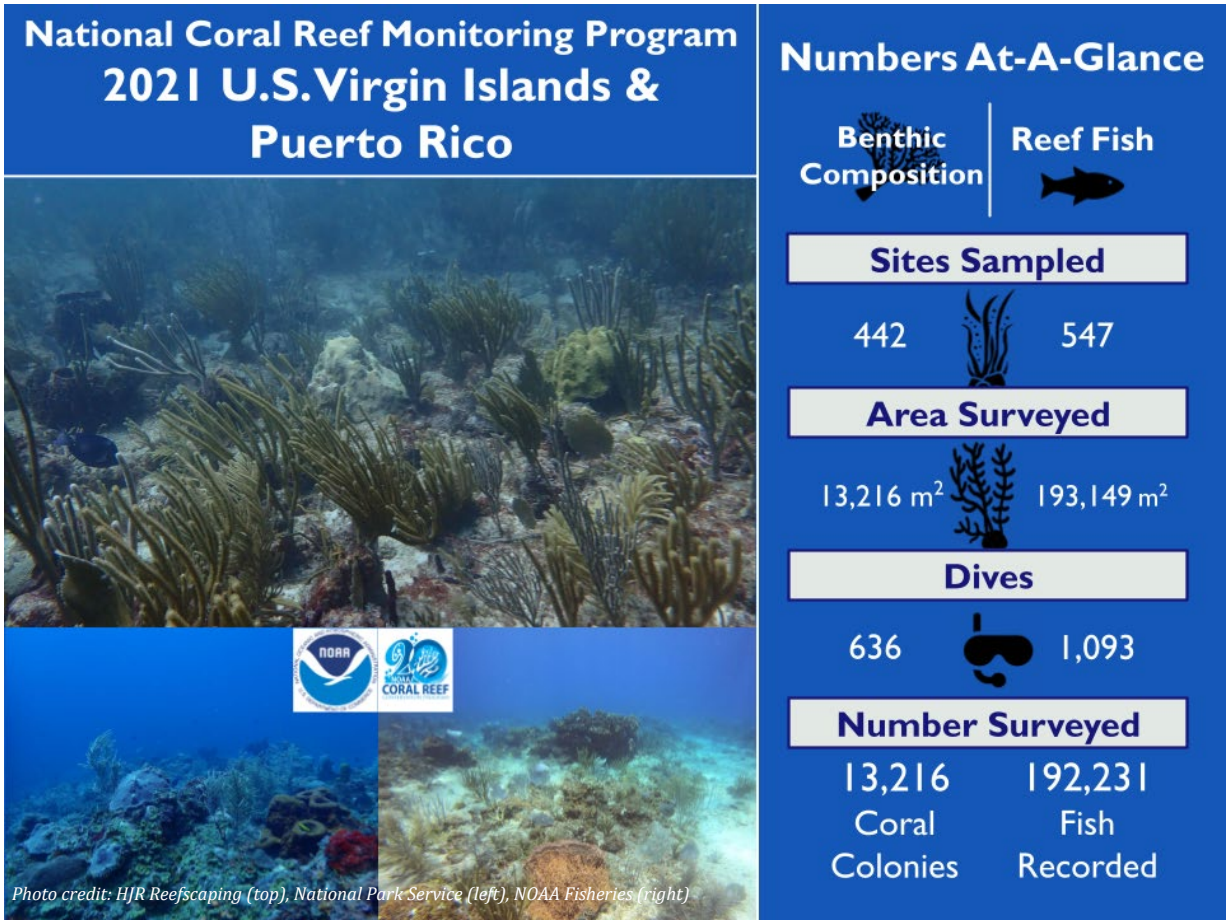
Acronyms

APT	All-Purpose Tool
CRCP	Coral Reef Conservation Program
CV	coefficient of variation
ESA	Endangered Species Act
LPI	line point intercept
NCCOS	National Centers for Coastal Ocean Science
NCRMP	National Coral Reef Monitoring Program
NOAA	National Oceanic and Atmospheric Administration
RVC	Reef Fish Visual Census
SCTLD	stony coral tissue loss disease
SEFSC	Southeast Fisheries Science Center
UPR	University of Puerto Rico
USVI	United States Virgin Islands

Executive Summary

National Oceanic and Atmospheric Administration (NOAA)'s National Coral Reef Monitoring Program (NCRMP) conducts biological sampling for benthic communities (corals and algae) and fish populations in the United States Virgin Islands (USVI) and Puerto Rico every other year. In 2021, NCRMP dive surveys occurred from summer (June) to early winter (December) on shallow-water (0–30 m) coral reefs and collected data on many thousands of individual coral colonies and fishes. NCRMP data are used to inform coral and fish population management strategies, document the occurrence of endangered species and coral disease, and assist with local monitoring efforts. Information about NCRMP's methods, data, and data products are available on the projects' website: https://www.coris.noaa.gov/monitoring/biological.html.



Report Overview

NCRMP provides large-scale, stratified random coral reef monitoring data to evaluate the status and trends of coral reefs and their communities. The NCRMP biological sampling effort consists of surveys of: 1) Fish Communities and Populations, and 2) Benthic Communities and Coral Populations. The goal of this report is to provide a broad overview of NCRMP's accomplishments and results by summarizing 2021 biological data collected by NOAA and regional partners in the shallow-water coral reef ecosystems in the USVI and Puerto Rico.

Sampling Overview

The NCRMP U.S. Caribbean sampling effort was atypical in 2021 due to the coronavirus pandemic. NOAA's NCRMP team and partner fieldwork constraints varied considerably, and NCRMP's core team was predominantly limited to remote participation. The field sampling effort was successful due to exceptional partner collaboration, participation, and commitment.

In 2021, sampling efforts occurred at the following locations and dates:

- St. Croix, USVI: June 14–25, 2021
- St Thomas and St. John, USVI: August 2–13, 2021
- Puerto Rico: June–December 2021

Partners involved in these efforts included:

- USVI
  - National Park Service
  - The Nature Conservancy
  - University of the Virgin Islands
  - USVI Department of Planning and Natural Resources
- Puerto Rico
  - Coastal Survey Solutions
  - HJR Reefscaping
  - Puerto Rico Department of Natural and Environmental Resources
  - University of Puerto Rico

Key Report Points

Benthic Community

- NCRMP benthic data showed widespread stony coral tissue loss disease (SCTLD) during the U.S. Caribbean surveys.
- Coral cover declined by 1.5%–5% in all three regions between 2013 and 2021.
- NCRMP coral data showed that approximately 5 to 11 coral species have coefficients of variation (CVs) of density less than 20%, indicating sufficient data for robust statistical analyses.

Fish Community

- NCRMP fish data showed that mature red hind (*Epinephelus guttatus*) and queen triggerfish (*Balistes vetula*) were regularly observed in the U.S. Caribbean surveys.
- Reefs in all locations are dominated by fishery non-targeted species of bicolor damselfish (*Stegastes partitus*), bluehead wrasse (*Thalassoma bifasciatum*), and yellowhead wrasse (*Halichoeres garnoti*).
- NCRMP fish data showed that a large number of fishery-targeted and non-targeted surveyed fishes, 19–46 reef fish species, have CVs of density 20% or less, meaning there are enough data to perform robust statistical analyses.

Introduction

Coral reefs are valuable ecosystems that provide people with goods and services, including food, coastal protection, and recreational opportunities. Despite the importance of coral reefs, these ecosystems are in decline from numerous human-made and natural threats (Hughes and Tanner, 2000; Knowlton, 2001). In response to these threats, National Oceanic and Atmospheric Administration (NOAA)'s Coral Reef Conservation Program (CRCP) established a National Coral Reef Monitoring Program (NCRMP) with partners across the United States (U.S.). This program is a strategic framework for conducting long-term, quantitative surveys of biological, climatic, and socioeconomic indicators in U.S. coral reef states and territories. The resulting data present a robust picture of the U.S. coral reef ecosystem condition and the communities connected to them.

NCRMP biological monitoring provides an assessment of the coral reef communities over a broad spatial scale in U.S. jurisdictions. The overall goal is to provide robust, quantitative data to document the status and trends of coral reef fishes, corals, and benthic communities in the Atlantic, Caribbean, and Gulf of Mexico basins at a regional (or island) scale (NOAA Coral Program, 2021; Towle et al., 2022). NCRMP generates large-scale, regional status and trend information of U.S. shallow-water (0–30 m) coral reef ecosystems. This context and perspective provide a dataset that can be used for coral reef management. Biological sampling occurs on a two-year cycle within the Atlantic, Caribbean, and Gulf of Mexico coral reef jurisdictions, including the U.S. Virgin Islands (USVI; including St. Thomas, St. John, and St. Croix), Puerto Rico, Florida, and the Flower Garden Banks National Marine Sanctuary (Figure 1).

Figure 1. Map of Atlantic regions sampled within the National Coral Reef Monitoring Program.

This report provides a summary of data collected by the biological sampling of NCRMP shallow-water coral reef ecosystems in the USVI and Puerto Rico in 2021. Data summaries for ecologically important metrics are provided for the most recent sampling year, and trends are reported from the onset of NCRMP. The full datasets for 2021 and prior can be obtained from the NCRMP Biological project webpage (https://www.coris.noaa.gov/monitoring/biological.html) and the NOAA's National Centers for Environmental Information database (see Appendix A for additional reference and archive information).

Methods

Sample Design

NCRMP biological monitoring (i.e., fish, corals, and benthic communities) uses a grid-based stratified random design that is optimized to efficiently sample for ecologically and commercially important species. Details of the sample frame protocol, methods, and definitions of the specific habitat types can be found in the Spatial Framework Protocols (NOAA NCCOS, 2018). In the U.S. Caribbean, the NCRMP sample frame has two jurisdictions: (1) Puerto Rico, a single sampling domain or region; and (2) U.S. Virgin Islands, which consists of two separate sampling domains or regions: (a) St. Croix and (b) St. Thomas and St. John. Each region has a unique set of strata specific to the local protected or managed zones and benthic habitat. The survey design ensures that sites for fish and corals are allocated by hard-bottom habitat type, depth, and management zone, with sites randomly distributed around the sampling region from nearshore to offshore to a maximum depth of 30 m.

The NCRMP biological monitoring team and partners strive to sample a specific quota of sites each survey year in each sampling domain. The actual number of sites sampled may vary each year due to numerous factors, such as weather conditions and resources. Fish and benthic sites are generally co-located but may not be sampled concurrently during the same dive. As additional NCRMP data are collected in future years, the strength of the data and trend analyses will continue to grow.

The U.S. Caribbean regions vary in their implementation and enforcement of spatially explicit closure areas (e.g., marine reserves and national parks) for recreationally and commercially targeted fish species. In the USVI, national parks seasonally close to some activities (e.g., recreational fishing), limit gear (e.g., no spearfishing), and prohibit commercial fishing. In St. Croix, national parks include Buck Island Reef National Monument and Salt River Bay Ecological Reserve. In St. Thomas and St. John, national parks include Virgin Islands Coral Reef National Monument and Virgin Islands National Park. The majority of NCRMP sampling occurs outside of the national parks; however, the sampling design provides enough power to detect differences between fish densities inside versus outside the collective parks. Although there are a number of other spatially managed areas in the USVI and Puerto Rico, for multiple reasons, the effect of spatial management reported herein was restricted to fish communities and national parks. Since Puerto Rico does not have national parks, the entire region was designated as “outside,” and no “inside” versus “outside” comparisons were made.

Sample Protocols

Field Surveys

Corals and benthic communities were monitored using a Benthic Community Assessment survey and a Coral Demographics survey (CRCP, 2022a; CRCP, 2022, b; Figure 2). The Benthic Community Assessment survey includes: (1) benthic cover (%) estimates using a line point intercept (LPI) approach along a 15-m transect, (2) presence/absence of Endangered Species Act (ESA)–listed coral species (in transect area; at site), (3) abundance of key macroinvertebrates, and (4) reef rugosity measurements within a 15 m × 2 m belt-transect area (CRCP, 2022a). At the same site, Coral Demographics surveys are conducted within a 10 m × 1 m belt-transect area (CRCP, 2022b). Within this transect, all live coral colonies ≧4 cm were counted, identified to species, and measured to the nearest centimeter (length, width, and height). Partial mortality was estimated as the percentage of the colony surface area showing old mortality, recent mortality, or both. Relative condition factors such as disease (present, slow, or fast) and bleaching (total, partial, or paling) were also recorded as presence or absence per colony. Only live coral colonies were included in the surveys; dead colonies with 100% mortality were not surveyed due to the unreliability of species-level identification of completely dead coral skeletons. In the Coral Demographics surveys, juvenile corals (<4 cm) were reported for species richness only and were not included in counts, size measurements, or estimates of condition.

NCRMP Coral Demographics surveys provide information on disease occurrence on individual coral colonies, and no disease identification is included. Disease progression rate estimates (i.e., slow or fast rates) were added at the request of partners as a rapid, general approach to identify potential stony coral tissue loss disease (SCTLD). However, further information has shown that rate is not a reliable indicator of SCTLD; therefore, NCRMP will revisit the inclusion of this classification approach in subsequent survey years. Additional information on how NCRMP can inform SCTLD response is provided in Towle (2021).

Coral bleaching (total, partial, paling, or none) is consistently surveyed during NCRMP sampling; however, field sampling dates do not always coincide with bleaching events. Therefore, peak bleaching events may not be represented comprehensively in NCRMP data.

Figure 2. Example of a diver collecting coral demographic data (bottom) and a diver collecting Reef Fish Visual Census fish survey data (top) in St. John. Photo credit: National Park Service.

The Reef Fish Visual Census (RVC) is a stationary point count sampling protocol (CRCP, 2022c) modified from Bohnsack and Bannerot (1986). A two-diver team surveyed all fish within adjacent 15-m diameter cylinders centered on each diver and extending vertically from the substrate to the sea surface. Within each cylinder, fish were identified to the species level and counted, and fork length was estimated to the nearest centimeter (Figure 2). Data collected by the diver survey pair were averaged at the site level.

Data Quality Assurance

NCRMP data quality standards were met using five primary approaches:

1) NCRMP surveyors demonstrated expertise in field identification prior to field surveys. Surveyors were trained in NCRMP methods through a) detailed training for new surveyors and b) annual refresher training for repeat surveyors;
2) NCRMP fish surveyors calibrated their length measurements and sizing using the All-Purpose Tool (APT), a 1-m stick with a 30-cm perpendicular attachment on one side marked in 1-cm increments,

during in-water practical training sessions and on personal training dives prior to field sampling;

3) Reciprocal data checks followed data collection at each site. Upon surveyors' return to the survey vessel after each dive, surveyors traded datasheets with their dive buddy and reviewed them to ensure all data were collected consistently and completely;
4) Divers entered their data into the online database and then compared their original datasheets with the database entries; and
5) Quality checks are applied to data after export from the database. Basic statistical analyses were conducted and included quality checks (e.g., by species and by diver). After the data were fully vetted through these quality checks, data were archived at NCEI and released publicly (Appendix A).

Analytical Methods

Corals and Benthic Communities

Coral demographic sampling within NCRMP targets a coefficient of variation (CV) of 20% or less for the regionally specific sampling design species. A 20% CV can be translated to the ability to statistically detect a 40% change in density. The sample allocation is optimized for species that are identified as major reef-building species or those of interest to management. The allocation species for St. Thomas and St. John in 2021 were *Colpophyllia natans*, *Diploria labyrinthiformis*, *Madracis decactis*, *Orbicella annularis*, and *O. faveolata*; in St. Croix, they were *C. natans*, *M. decactis*, *Meandrina meandrites*, *O. annularis*, *O. faveolata*, *and O. franksii*; and in Puerto Rico, they were *D. labyrinthiformis*, *M. decactis*, *O. annularis*, *O. faveolata*, and *O. franksii*.

Standard metrics, including benthic cover (% cover of corals and macroalgae), coral species occurrence, coral density, and relative size composition, are reported herein. Computational formulas of standard metrics for single-stage stratified random sampling design are provided in detail in Smith et al. (2011), Groves and Viehman (2023), and Viehman, Groves, et al. (in press). For temporal comparisons, a pairwise two-tailed t-test was performed to evaluate differences between years, where appropriate (see Results section). Site-level coral bleaching and disease prevalence were calculated as the percentage of colonies with any bleaching or disease divided by the total number of corals by species at each site. Domain-level coral bleaching and disease prevalence by species were calculated as the mean percentage of colonies with any bleaching/disease divided by the total number of corals for each species across all sites and strata; this was then weighted by the proportion of the strata within the entire sampling domain (Smith et al., 2011).

NCRMP analyses scripts for corals and benthic communities are open source and available at NCRMP **Benthic R package** (Groves and Viehman, 2023).

Fish Communities

NCRMP fish sampling similarly targets a CV of 20% or less for the regionally specific sampling design species. In the U.S. Caribbean, the sample allocation selects for fishery-targeted and non-targeted, ecosystem species. In all sampling domains, the allocation species are all life stages of blue tang (*Acanthurus coeruleus*), foureye butterflyfish (*Chaetodon capistratus*), French grunt (*Haemulon flavolineatum*), coney (*Cephalopholis fulva*), red hind (*Epinephelus guttatus*), queen triggerfish (*Balistes vetula*), stoplight parrotfish (*Sparisoma viride*), and yellowtail snapper (*Ocyurus chrysurus*). Other common reef fish species or fishes that share characteristics to the allocation species are similarly well sampled.

Standard fish metrics, including density, occurrence, and relative length composition, are reported herein. Computational formulas of standard metrics for single-stage stratified random sampling design are provided in detail in Grove et al. (2021) and Bryan et al. (2016), and a two-tailed t-test was performed to evaluate density between years inside versus outside of spatial protection, where appropriate (see Results section).

Fish analysis scripts are open source and available at NCRMP **Fish R package** (Ganz and Blondeau, 2015).

Results

In 2021, NCRMP surveyed 550 total sites in the USVI and Puerto Rico (Figure 3). These included a total of 316 in the USVI regions, where 165 unique sites were in the St. Thomas and St. John region, and 151 were in the St. Croix region; and 234 were in the Puerto Rico region (Table 1). Due to COVID-19 restrictions, fewer surveyors were able to participate in field sampling, and subsequently, fewer sites were surveyed compared to previous years (e.g., western St. Croix, northern Puerto Rico). In 2021, for benthic sampling, 50%–57% of the targeted sites were surveyed, and for fish sampling, 59%–78% of the targeted sites were surveyed. An additional fish sampling effort (i.e., calibration) led to the higher number of fish surveys in Puerto Rico. Beginning in 2019, all islands were surveyed during the same calendar year (Table 1; odd years; for more details, see Grove et al. [2021]).

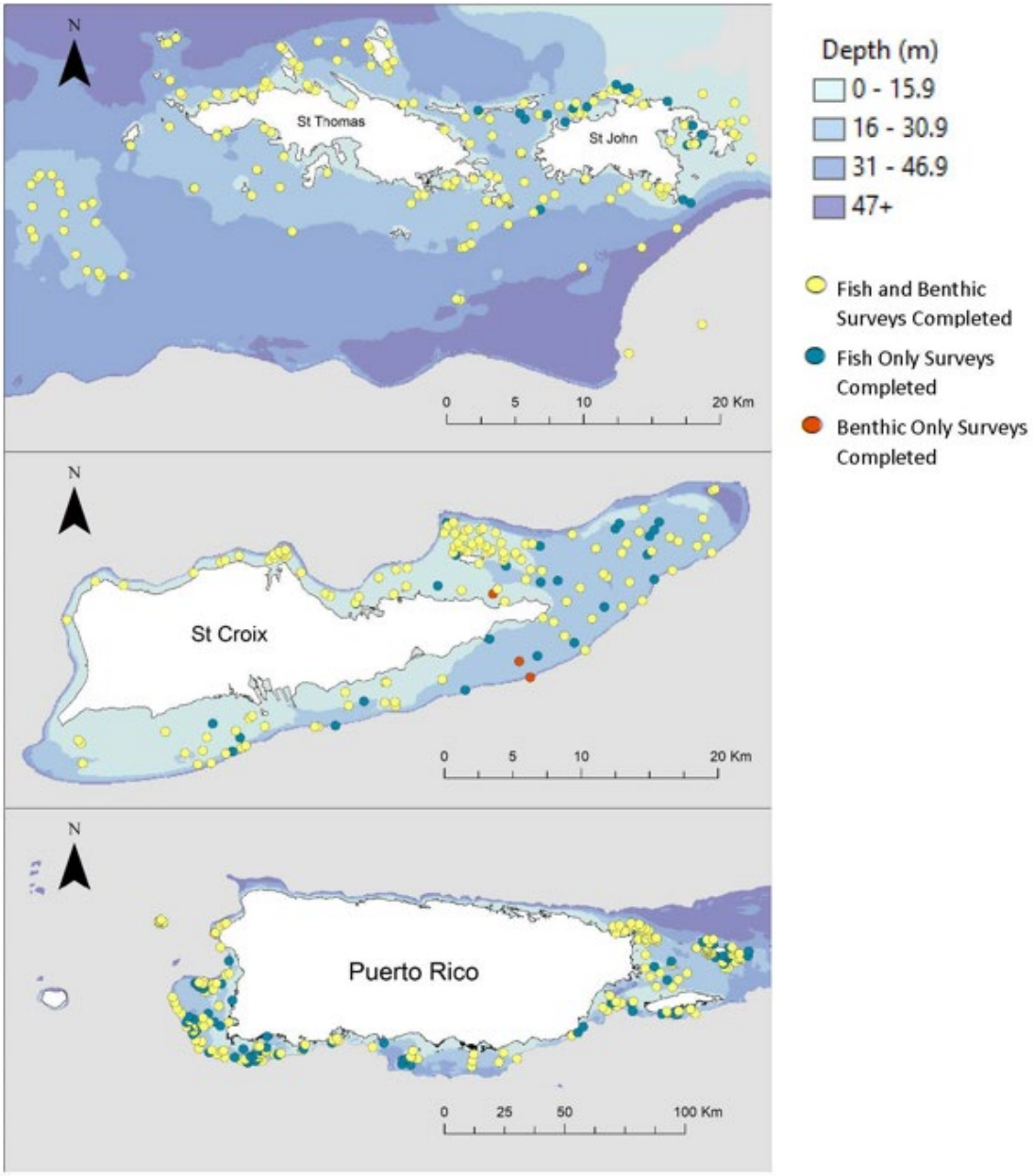


Figure 3. NCRMP survey sites sampled in St. Thomas and St. John (top), St. Croix (middle), and Puerto Rico (bottom) in 2021. Blue, yellow, and red circles indicate survey locations. Legend shows bathymetric depth (m) gradients in each sampling region along the mapped zone of the shelf edge. Gray zone indicates unmapped areas. NCRMP = National Coral Reef Monitoring Program.

Table 1. NCRMP fish and benthic sites sampled by year in each U.S. Caribbean region (Puerto Rico, St. Croix, and St. Thomas and St. John). NCRMP = National Coral Reef Monitoring Program.

	U.S. Virgin Islands				Puerto Rico	
	St. Croix		St. Thomas & St. John			
Year	*Fish*	*Benthic*	*Fish*	*Benthic*	*Fish*	*Benthic*
2021	148	124	165	147	234	171
2019	314	257	322	239	203	159
2017	181	175	239	235	-	-
2016	-	-	-	-	240	162
2015	239	139	255	168	-	-
2014	-	-	-	-	230	230
2013	-	-	283	283	-	-

Benthic Community Results

At the time of NCRMP sampling in 2021, SCTLD was widespread across the USVI and Puerto Rico. Coral density had been declining in many species prior to the onset of SCTLD; however, this disease has caused continued or accelerated declines in many of the SCTLD-susceptible coral species (Figures 4 and 5). For additional information on SCTLD in the USVI, see Virgin Islands Coral Disease - VI CDAC.

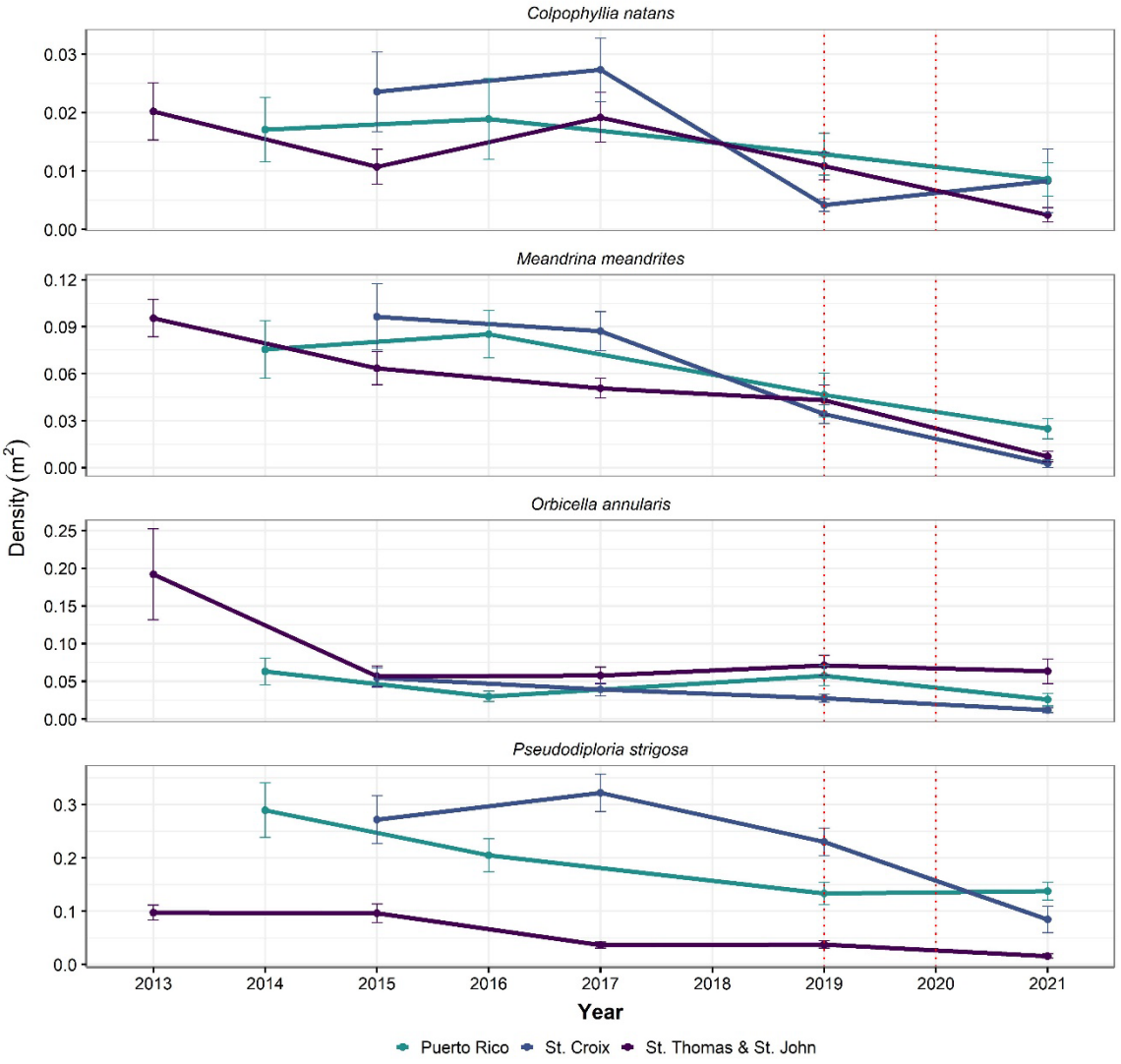


Figure 4. Mean coral density (colonies/m^2 ± SE) over time for four of the coral species susceptible to stony coral tissue loss disease (SCTLD) in St. Thomas and St. John (purple), St. Croix (blue), and Puerto Rico (turquoise). Vertical red dotted lines indicate the year of first sighting of SCTLD in each geography: St. Thomas (Jan. 2019), Puerto Rico (Oct. 2019), St. John (Jan. 2020), and St. Croix (July 2020). Note the y-axes differ by species. SE = standard error.

Figure 5. Examples of (left) a diver collecting benthic data in the U.S. Virgin Islands. (Photo credit: National Park Service) and (right) disease on a *Diploria labyrinthiformis* colony in Puerto Rico. Photo credit: HJR Reefscaping.

Coral and Macroalgae Cover

Mean coral cover shows a declining trend over time for all three regions but was statistically significant in both USVI regions (Figure 6). In 2021, mean coral cover was 4.3% ± 0.46 standard error (SE) in St. Thomas and St. John, 2.1% ± 0.26 SE in St. Croix, and 5.2% ± 0.41 SE in Puerto Rico.

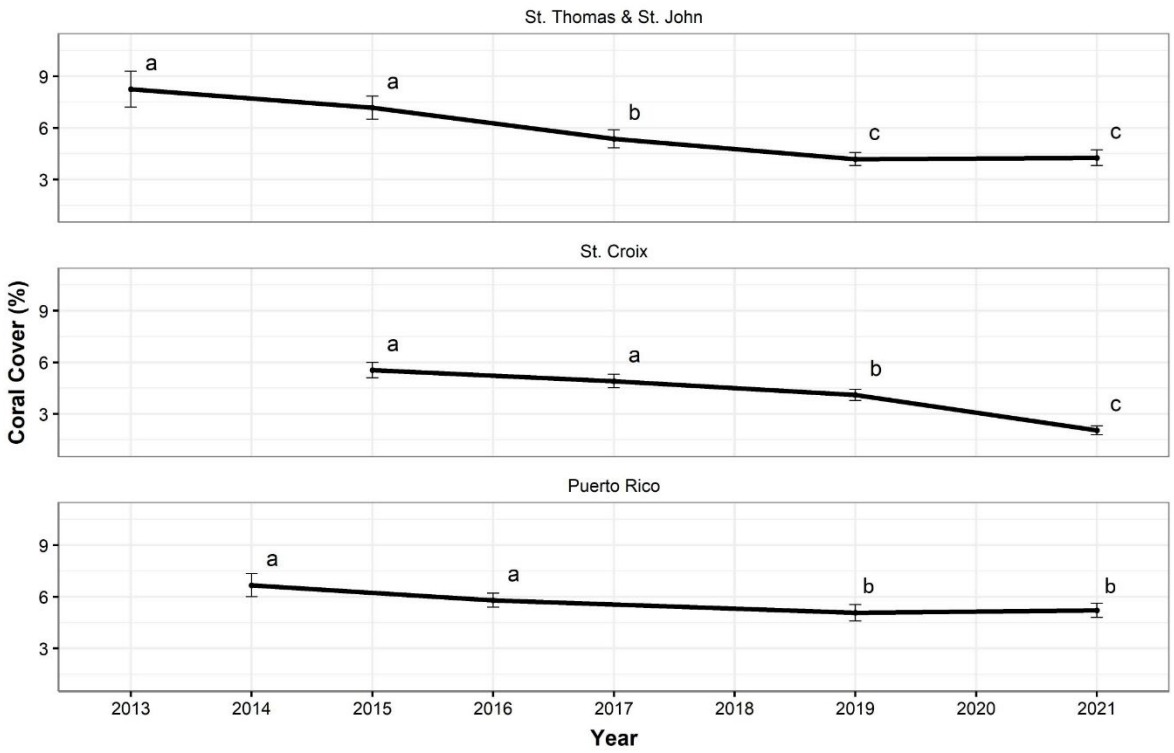


Figure 6. The mean coral cover (% cover ± SE) by survey year in the U.S. Virgin Islands and Puerto Rico from 2013 to 2021. Statistical significance (Tukey's two-tailed t-test), if present, is reported at $p < 0.05$, and different letters (e.g., a and b) denote a difference between survey years. SE = standard error.

Macroalgae cover was variable; however, all three of the U.S. Caribbean sampling regions exhibited significant increases in macroalgae between 2019 and 2021 (Figure 7). In 2021, macroalgae cover ranged from approximately 23%–33% (St. Thomas and St. John: 32.6% ± 2.19; St. Croix: 23.8% ± 2.69; Puerto Rico: 23.4% ± 1.49). Macroalgae cover is strongly influenced by survey timing, habitat type, and the particular functional group or species of macroalgae.

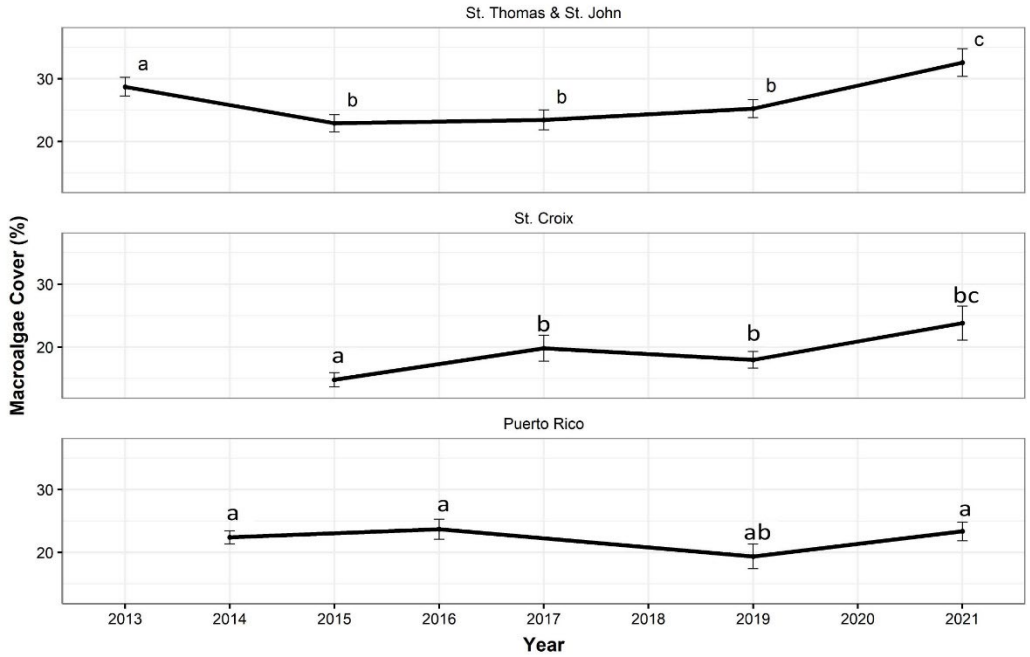


Figure 7. Mean macroalgae cover (% cover ± SE) by survey year in the U.S. Virgin Islands and Puerto Rico from 2013 to 2021. Statistical significance (Tukey's two-tailed t-test), if present, is reported at $p < 0.05$, and different letters (e.g., a and b) denote a difference between survey years. SE = standard error.

Coral Species Occurrence

NCRMP 2021 Coral Demographic Survey results show that *Porites astreoides* and *Siderastrea siderea* continue to represent with the highest species occurrences. CVs of densities are approximately 20% or less for 5–11 individual species, varying by region. In St. Thomas and St. John, 11 coral species had ≤20% CVs including: *Orbicella faveolata*, *O. franksi*, *Montastraea cavernosa*, *Madracis decactis*, and *Stephanocoenia intersepta* (Figure 8). In St. Croix, only five coral species had ≤20% CVs: *Agaricia agaricites*, *O. faveolata*, *O. franksi*, *Porites astreoides*, and *Siderastrea siderea* (Figure 9). In Puerto Rico, seven coral species had ≤20% CVs: *A. agaricites*, *M. cavernosa*, *O. faveolata*, *P. astreoides*, *Pseudodiploria strigosa*, *S. siderea*, and *S. intersepta* (Figure 10). A 20% CV of density can be translated to the ability to statistically detect a 40% change; therefore, a lower CV of density increases the sensitivity to detect changes in metrics (e.g., density, occurrence, condition). As coral species continue to decline (i.e., become less prevalent) from threats such as SCTLD, additional surveys will be required to achieve a 20% CV of density.

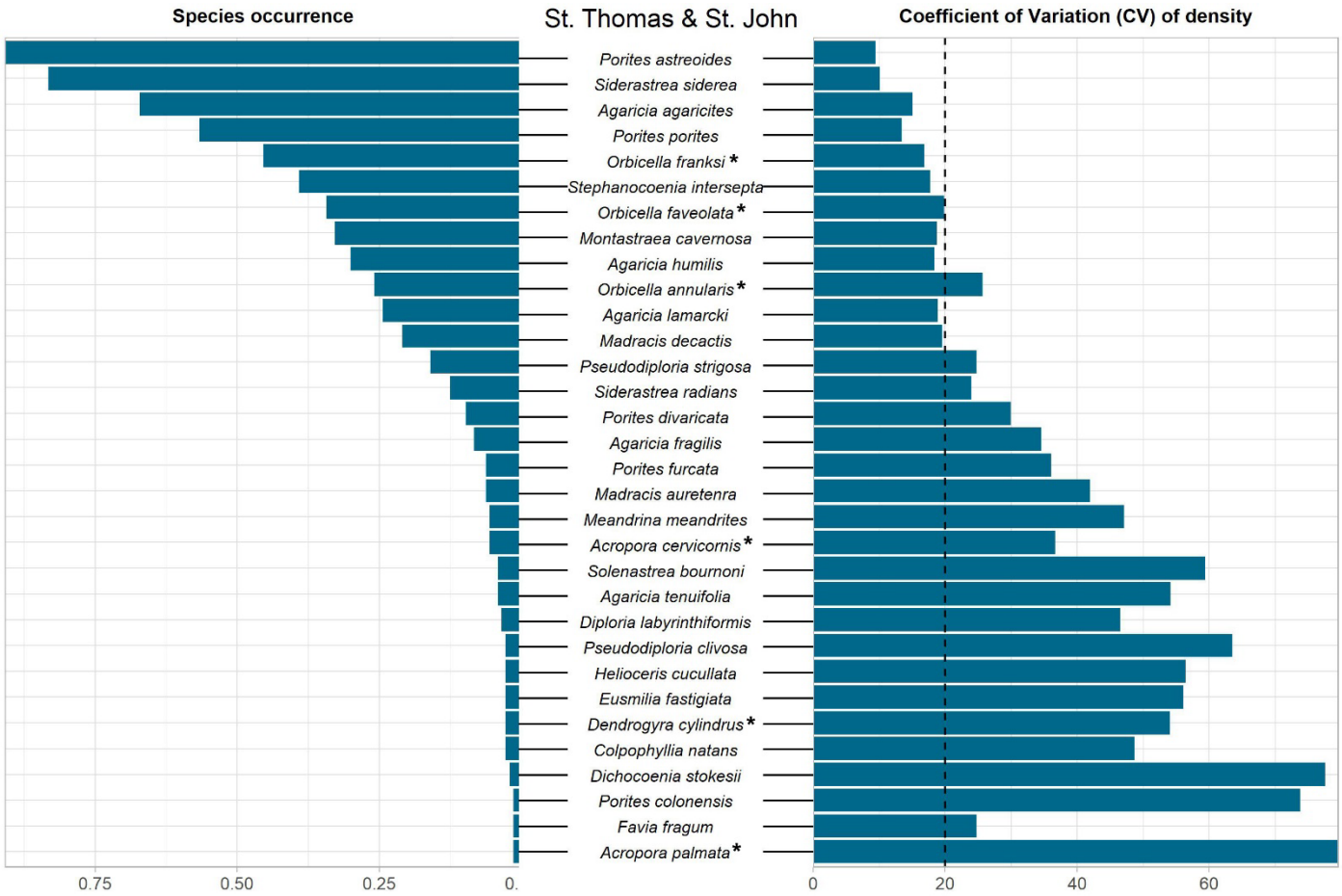


Figure 8. Coral species occurrence and coefficient of variation (CV) of density in St. Thomas and St. John coral demographics surveys in 2021. Species with an occurrence less than 0.01 are not shown. Dashed vertical line on the CV plot indicates the target CV of 20%. * indicates Endangered Species Act–listed species.

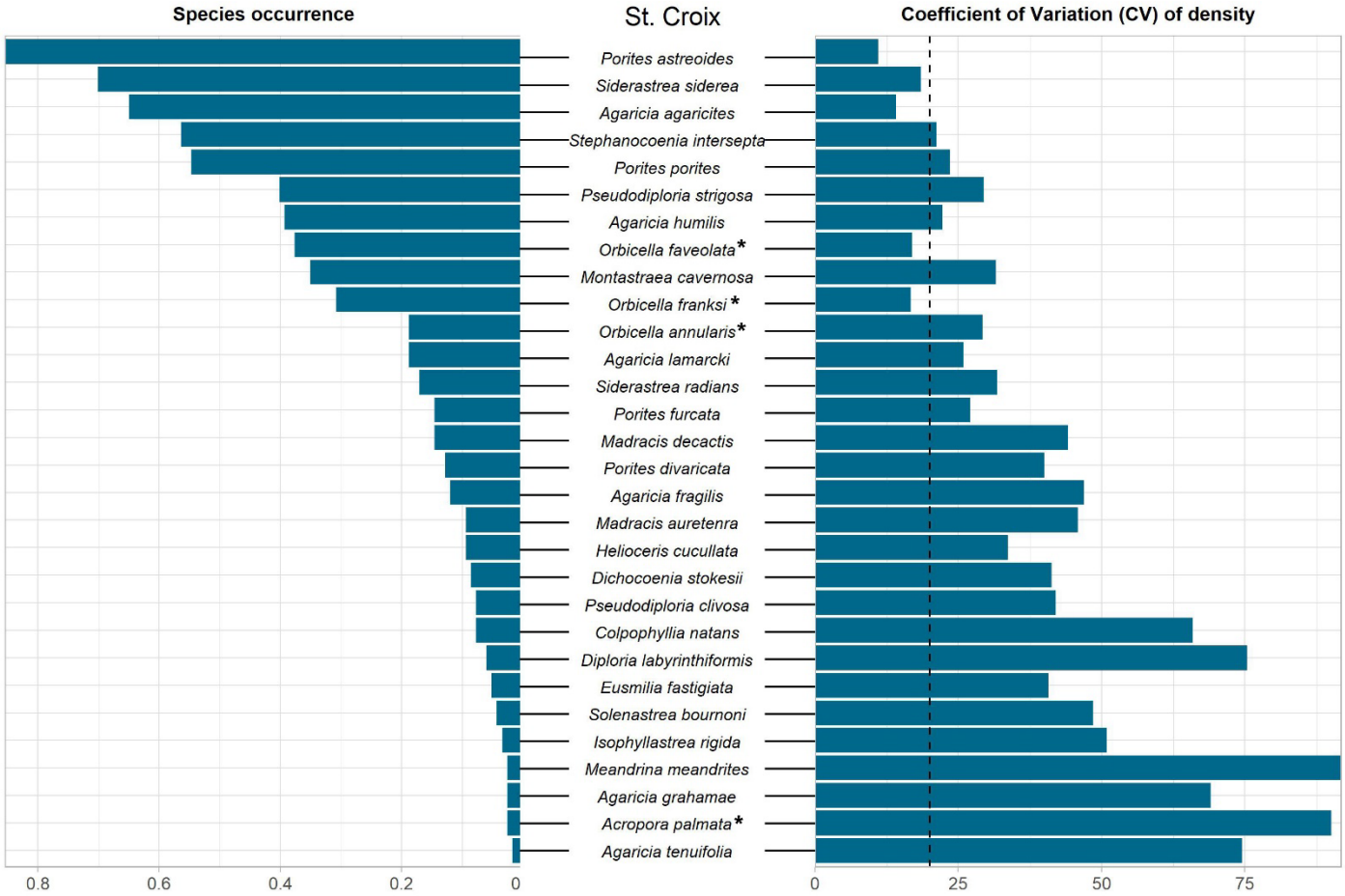


Figure 9. Coral species occurrence and coefficient of variation (CV) of density in St. Croix coral demographics surveys in 2021. Species with an occurrence less than 0.01 are not shown. Dashed vertical line on the CV plot indicates the target CV of 20%. * indicates Endangered Species Act–listed species.

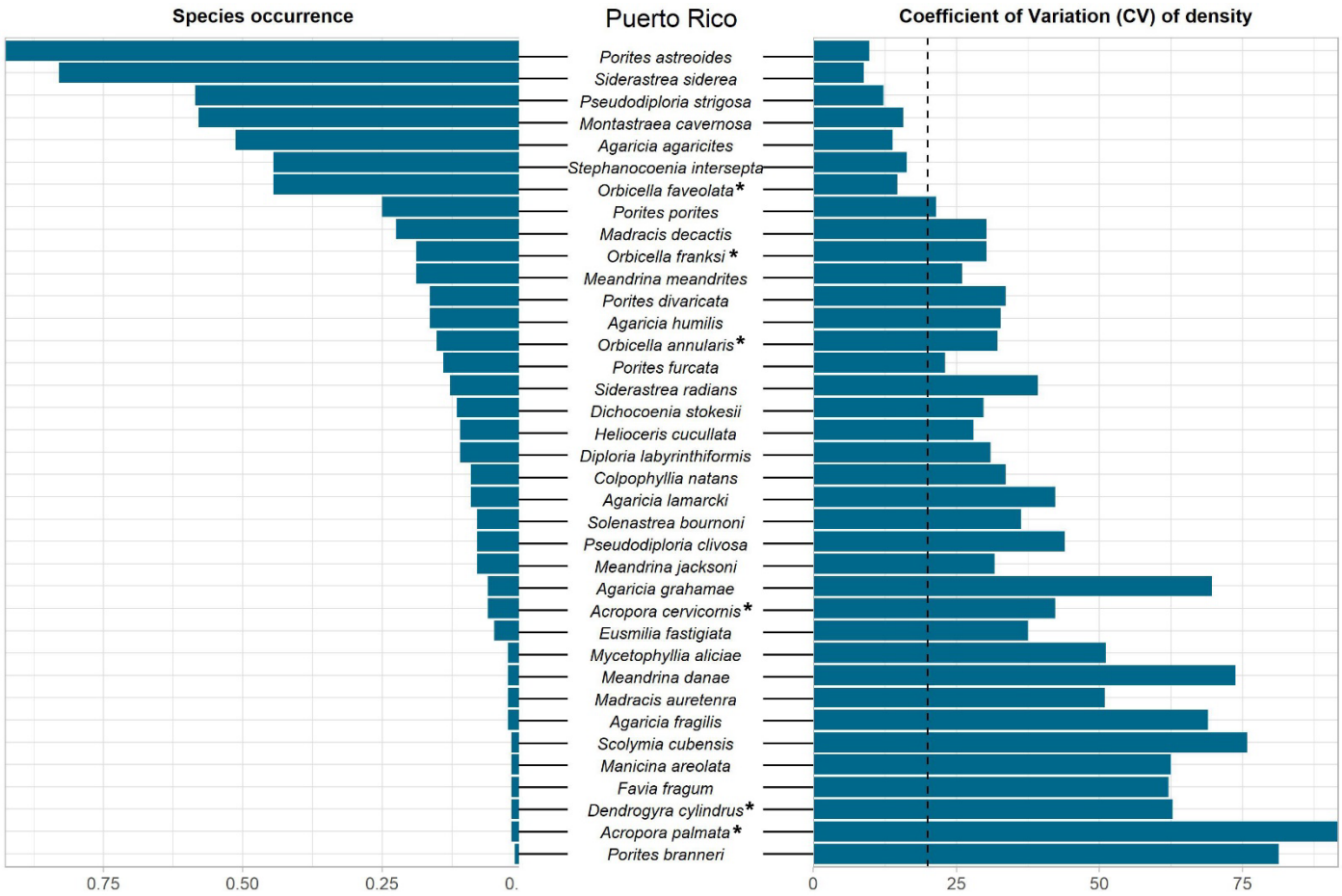


Figure 10. Coral species occurrence and coefficient of variation (CV) of density in Puerto Rico coral demographics surveys in 2021. Species with an occurrence less than 0.01 are not shown. Dashed vertical line on the CV plot indicates the target CV of 20%. * indicates Endangered Species Act–listed species.

Occurrences for ESA-listed coral species were calculated from the Benthic Community Assessment's ESA species surveys (presence or absence; at the transect and at the site) based on species presence either in the transect survey area or at the site. For the 269 Benthic Community Assessment sites surveyed in the USVI in 2021, *O. annularis* was present at 33% of sites, *O. faveolata* was present at 49% of sites, and *O. franksi* was present at 46% of sites. Other ESA-listed species were observed at much lower frequencies of occurrence: *Acropora cervicornis at* 8.2%, *Acropora palmata* at 12%, *Dendrogyra cylindrus* at 7.4%, and *Mycetophyllia ferox* at 1.1%). In Puerto Rico in 2021, orbicellids were observed at 18%–60% of the 171 benthic sites surveyed, and all other ESA-listed species were observed at lower frequencies (*A. cervicornis* = 14%, *A. palmata* = 4.1%, *D. cylindrus* = 18%, and *M. ferox* = 1.8%).

Coral Density and Size Distribution

The mean density of corals in Caribbean regions in 2021 was dominated by the following species: *P. astreoides*, *S. siderea*, *A. agaricites*, *P. strigosa*, *M. cavernosa*, and *Porites porites* (Figure 11). Coral density has declined over time in the U.S. Caribbean (Figure 12) and, in 2021, was less than 3 colonies/m^2 in all three regions. In the USVI, mean coral density declined from 4.3 ± 0.23 colonies/m^2 in 2013 to 2.5 ± 0.17 in 2021 in St. Thomas and St. John, and in St. Croix, mean coral density declined from 3.1 ± 0.27 colonies/m^2 in 2015 to 1.5 ± 0.14 in 2021. Similarly, in Puerto Rico, mean coral density declined from 3.3 ± 0.28 colonies/m^2 in 2014 to 2.1 ± 0.14 in 2021. Overall, the mean percentage of old mortality on coral colonies declined in all three regions and, in 2021, ranged from 10% to 11% (Figure 13). For all regions, the mean percentage of recent mortality was low (≤1%; Figure 14). In St. Croix, a significant increase in the mean percentage of recent mortality on coral colonies was detected from 2019 to 2021.

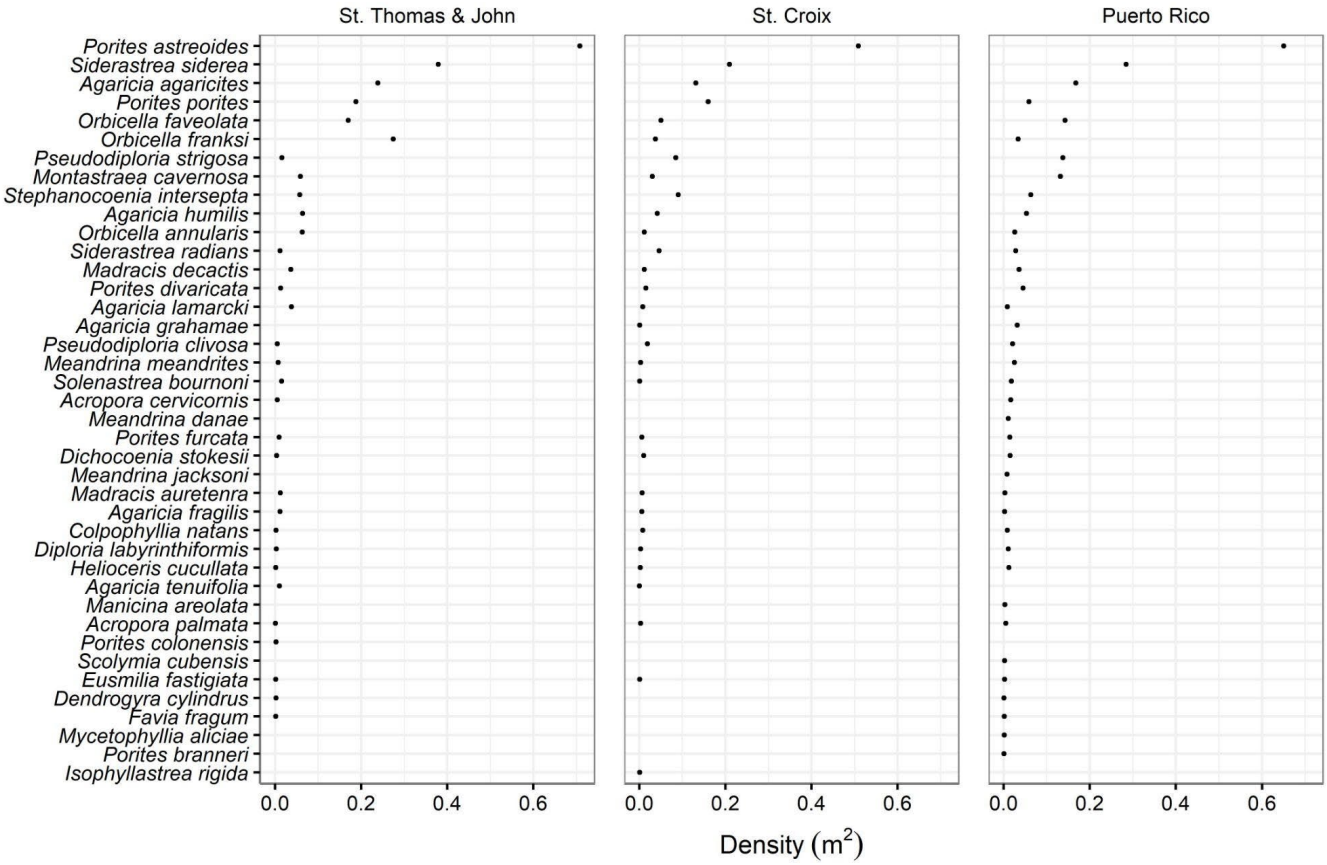


Figure 11. Mean density of corals (colonies/m^2) by species in the U.S. Virgin Islands and Puerto Rico in 2021. Only species with densities above zero in at least one region are shown.

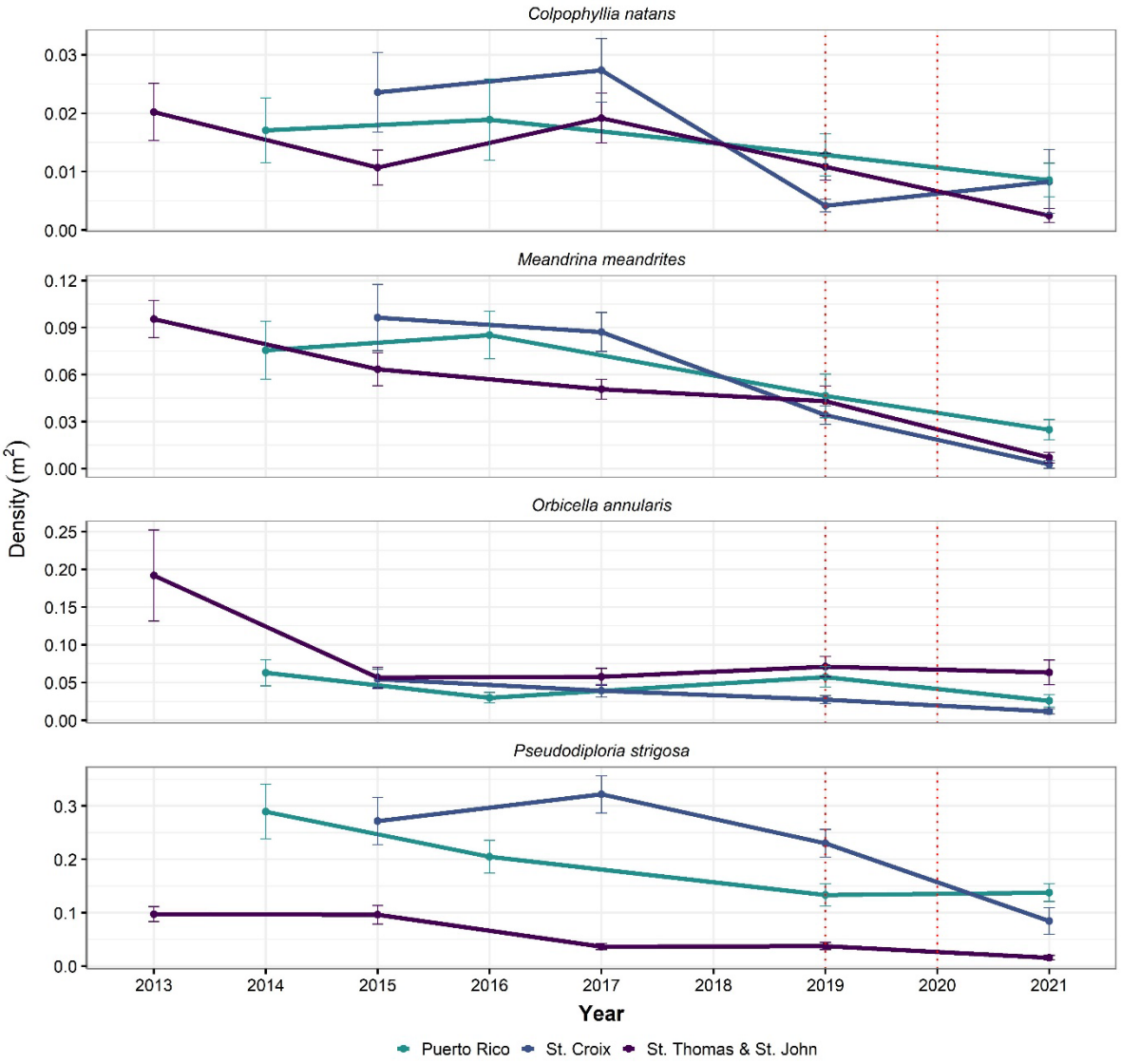


Figure 12. Mean adult coral density (colonies/m² ± SE) by survey year in the U.S. Virgin Islands and Puerto Rico from 2013 to 2021. Statistical significance (Tukey's two-tailed t-test), if present, is reported at $p < 0.05$, and different letters (e.g., a and b) denote a difference between survey years. SE = standard error.

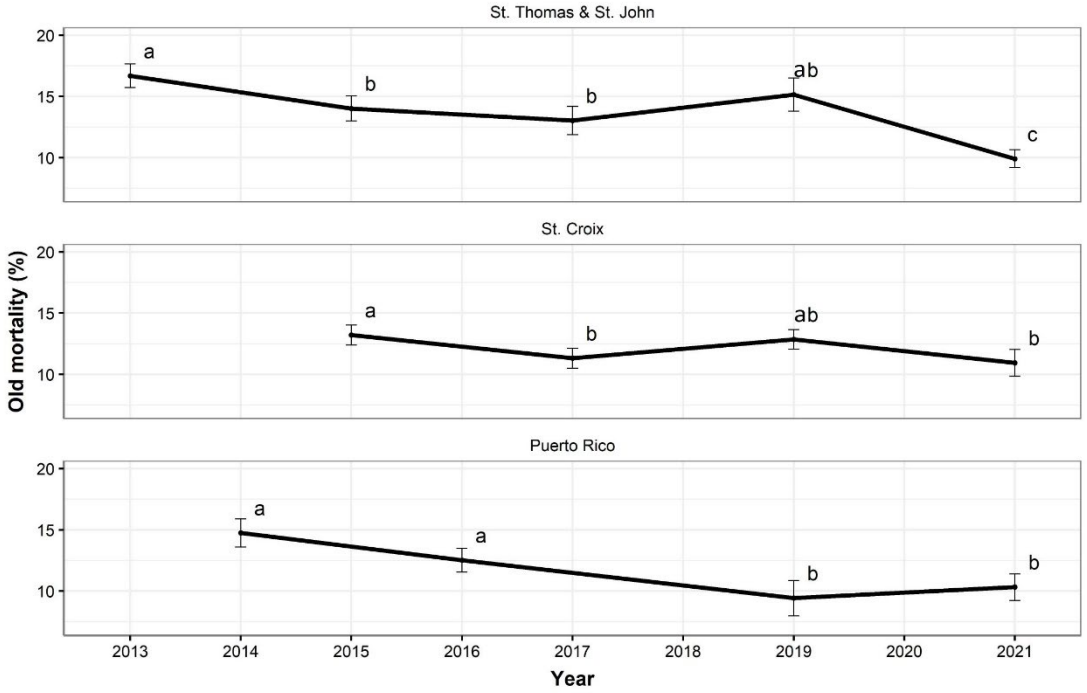


Figure 13. Mean percentage of old mortality on coral colonies (% of colony ± SE) by survey year in the U.S. Virgin Islands and Puerto Rico from 2013 to 2021. Statistical significance (Tukey's two-tailed t-test), if present, is reported at $p < 0.05$, and different letters (e.g., a and b) denote a difference between survey years. SE = standard error.

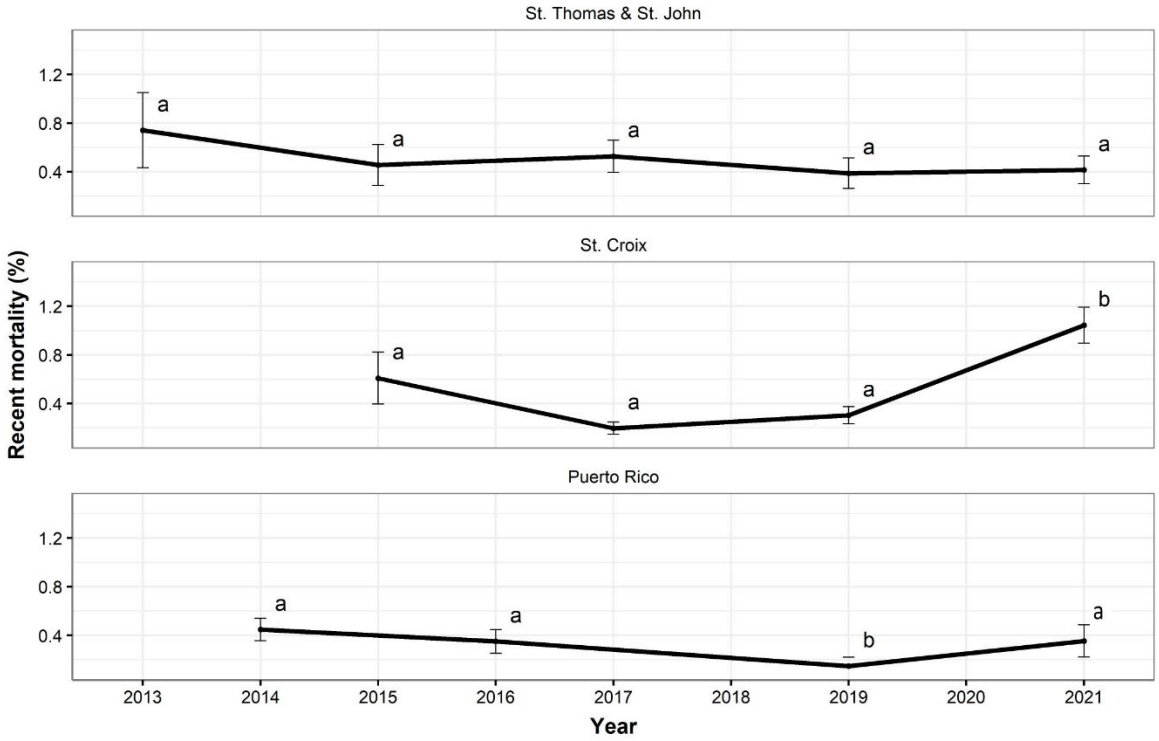


Figure 14. Mean percentage of recent mortality on coral colonies (% of colony ± SE) by survey year in the U.S. Virgin Islands and Puerto Rico from 2013 to 2021. Statistical significance (Tukey's two-tailed t-test), if present, is reported at $p < 0.05$, and different letters (e.g., a and b) denote a difference between survey years. SE = standard error.

A comparison of binned relative length (in centimeters) frequencies for four representative coral species (*Meandrina meandrites*, *M. cavernosa*, *O. annularis*, and *P. strigosa*) shows that maximum colony length has gradually declined over time since initial NCRMP surveys (Figures 15–17). An increase in the smallest size class (4–15 cm) in several species in each region could mean that juveniles are surviving and growing to more than 4 cm (the minimum size for NCRMP Coral Demographic survey measurements); alternatively, it could indicate partial mortality of larger size classes of corals. Representative species were selected based on CV, ESA status, SCTLD susceptibility, and ecological value (e.g., reef building capability). Colony size is an important component of coral population status that can be easily misinterpreted. For example, many small colonies can lead to a high coral density, and in this case, high coral density does not indicate a healthier reef with more large corals that are critical for reef building.

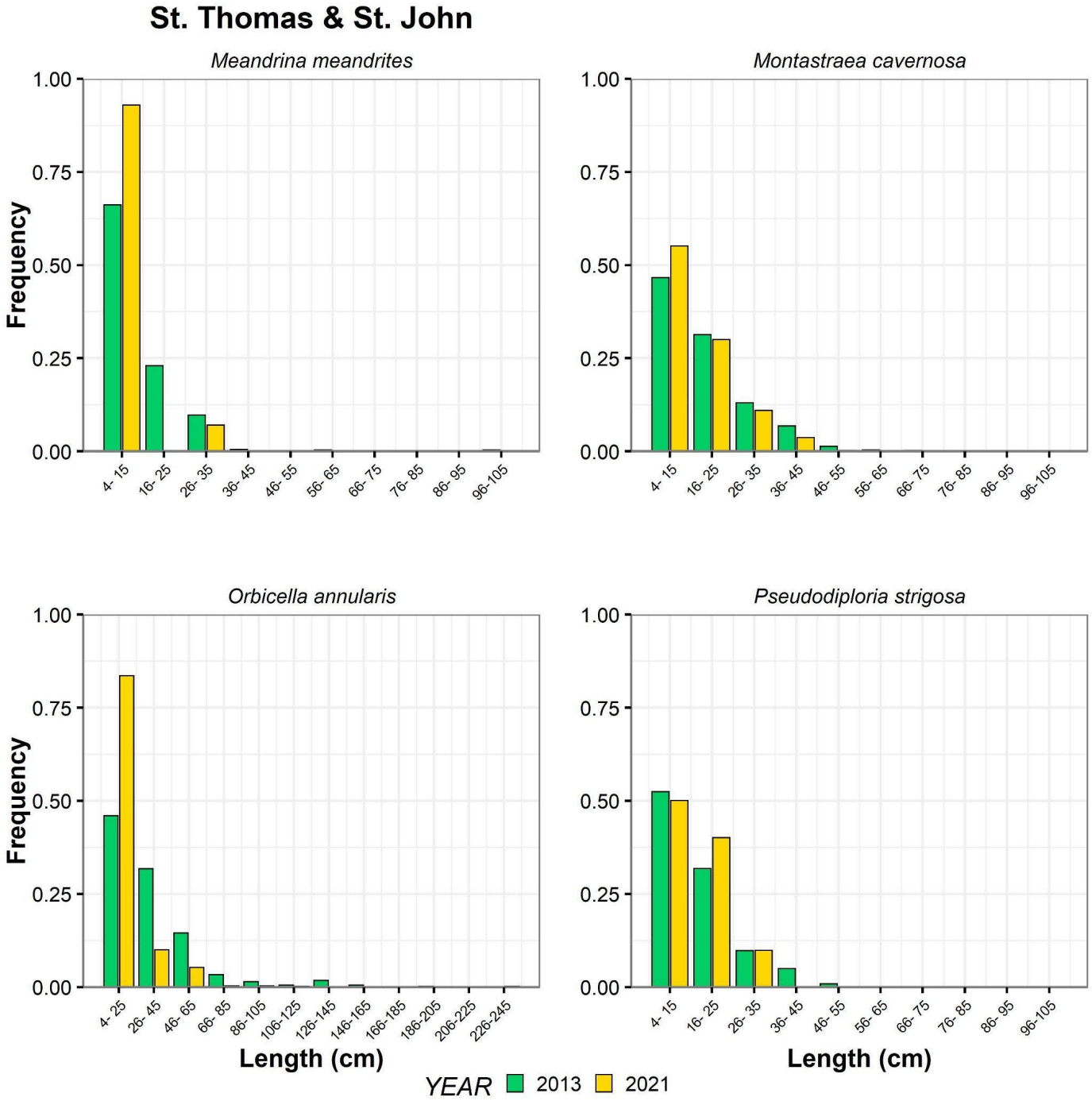


Figure 15. Relative length (maximum diameter) frequency of representative coral species in St. Thomas and St. John in 2013 (green) and 2021 (yellow).

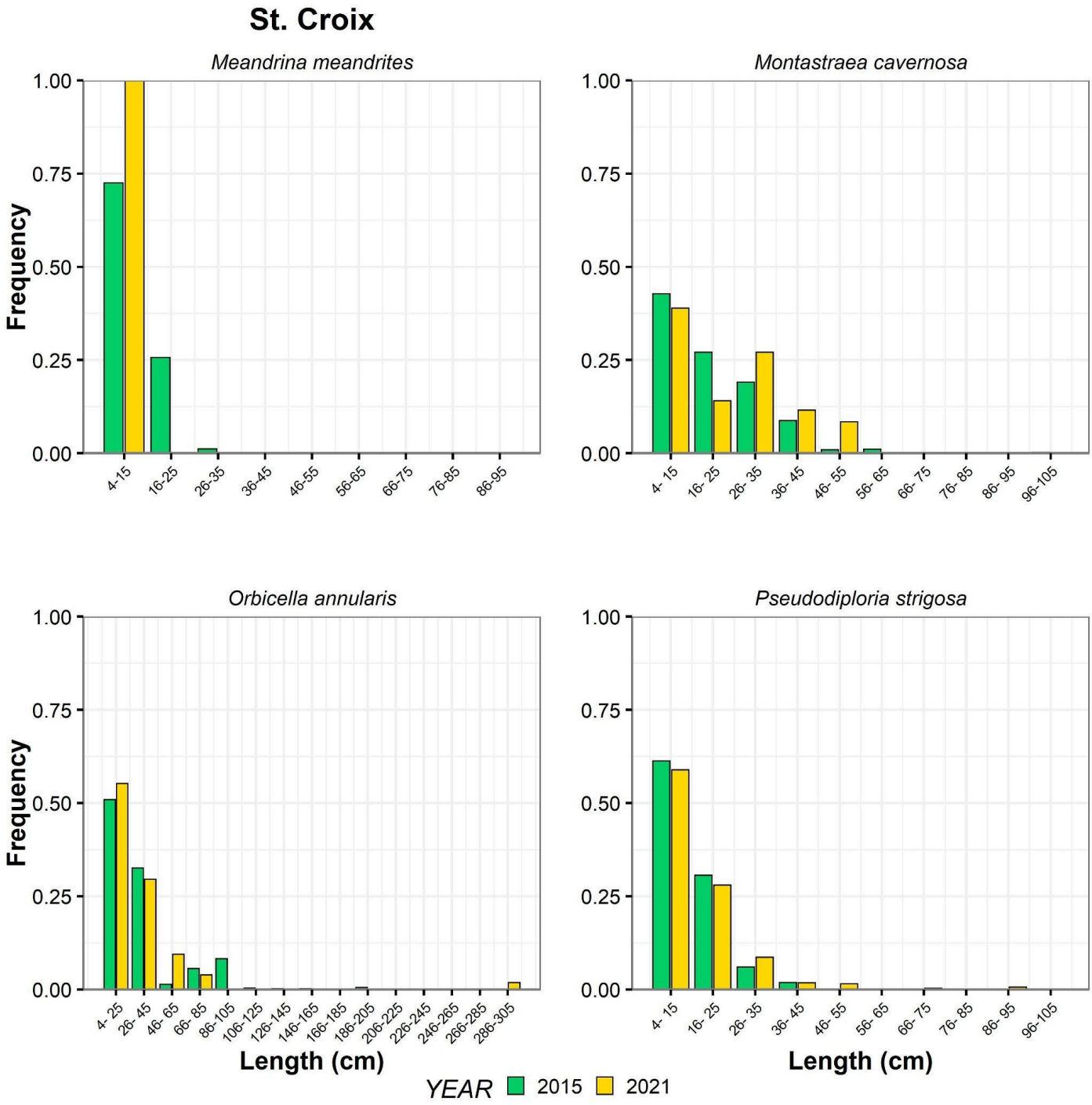


Figure 16. Relative length (maximum diameter) frequency of representative coral species in St. Croix in 2015 (green) and 2021 (yellow).

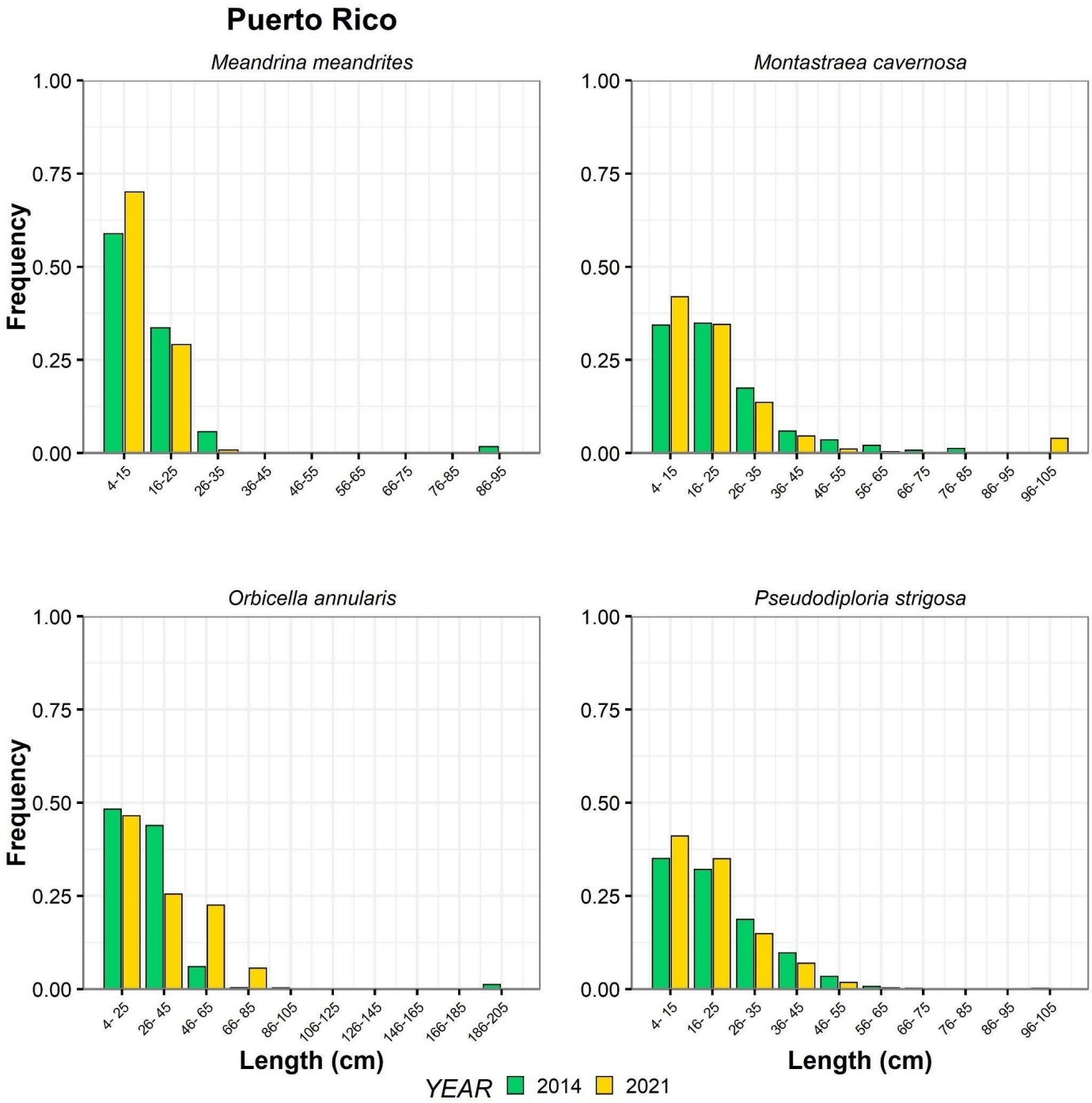


Figure 17. Relative length (maximum diameter) frequency of representative coral species in Puerto Rico in 2014 (green) and 2021 (yellow).

Coral Bleaching and Disease

Bleaching was present on multiple coral species for the 2021 sampling year (Figure 18). For all three regions, orbicellids showed bleaching in 2021. In the USVI, the coral species with the highest bleaching prevalence in St. Thomas and St. John were *Agaricia lamarcki*, *S. intersepta*, and *Acropora palmata*; and in St Croix, these were *Dichocoenia stokesii*, *S. intersepta*, and *O. franksi* (Figure 18). In Puerto Rico, the coral species with the highest bleaching prevalence were *Solenastrea bournoni*, *M. meandrites*, and *Diploria labyrinthiformis* (Figure 18).

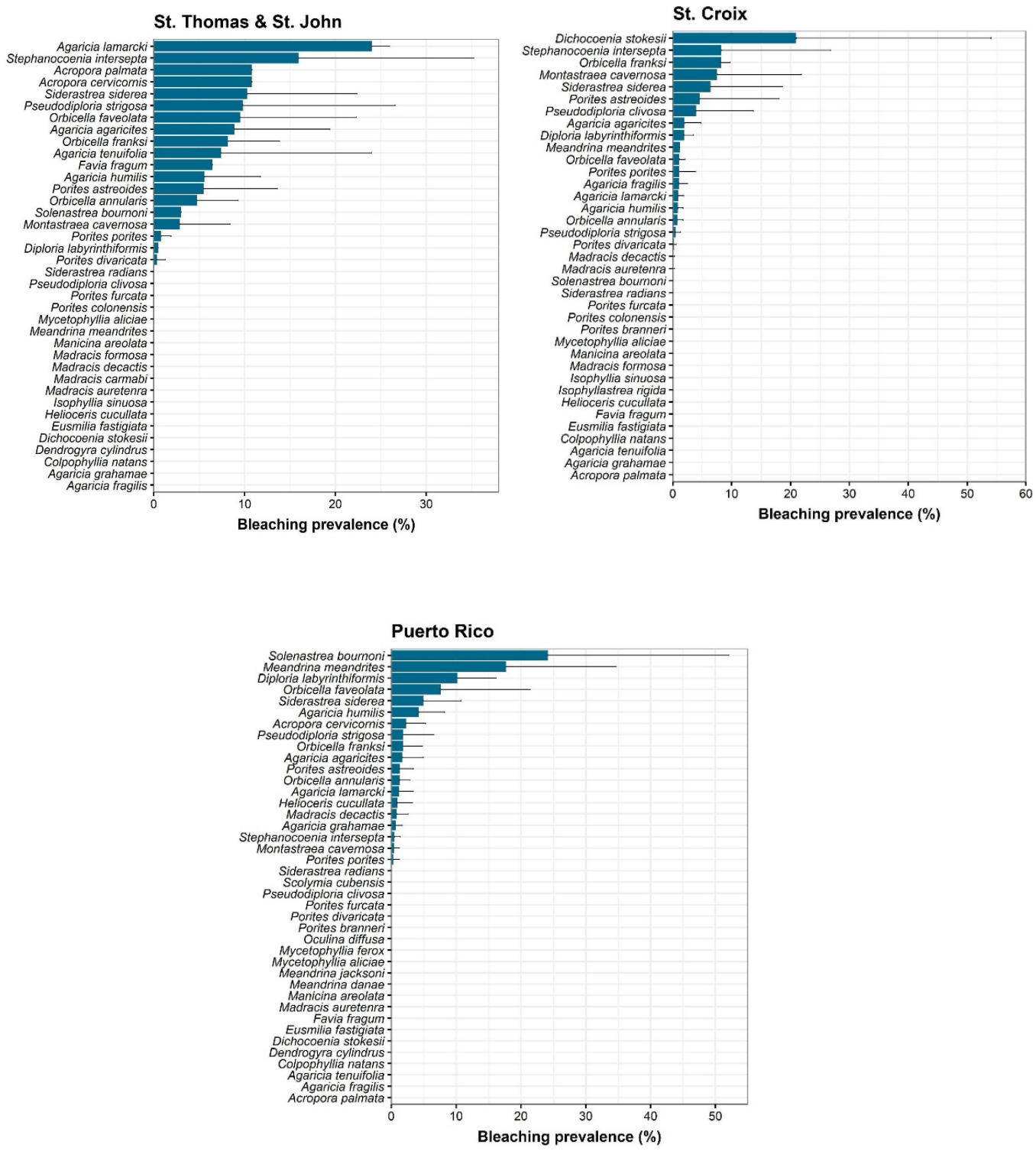


Figure 18. Mean bleaching prevalence (% ± SE) in 2021 by coral species for (top left) St. Thomas and St. John, (top right) St. Croix, and (bottom) Puerto Rico. Only species that were present in the 2021 National Coral Reef Monitoring Program coral demographics surveys are included. SE = standard error.

Coral disease was present on multiple coral species for the 2021 sampling year (Figure 19). In the USVI, the coral species with the highest prevalence of coral disease were (St. Thomas and St. John) *O. faveolata*, *A. cervicornis*, and *S. siderea*; and (St. Croix) *Siderastrea radians*, *S. siderea*, and *Pseudodiploria clivosa* (Figure 19). In Puerto Rico, the coral species with the highest disease prevalence were *S. siderea*, *Agaricia humilis*, and *O. faveolata* (Figure 19).

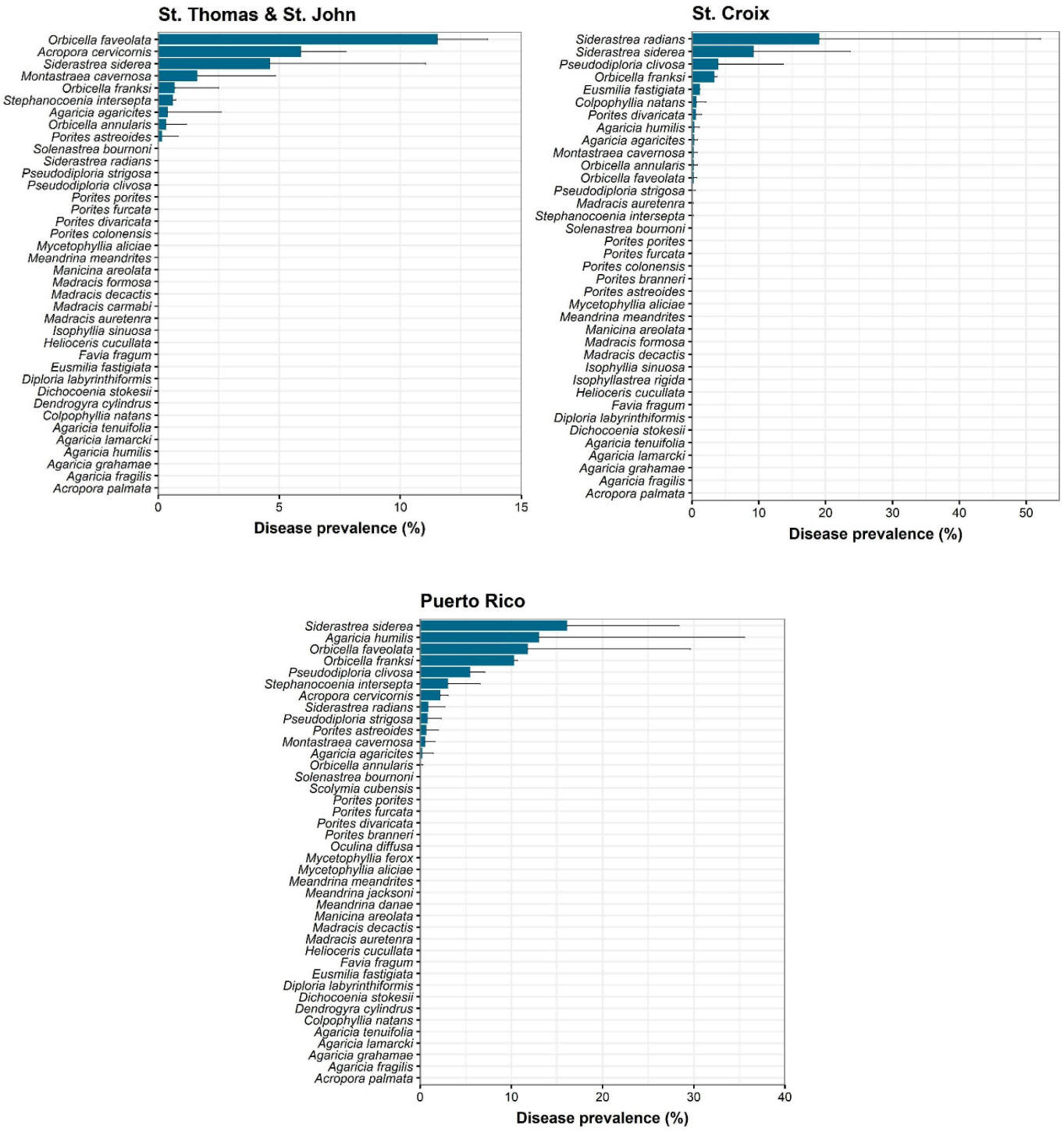


Figure 19. Mean disease prevalence (% ± SE) by coral species for (top left) St. Thomas and St. John, (top right) St. Croix, and (bottom) Puerto Rico in 2021. Only species that were present in the 2021 National Coral Reef Monitoring Program coral demographics surveys are included. SE = standard error.

Fish Community Results

Fish Species Occurrence

Even though NCRMP does not specifically target all the species in the sampling design, NCRMP fish survey results show that 19–46 individual species have CVs of density that are 20% or less. A 20% CV of density can

be translated to the ability to statistically detect a 40% change; therefore, a lower CV increases our ability to detect differences. Typically, CVs of density 20% or less include >30 individual species, but due to the coronavirus pandemic, fewer sites were collected (e.g., 148 sites of the targeted 250 sites were sampled in St. Croix) and higher variability is present in the 2021 dataset. NCRMP does not allocate for species such as bicolor damselfish (*Stegastes partitus*) and yellowhead wrasse (*Halichoeres garnoti*), each seen in >75% of surveys in St. Thomas and St. John (Figure 20) even though they meet the CV criteria of 20% or less because common, ubiquitous species such as these do not provide strong statistical power in analyzing differences in fish species metrics. Similarly, in both St. Croix (Figure 21) and Puerto Rico (Figure 22) data show that the redband parrotfish (*Sparisoma aurofrenatum*) and slippery dick (*Halichoeres bivittatus*) are each highly ubiquitous species that meet the CV of density criteria of 20% or less, highlighting the importance of allocating for species that meet the CV criteria but are often under sampled due to lower occurrence on the reefs.

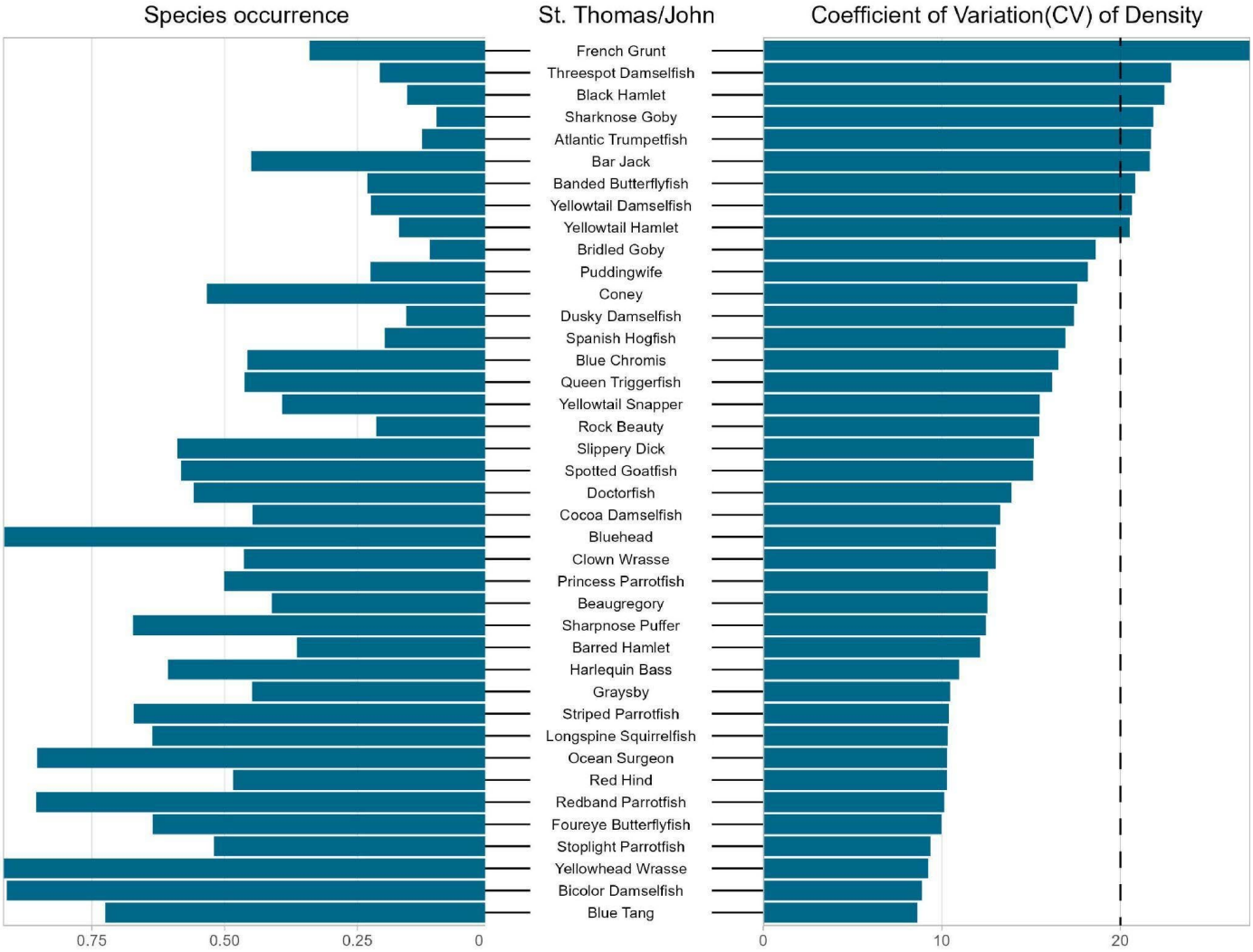


Figure 20. Occurrence of reef fish species with a coefficient of variation (CV) of density ≤25% and allocation species. Species are sorted by increasing CV of density in St. Thomas and St. John, U.S. Virgin Islands in 2021. Dashed vertical line on the CV plot indicates the target CV of 20%.

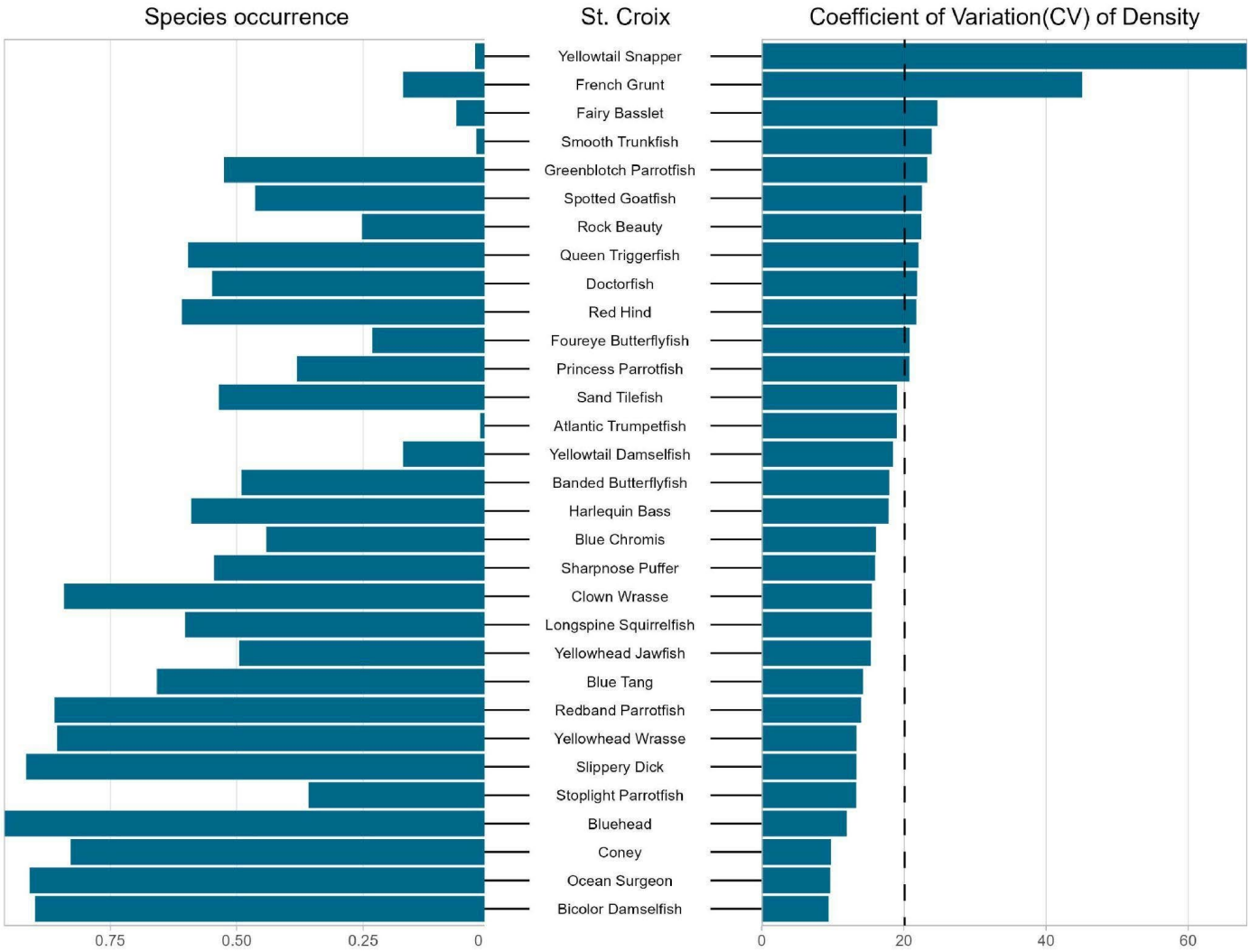


Figure 21. Occurrence of reef fish species with a coefficient of variation (CV) of density ≤25% and allocation species. Species are sorted by increasing CV of density in St. Croix, U.S. Virgin Islands in 2021. Dashed vertical line on the CV plot indicates the target CV of 20%.

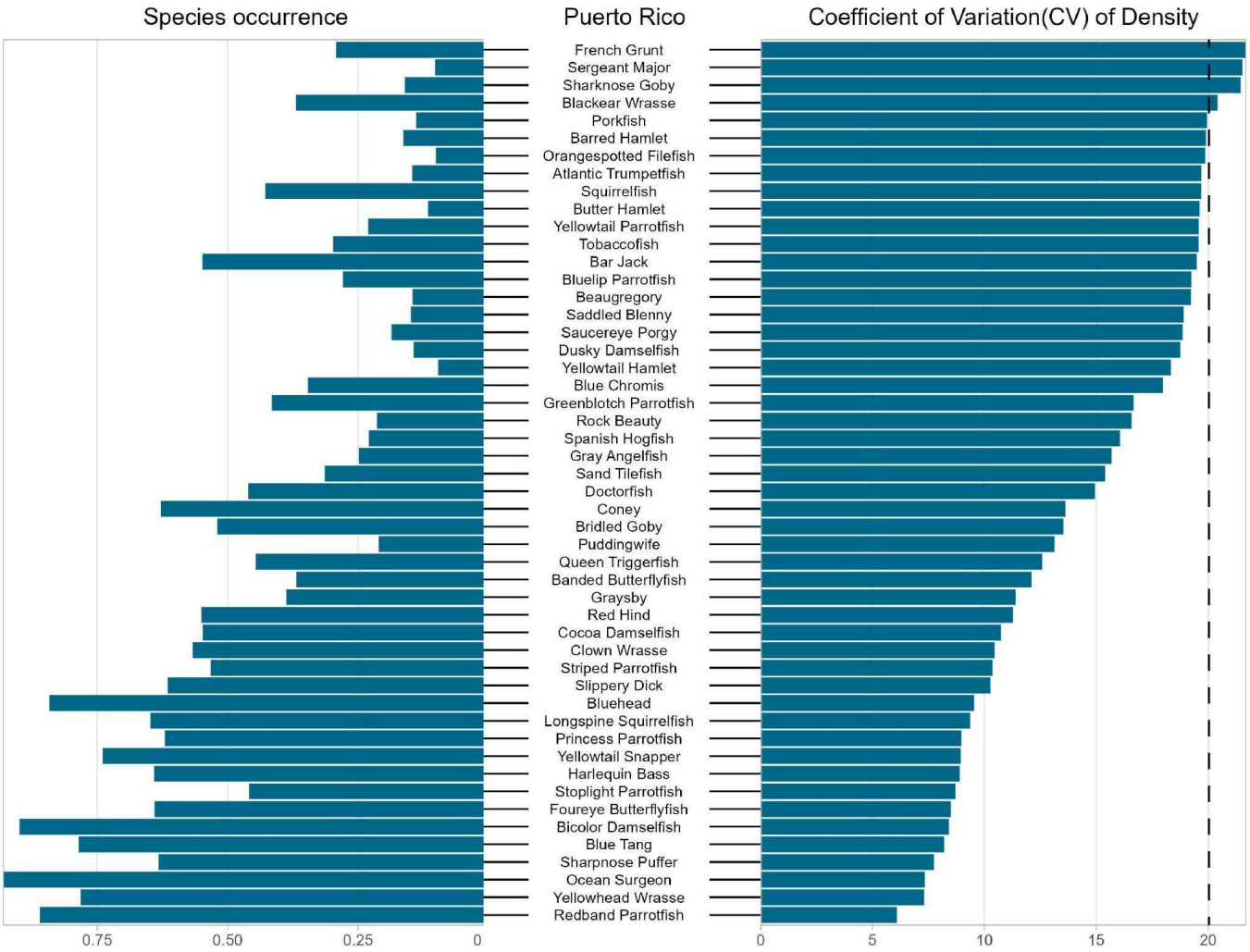


Figure 22. Occurrence of reef fish species with a coefficient of variation (CV) of density ≤25% and allocation species. Species are sorted by increasing CV of density in Puerto Rico in 2021. Dashed vertical line on the CV plot indicates the target CV of 20%.

Fish Density

Typically, fishes are grouped together (e.g., guilds, trophic, and genera) and presented as a single analysis metric (e.g., density, occurrence, or biomass). However, these groups are often dominated by a single or a few species. When all species are combined, it can result in a misinterpretation of the data since it is often assumed that each species equally contributes to the total. In the U.S. Caribbean, three species of parrotfish make up >75% of the total parrotfish density highlighting the importance of analyzing and reporting species-specific information. Striped (*Scarus iseri*), redband (*Sparisoma aurofrenatum*), and princess (*Scarus taeniopterus*) parrotfish dominate the parrotfish taxonomic group for all sampling domains and, as an example, are illustrated in St. Thomas and St. John (Figure 23).

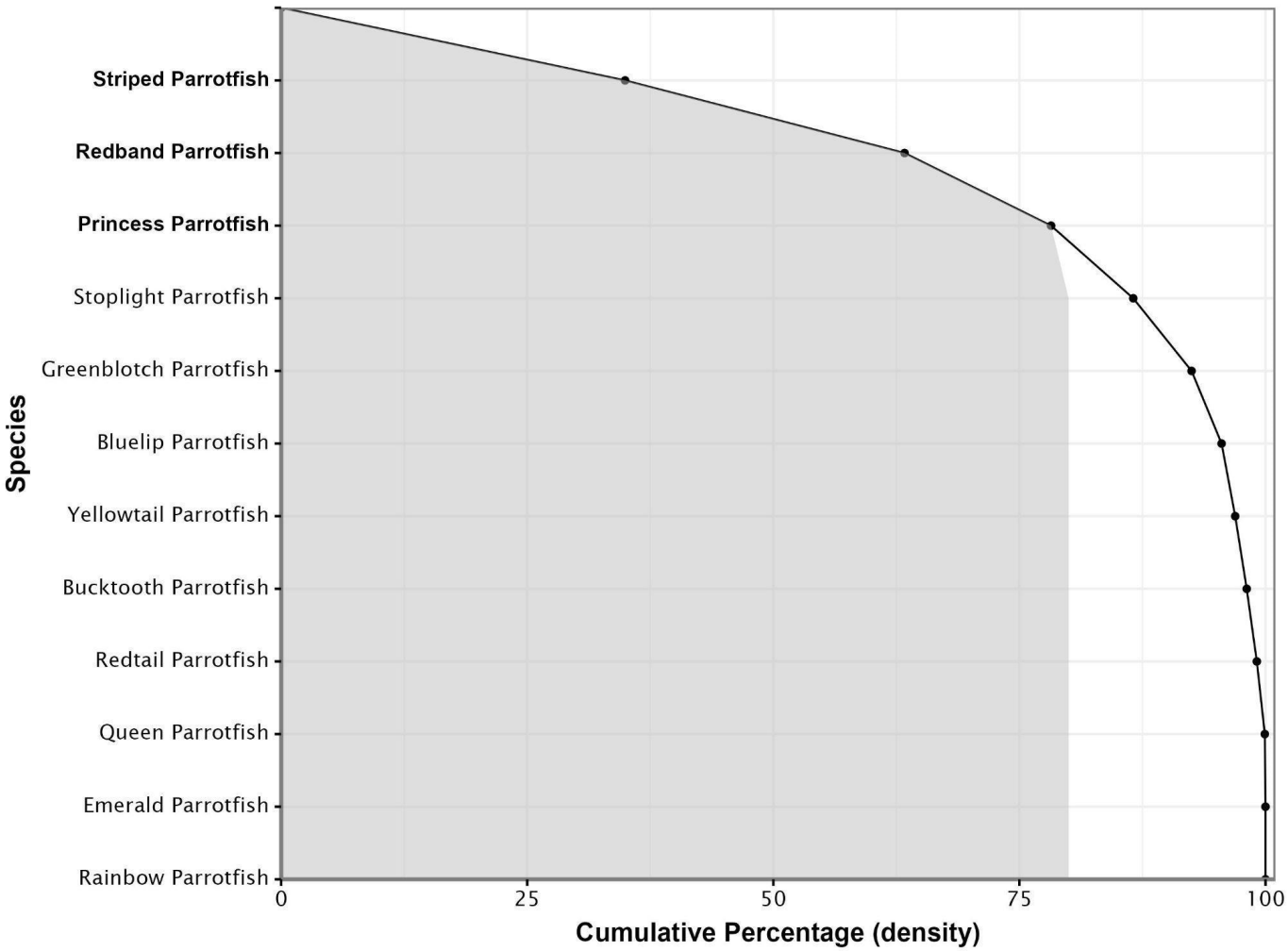


Figure 23. Cumulative density for parrotfishes in National Coral Reef Monitoring Program sampling year 2021 in St. Thomas and St. John. The three dominant species of parrotfish are in bold, and their contribution to the total cumulative density is shaded in gray.

NCRMP's comprehensive sampling design strategy provides a broad, population-level perspective on the reef fish community. This community is composed of fishery-target and non-target species ranging from small, cryptic (e.g., gobies [Gobiidae] and jawfish [Opistognathidae]) to larger, mobile fishes (e.g., barracuda [*Sphyraena barracuda*]), and spans all trophic levels. Figure 24 shows the mean density (individuals ha^{-1}) for the top 50 species by occurrence in 2021 in each sampling domain and illustrates the similarities in species composition on the reefs in these three regions, with all three regions dominated by fishery non-targeted species of bicolor damselfish and bluehead wrasse (*Thalassoma bifasciatum*).

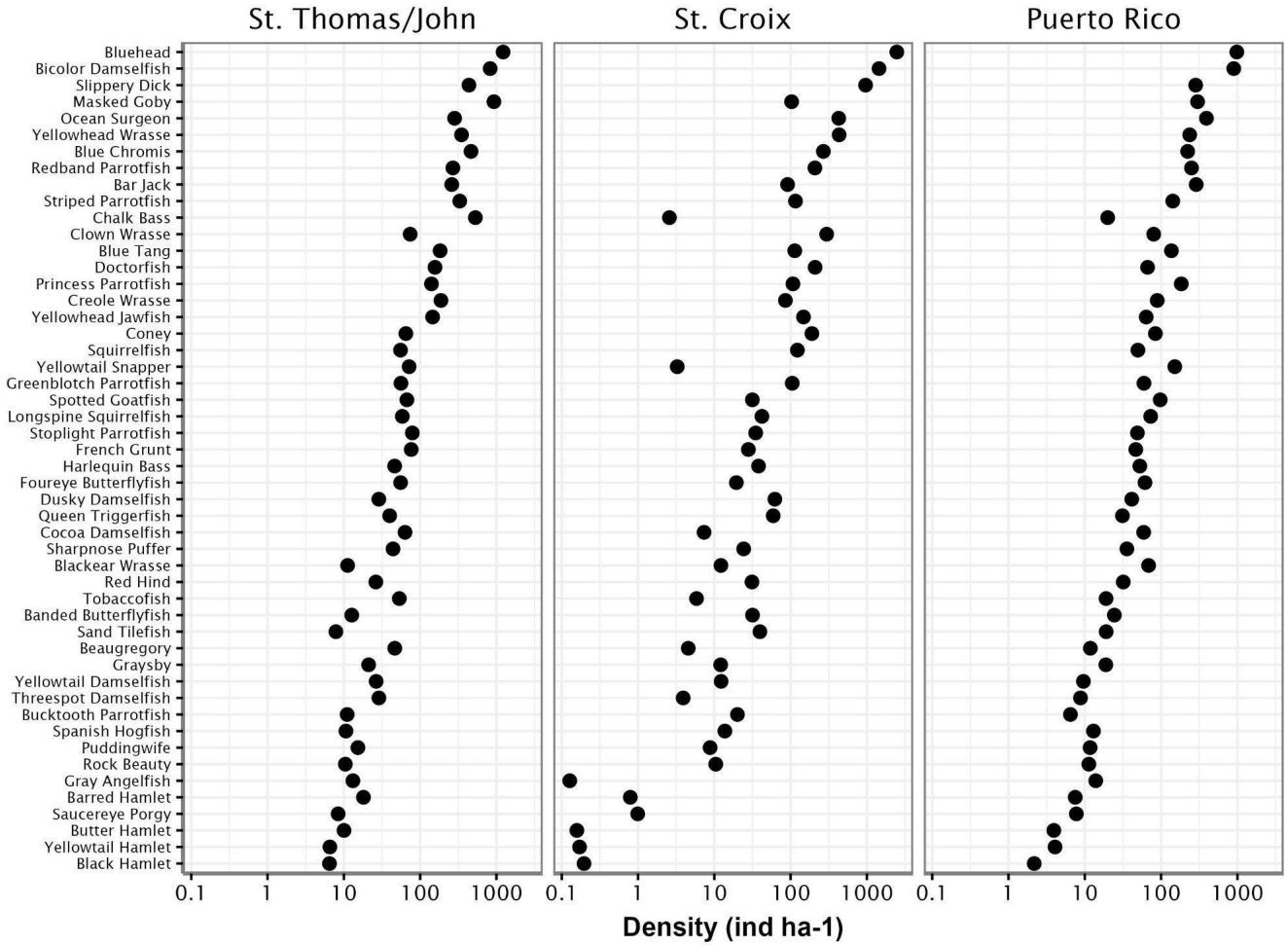


Figure 24. Mean density by region in 2021 of the top 50 (by occurrence) reef fish species. Fish densities are presented on a log scale and show the number of fish per hectare.

Differences between inside and outside spatially managed areas in these regions were analyzed (e.g., national parks in USVI) for a diverse group of fishery target species including snappers, groupers, triggerfish, and parrotfish. Out of the eight species evaluated, one species in St. Thomas and St. John (coney) and four species (stoplight parrotfish, coney, queen triggerfish, and red hind) in St. Croix showed significant differences between inside and outside of national parks (Table 2).

Table 2. Density of selected fishery target species by region, both inside and outside of national park boundaries in U.S. Virgin Islands and for Puerto Rico in 2021. Densities are reported as number of individuals per 177 m2 ± SE and represent all life stages; significance (Tukey's two-tailed t-test) was accepted at p <0.05 (*). SE = standard error.

	St Thomas / John			St Croix			Puerto Rico
Species	*Outside*		*Inside*	*Outside*		*Inside*	*Outside*
Stoplight Parrotfish	**1.42** (0.02)		**1.18** (0.03)	**0.38** (0.01)	*	**3.16** (0.32)	**0.86** (0.01)
Coney	**1.27** (0.05)	*	**0.32** (0.02)	**3.45** (0.13)	*	**2.30** (0.06)	**1.48** (0.04)
Yellowtail Snapper	**1.24** (0.05)		**1.40** (0.11)	**0.01** (0.00)		**0.58** (0.21)	**2.66** (0.06)
Queen Trigger	**0.68** (0.01)		**0.81** (0.11)	**1.09** (0.06)	*	**0.52** (0.01)	**0.55** (0.01)
Red Hind	**0.46** (0.01)		**0.48** (0.03)	**0.57** (0.02)	*	**0.30** (0.01)	**0.56** (0.01)
Gray Snapper	**0.10** (0.01)		**0.0** (0.00)	**0.01** (0.01)		**0.00** (0.00)	**0.06** (0.01)
Mutton Snapper	**0.14** (0.01)		**0.11** (0.01)	**0.01** (0.01)		**0.01** (0.01)	**0.03** (0.01)
Hogfish	**0.02** (0.01)		**0.01** (0.01)	**0.00** (0.00)		**0.00** (0.00)	**0.11** (0.01)

NCRMP surveys capture a snapshot of coral reef fish populations. Reporting biennial trends over time provides a comprehensive perspective of changes in reef fish populations. In particular, trend data can provide insight into how fishery target species respond to management actions including spatial management (e.g., national park boundaries), fishing regulations (e.g., minimum size at capture, bag limits, and gear limitations), and natural events (e.g., hurricanes). Statistical comparisons of density were tested separately for the most recent three survey years (i.e., 2016 or 2017, 2019, and 2021) and each protected status for the four representative fishery target species that are subject to different management regulations and are consistently observed in high enough numbers to detect change (Figures 25 and 26). Within the USVI protected areas, species-specific densities were relatively similar among survey years; no differences were observed in St. Thomas and St. John, and two out of the four species (i.e., red hind and stoplight parrotfish) showed significant differences between one or two survey years in St. Croix (Figures 25 and 26). In comparison, species-specific densities were variable among survey years in areas open to fishing in the three U.S. Caribbean regions. Every species in the USVI, and half the species in Puerto Rico showed significant differences between one or two survey years. In Puerto Rico, red hind and queen triggerfish had similar densities for all survey years. Collectively, no clear pattern was evident by species, protected status, or region (Figures 25 and 26). For example, in 2021, yellowtail snapper densities in areas open to fishing were similar to previous years in St. Thomas and St. John, statistically lower in St. Croix, and statistically higher in Puerto Rico (Figure 26).

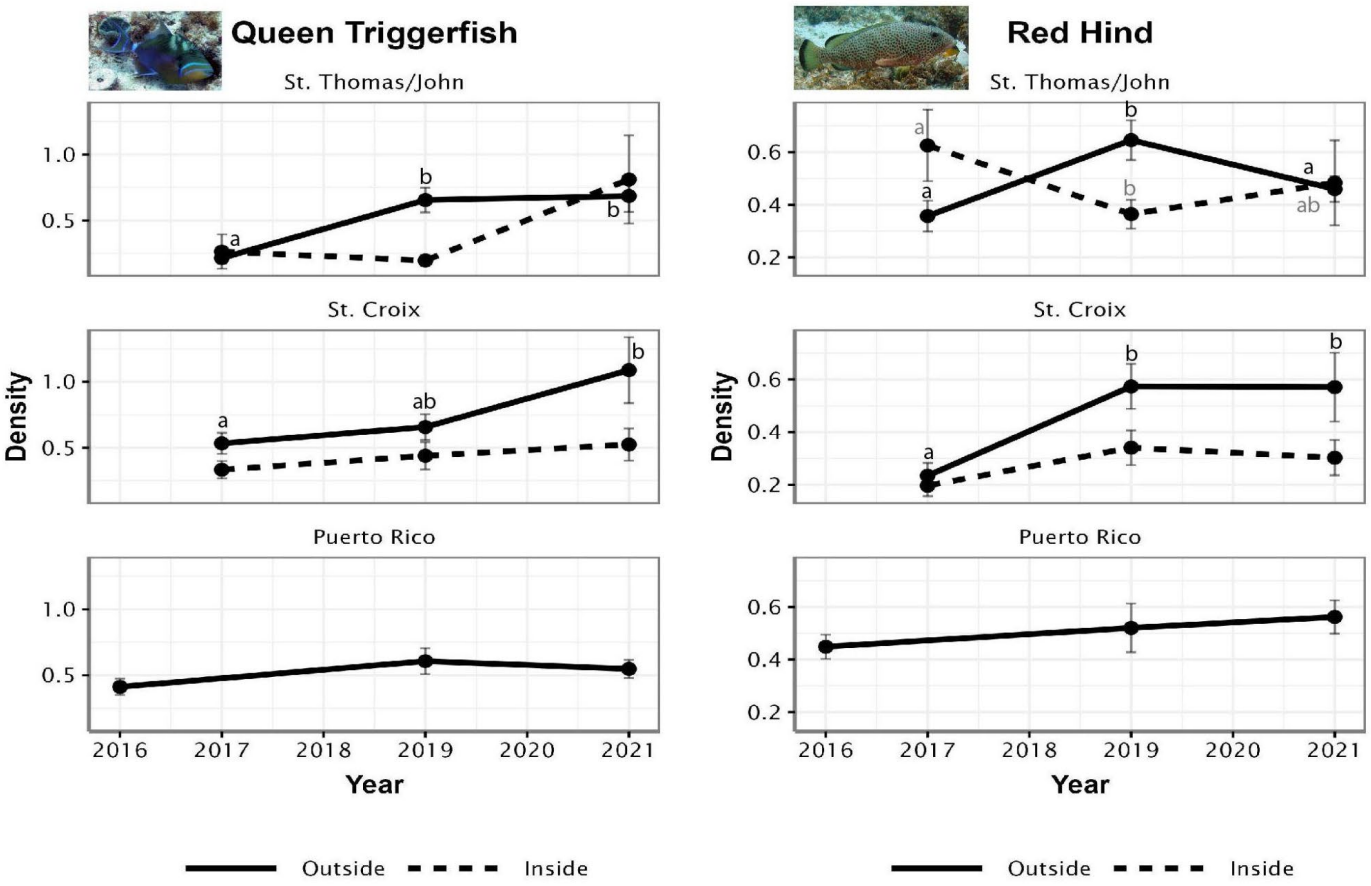


Figure 25. Density of queen triggerfish and red hind by region and year. Densities are reported as the number of individuals per 177 m2 ± SE and represent all life stages; statistical significance (Tukey's two-tailed t-test), if present, is reported at p <0.05, and different letters (e.g., a and b) denote a difference between survey years within each protected status. Protected status refers to sites inside (dashed lined) or outside (solid line) of a U.S. Virgin Islands national park boundary; all of Puerto Rico is considered to be outside (solid line). Photo credits: NOAA Photo Library.

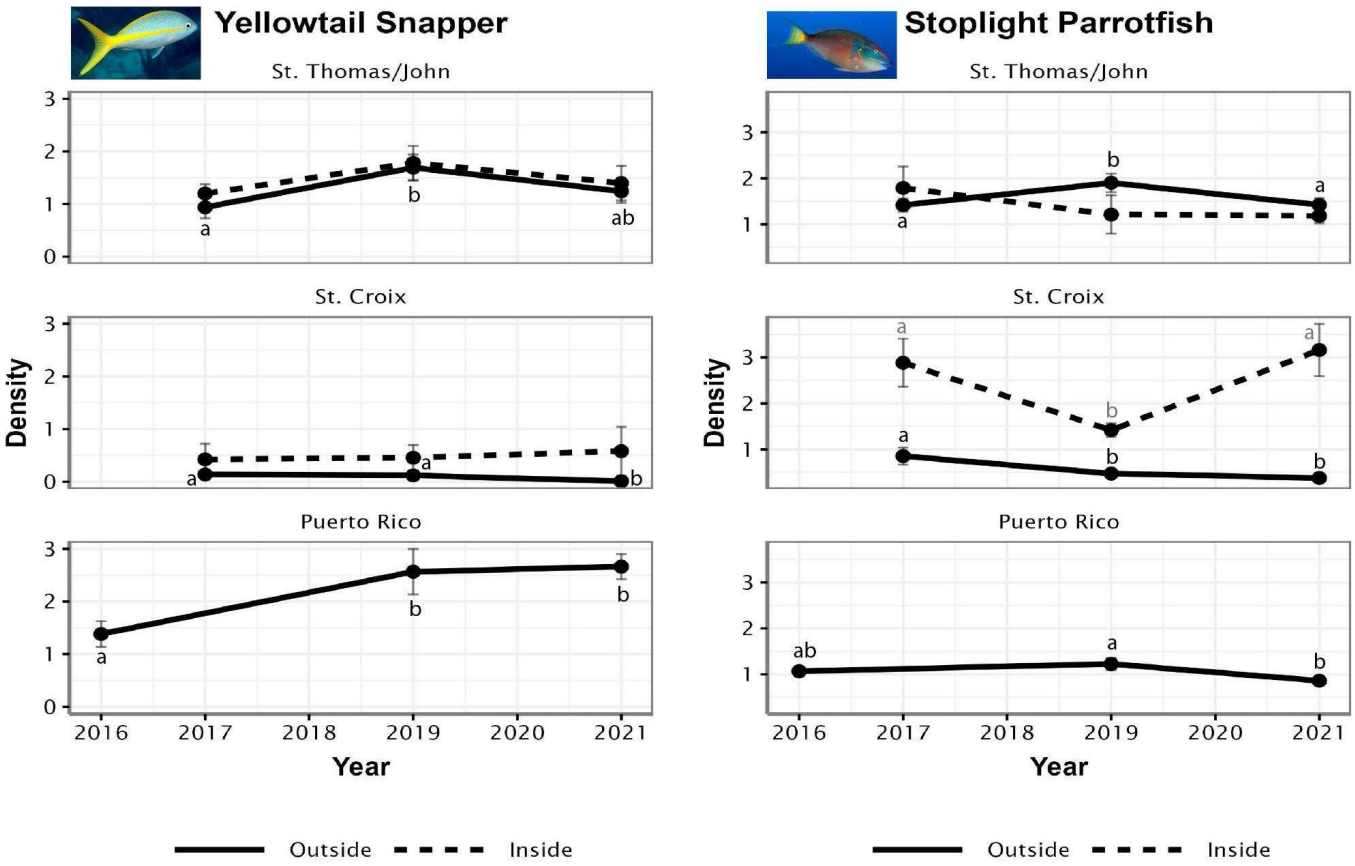


Figure 26. Density of yellowtail snapper and stoplight parrotfish by region and year. Densities are reported as the number of individuals per 177 m2 ± SE and represent all life stages; statistical significance (Tukey's two-tailed t-test), if present, is reported at p <0.05, and different letters (e.g., a and b) denote a difference between survey years within each protected status. Protected status refers to sites inside (dashed line) or outside (solid line) of a U.S. Virgin Islands national park boundary; all of Puerto Rico is considered to be outside (solid line). Photo credits: Jiangang Luo (University of Miami; yellowtail snapper) and NOAA Fisheries (stoplight parrotfish). SE = standard error.

Fish Size Distribution

Length compositions provide a detailed description of a selected fish's population structure. These highly informative figures can show the length at which a fish species recruits to the coral reef from their nursery habitat, length classes that are selected by the local recreational and commercial fisheries, and the success of some fisheries management regulations (e.g., minimum length of capture). In general, populations typically consist of younger, smaller fish than older, larger fish, and once fishes fully recruit to coral reef habitat (i.e., the survey area), each subsequent length class should have fewer observed fish. A primary goal of fisheries management is to maintain enough large, mature fish to support successful reproduction to ensure both the health of the stock and future of the fishery. Figures 27 and 28 show relative length frequency histograms for the same representative and diverse group of fishery target species. For queen triggerfish, fewer fish are observed at >35-cm fork length in all regions (Figure 27). While larger individuals of this species are observed less often, it is encouraging that size classes above their published length-at-maturity (21.4 cm; Shervette and Rivera-Hernández, 2022) are observed. Stoplight parrotfish are similarly observed at multiple size classes ranging from small (5–10 cm) to large (30–35 cm) in all three regions (Figure 28).

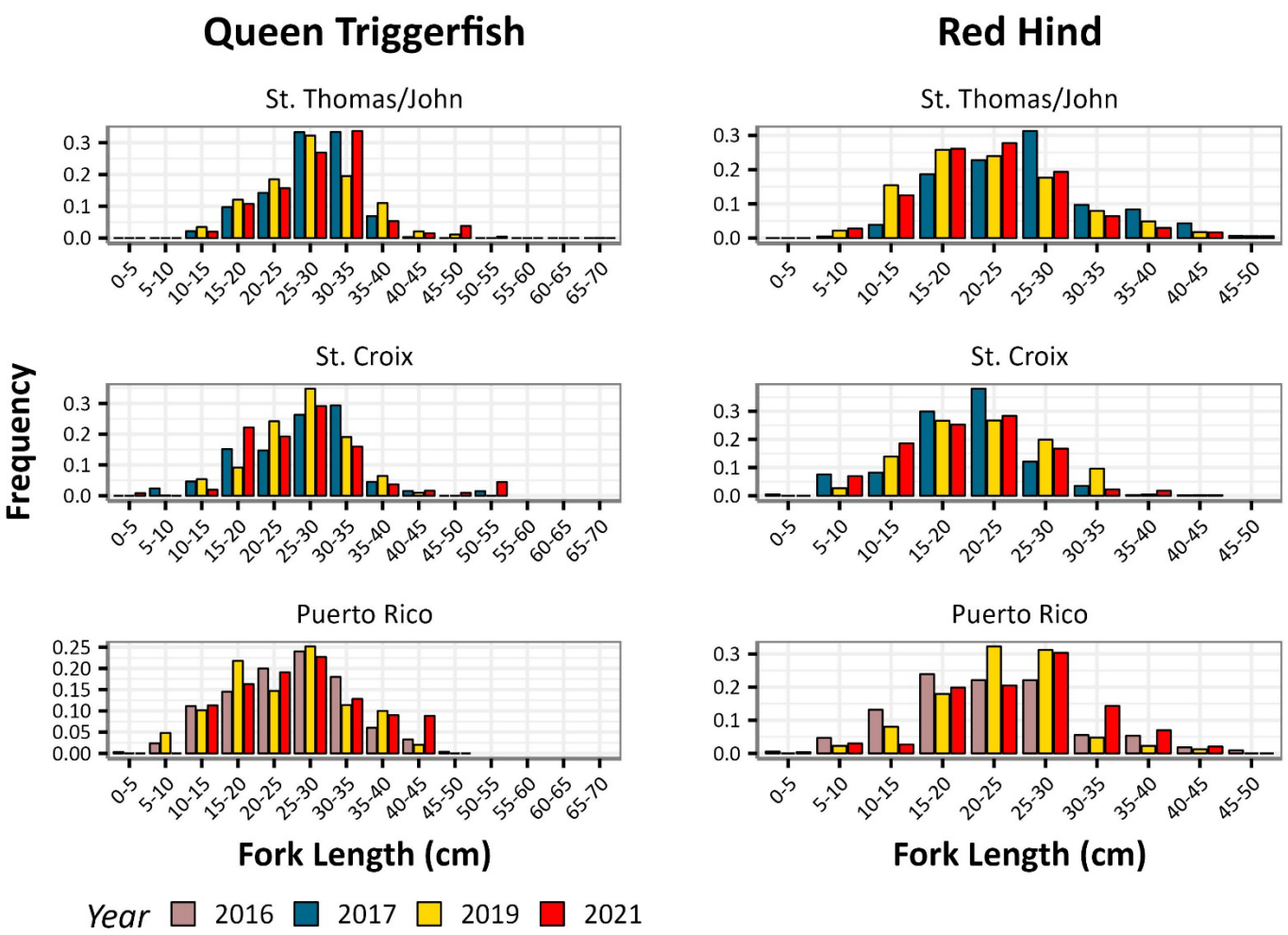


Figure 27. Relative length frequency of selected fishery target species including queen triggerfish (left) and red hind (right) for each region and most recent National Coral Reef Monitoring Program sample years, indicated by color. Note: y-axis varies by species and region.

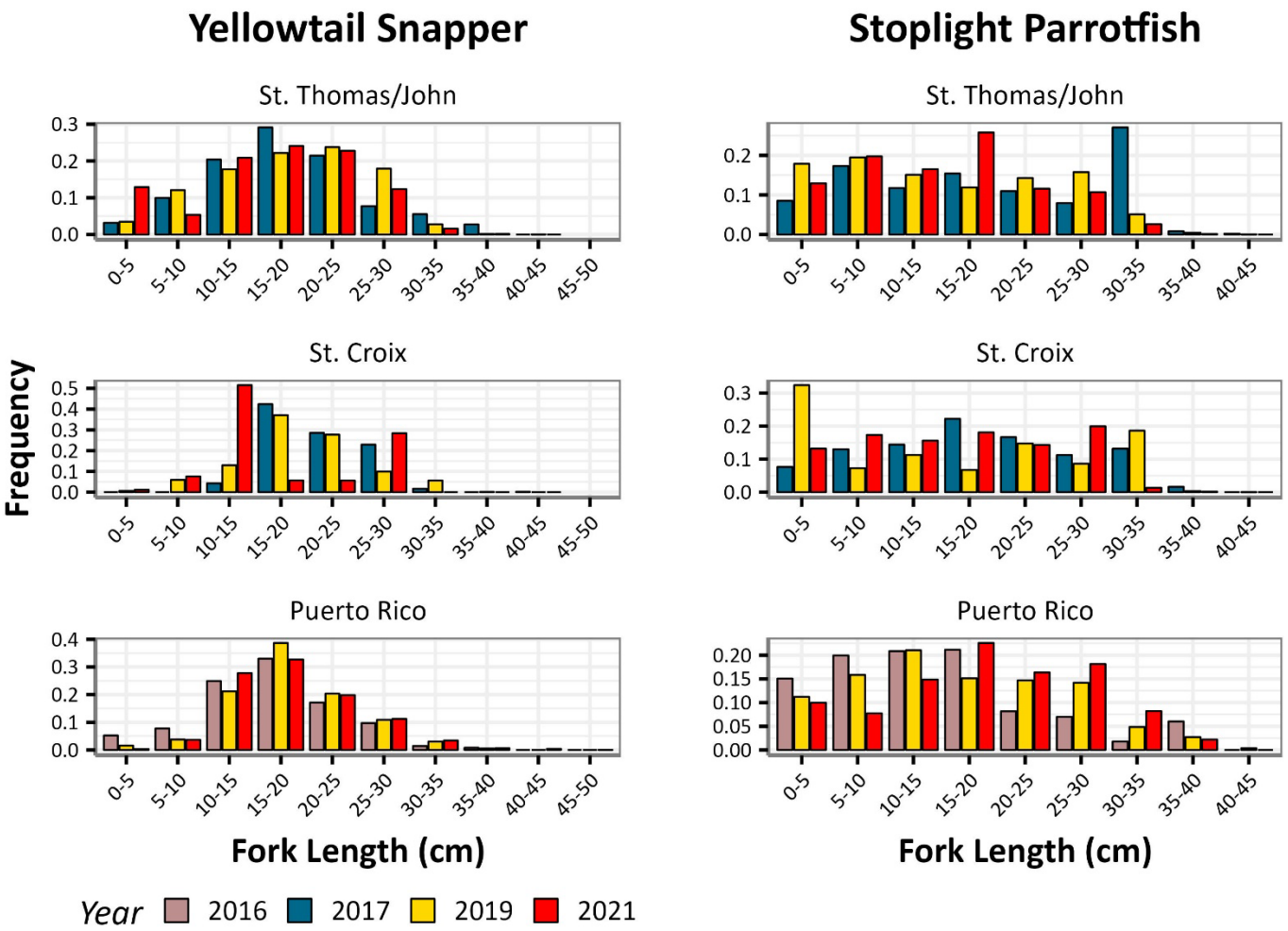


Figure 28. Relative length frequency of selected fishery target species including yellowtail snapper (left) and stoplight parrotfish (right) for each region and most recent National Coral Reef Monitoring Program sample years, indicated by color. Note: y-axis varies by species and region.

Summary

NCRMP surveyed over 550 sites in 2021. Despite many pandemic-related obstacles, NCRMP achieved a moderate sampling effort (i.e., surveyed 50% to 78% of the targeted sites) in the U.S. Caribbean. As expected, fewer sites surveyed led to more variability in the 2021 datasets; however, sufficient data were collected to allow for standard analyses of comparisons and trends.

NCRMP benthic community data showed continued declines in coral cover and increases in macroalgae cover in all regions over time since the first NCRMP missions (2013–2015). The coral species *Porites astreoides* and *Siderastrea siderea* had the highest frequencies of occurrence and densities in all regions. A fall 2021 coral bleaching event affected multiple species in both the USVI and Puerto Rico. Some of the Puerto Rico surveys captured data from the bleaching event. In the USVI, however, NCRMP surveys were in the summer prior to the bleaching event. SCTLD continued to be widespread in the USVI and Puerto Rico during 2021 surveys. All three regions showed a steady decline in old mortality during the majority of the monitoring program. However, this is unlikely to be an indication of improving reef conditions. As large coral colonies continue to lose living tissue and become colonized by other organisms, the extent of the original colony becomes harder to determine, and the remaining sections of living tissue can appear as many smaller colonies. Additionally, the NCRMP demographic methodology only collects data on coral colonies with live tissue. The concurrent decline of coral density in all regions may suggest that these colonies are dying rapidly and being removed from the population rather than persisting with large sections of colonized coral skeleton.

NCRMP fish data showed that a number of fishery-targeted and non-targeted surveyed fishes, presently 19–46 reef fish species, have CVs of density that are 20% or less. This wide breadth of species regularly observed can be used to reliably monitor trends in species that are often overlooked by fishery-dependent surveys (e.g., smaller or ESA-listed species) yet are valuable components of the coral reef ecosystem (i.e., herbivores or prey species) and can be regionally important (e.g., for culture and ecotourism). In parrotfishes, three species (redband, princess, and striped parrotfish) made up >75% of the total regional parrotfish density in all regions, highlighting the importance of species-specific analyses as opposed to broader groupings. Broader groupings such as “all parrotfishes” can unintentionally be misleading as it is often assumed that each species equally contributes to the results (e.g., density, trends); however, in this case, 3 out of the 12 parrotfish species observed would predominantly be responsible for any results in a broader grouping. The importance of species-specific analyses generally extends to all fish groupings (e.g., groupers, snappers, damselfishes, angelfishes, etc.). In the USVI in 2021, the density of selected fishery-target species varied inside and outside of the national parks with one (St. Thomas and St. John) or four (St. Croix) of the eight species having significant differences. Some species had higher densities outside of protected areas, which could be related to a number of factors including, but not limited to, differences in habitat type and quality and lack of effective enforcement. For all survey years, trend data were variable within each species, protected status, and regions. For fishery-targeted species, it is critical to have estimates of both number and size for management (e.g., setting fishery regulations that allow for a species to reproduce before becoming available for capture). As a fishery-independent survey, NCRMP collects numbers and sizes on all observed fishes to the nearest centimeter, and, generally, fishes were most common from 15 cm to 30 cm, presumably before capture by the fishery (e.g., red hind, yellowtail snapper, and queen triggerfish).

References

Bohnsack, J., and Bannerot, S. (1986). A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA National Marine Fisheries Service. NOAA Technical Report NMFS 41. 15 pp.

Bryan, D. R., Smith, S. G., and Ault, J. S. (2016). Feasibility of a regionwide probability survey for coral reef fish in Puerto Rico and the U.S. Virgin Islands. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*, *8*:135–146. https://doi.org/10.1080/19425120.2015.1082520

Ganz, H., and Blondeau, J. (2015). Reef Visual Census statistical package in R (website). R package version 1.0.0. Retrieved February 19, 2021 from https://github.com/jeremiaheb/rvc

Grove, L. J. W., J. Blondeau, and J. S. Ault. (2021). National Coral Reef Monitoring Program's Reef Fish Visual Census Metadata for the U.S. Caribbean. SEDAR80-WP-02. SEDAR80, North Charleston, SC. 55 pp.

Groves, S., and Viehman, T. S. (2023). NCRMP Benthics statistical package in R (website). R package version 1.0.0. Retrieved February 19, 2023 from https://github.com/MSE-NCCOS-NOAA/NCRMP_benthics

Hughes, T., and Tanner, J. (2000). Recruitment failure, life histories, and long-term decline of Caribbean corals. *Ecology*, *81*(8), 2250–2263. https://doi.org/10.2307/177112

Knowlton, N. (2001). The future of coral reefs. *Proceedings of the National Academy of Sciences*, *98*(10), 5419–5425. https://doi.org/10.1073/pnas.091092998

CRCP. (2022a). National Coral Reef Monitoring Program (NCRMP) Benthic community assessment survey field protocols for U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, and U.S. Virgin Islands – 2022. NOAA Coral Reef Conservation Program, 29 pp. https://doi.org/10.25923/0708-8333

CRCP. (2022b). National Coral Reef Monitoring Program (NCRMP) Coral demographics survey field protocols for U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, U.S. Virgin Islands – 2022. NOAA Coral Reef Conservation Program, 27 pp. https://doi.org/10.25923/9a1r-m911

CRCP. (2022c). National Coral Reef Monitoring Program (NCRMP) Reef Visual Census (RVC) fish survey protocols U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, and U.S. Virgin Islands – 2022. NOAA Coral Reef Conservation Program, 21 pp. https://doi.org/10.25923/1baa-5g44

NOAA Coral Program (2021). National Coral Reef Monitoring Plan. Silver Spring, MD, NOAA Coral Reef Conservation Program. https://doi.org/10.25923/fqkq-w497

NOAA NCCOS. (2018). NCRMP Sample frame development protocols for U.S. Caribbean and FGBNMS. NOAA National Center for Coastal Ocean Services. 12 pp. Retrieved February 19, 2021 from https://www.nodc.noaa.gov/archive/arc0101/0157633/7.7/data/0-data/Atlantic/Biological/Caribbean_Gulf-of-Mexico/NCRMP_Protocol_SampleFrame%20Protocol_2016.pdf

Shervette, V., and Rivera-Hernández, J. M. (2022). Report on the status of U.S. Caribbean queen triggerfish *Balistes vetula* age, growth, and reproductive biology for the SEDAR80 Stock Assessment. SEDAR80-WP-07. SEDAR, North Charleston, SC. 26 pp.

Smith, S. G., Swanson, D. W., Chiappone, M., Miller, S.L., and Ault, J. S. (2011). Probability sampling of stony coral populations in the Florida Keys. *Environmental Monitoring and Assessment*, *183*(1-4):121–138. https://doi.org/10.1007/s10661-011-1912-2

Towle, E. K., Donovan, E. C., Kelsey, H., Allen, M. E., Barkley, H., Blondeau, J., Brainard, R. E., Carew, A., Couch, C. S., Dillard, M. K., Eakin, C. M., Edwards, K., Edwards, P. E. T., Enochs, I. C., Fleming, C. S., Fries, A. S., Geiger, E. F., Grove, L. J., Groves, S. H., Gorstein, M., Heenan, A., Johnson, M. W., Kimball, J., Koss, J. L., Kindinger, T., Levine, A. Manzello, D. P., Miller, N., Oliver, T., Samson, J. C., Swanson, D., Vargas-Angel, B., Viehman, T. S., and Williams, I. D. (2022). A national status report on United States coral reefs based on 2012–2018 data from National Oceanic and Atmospheric Administration's National Coral Reef Monitoring Program. Frontiers in Marine Science, p.1999. https://doi.org/10.3389/fmars.2021.812216

Towle, E. K. (2021). How can the national coral reef monitoring program help inform stony coral tissue loss disease monitoring? 2021 featured stories: June [website]. NOAA Coral Reef Conservation Program. Retrieved May 12, 2022 from https://coralreef.noaa.gov/aboutcrcp/news/featuredstories/june21/stony-coral.html

Viehman T. S.,* Groves, S. H.,* Grove, L. J. W., Smith, S. G., Mudge, L., Donovan, C., Edwards, K. F., and Towle, E. (in press). Assessing the status of Florida coral reefs using a standardized, objective approach. *Bulletin of Marine Science*. * equal authorship. https://doi.org/10.5343/bms.2022.0025

Appendix A: Supplemental Information

NCEI Data Package References

U.S. Virgin Islands

- **USVI Benthic Collections** (all years):
  NOAA National Centers for Coastal Ocean Science (NCCOS) (2018). National Coral Reef Monitoring Program: Assessment of coral reef benthic communities in the U.S. Virgin Islands. [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.7289/v5ww7fqk (Accessed April 2023).

- **2021 USVI Benthic Data:**
  National Centers for Coastal Ocean Science (NCCOS); Southeast Fisheries Science Center (SEFSC) (2022). National Coral Reef Monitoring Program: Assessment of coral reef fish communities in the U.S. Virgin Islands from 2021-06-14 to 2021-08-13 (NCEI Accession 0270582). [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/0270582 (Accessed April 2023).

- **USVI Fish Collections** (all years):
  NOAA National Centers for Coastal Ocean Science (NCCOS) (2018). National Coral Reef Monitoring Program: Assessment of coral reef fish communities in the U.S. Virgin Islands. [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.7289/v5f769mm (Accessed April 2023).

- **2021 USVI Fish Data:**
  National Centers for Coastal Ocean Science (NCCOS); Southeast Fisheries Science Center (SEFSC) (2022). National Coral Reef Monitoring Program: Assessment of coral reef benthic communities in the U.S. Virgin Islands from 2021-06-14 to 2021-08-13 (NCEI Accession 0270849). [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/0270849 (Accessed April 2023).

Puerto Rico

- **Puerto Rico Benthic Collections** (all years):
  NOAA National Centers for Coastal Ocean Science (NCCOS); Southeast Fisheries Science Center (SEFSC) (2018). National Coral Reef Monitoring Program: Assessment of coral reef benthic communities in Puerto Rico. [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.7289/v5pg1q23 (Accessed April 2023).

- **2021 Puerto Rico Benthic Data**:
  National Centers for Coastal Ocean Science (NCCOS); Southeast Fisheries Science Center (SEFSC) (2022). National Coral Reef Monitoring Program: Assessment of coral reef benthic communities in Puerto Rico from 2021-04-30 to 2021-12-24 (NCEI Accession 0272313). [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/0272313 (Accessed April 2023).

- **Puerto Rico Fish Collections** (all years):
  NOAA National Centers for Coastal Ocean Science (NCCOS); NOAA Southeast Fisheries Science Center (SEFSC) (2018). National Coral Reef Monitoring Program: Assessment of coral reef fish communities in Puerto Rico. [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.7289/v5t72frz (Accessed April 2023).

- **2021 Puerto Rico Fish Data**:
  National Centers for Coastal Ocean Science (NCCOS); Southeast Fisheries Science Center (SEFSC) (2022). National Coral Reef Monitoring Program: Assessment of coral reef fish communities in the U.S. Virgin Islands from 2021-06-14 to 2021-08-13 (NCEI Accession 0270582). [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/0270582 (Accessed April 2023).

NCRMP Local Partner Programs

NCRMP provides a broad geographic context to supplement local monitoring efforts and studies of tropical reef ecosystems. For more information on local partner programs in these regions, see:

Territorial Coral Reef Monitoring Program (TCRMP)
https://sites.google.com/site/usvitcrmp/

Puerto Rico Long-Term Coral Reef Monitoring Program
https://www.ncei.noaa.gov/archive/accession/0204647

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