NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION AND
THE UNIVERSITY OF MARYLAND CENTER FOR ENVIRONMENTAL SCIENCE

2020 Status Report Scoring Methodology for Atlantic Jurisdictions

Indicator calculations and scoring for coral reef status reports of the Atlantic jurisdictions: Flower Garden Banks, the United States Virgin Islands, Puerto Rico, and Florida's Coral Reef

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I. BACKGROUND

I.I. The motivation behind status and trends reporting

The National Oceanic and Atmospheric Administration Coral Reef Conservation Program (NOAA CRCP) invests significant funds to support a National Coral Reef Monitoring Program (NCRMP) throughout the U.S. Pacific, Atlantic, and Gulf of Mexico coral reef areas. A key component of this program is periodic, national-level assessment on the status and trends of U.S. coral reef areas. To develop and implement this report framework, NOAA CRCP partnered with the Integration and Application Network (IAN) at the University of Maryland Center for Environmental Science (UMCES). The framework, termed herein a status report, is based on the timely and transparent assessment of biophysical and human dimension indicators against references that are synthesized into overall condition scores for each jurisdiction. The primary purpose of the CRCP status report products is to communicate the status and trends of U.S. coral reefs to Congress, NOAA leadership, and the interested public. The primary purpose of this document is to describe the scoring process used for all the Atlantic jurisdictions: Florida, the United States Virgin Islands (USVI), Puerto Rico, and the Flower Garden Banks.

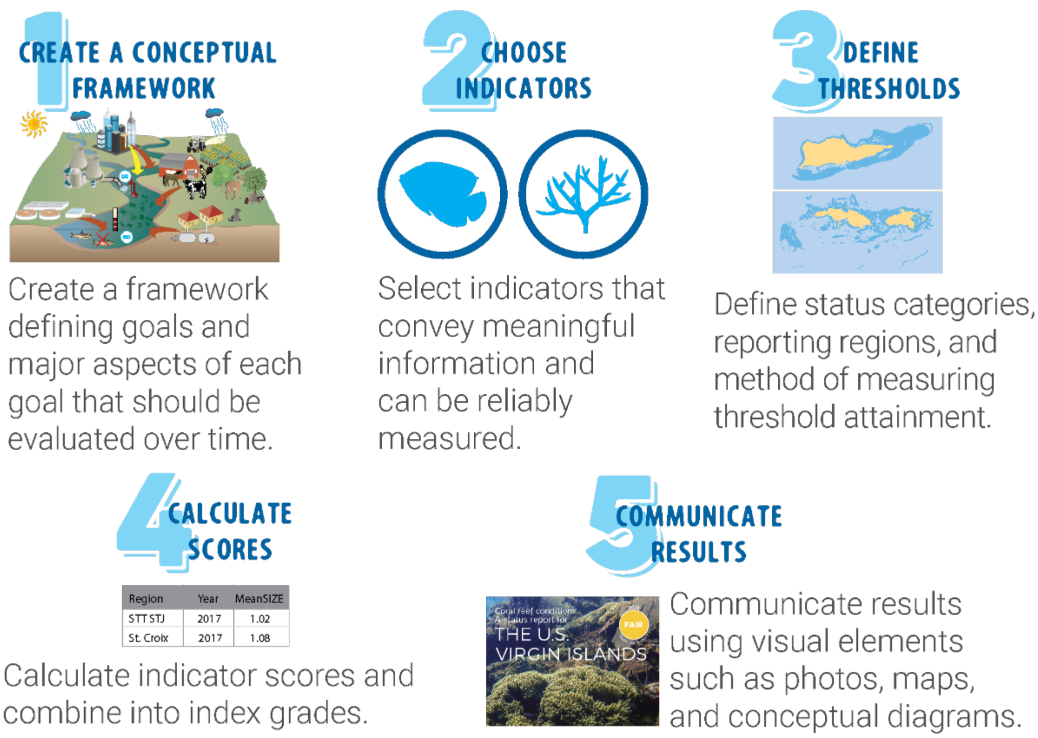
Ecosystem condition assessments are a common approach to synthesizing a large amount of ecosystem monitoring data into a public-friendly report that can be understood by decision makers, managers, and scientists alike. Fundamentally, status reports help answer the question: “how is the ecosystem doing?” The goals of a status report are to provide a broad-level assessment, communicate complex information, use monitoring (not modeling) data, and engage communities. These assessments are produced by a variety of groups from small, community-based organizations to regional management agencies, to large international partnerships. To advance this effort, NOAA CRCP and IAN UMCES brought together science experts, natural resource managers, and other stakeholders from NOAA and local jurisdictions to develop biological, climatological, and human connection indicators and references for coral reefs.

A coral reef status report addresses the need to summarize and communicate coral reef monitoring and assessment in U.S. jurisdictions to decision-makers, policy-makers, and the public. Additionally, the process of creating the status report provides a framework for future reporting of coral reef health. These assessments provide the status of U.S. coral reef areas in order to track change over time and evaluate ecosystem condition, not management efforts or restoration success. The goals stated above are accomplished by producing a simple and concise product that tells the story of coral reefs using effective visual and narrative elements. All jurisdictions are assessed on coral & algae, fish, climate, and human connection indicators. To allow for regionally and context-specific baselines, the scoring of indicators is unique to each jurisdiction. References and areas against which data are evaluated are developed based on literature review, regulatory guidelines, institutional goals, biological limits, reference conditions, historical benchmarks, and expert judgement. These references are determined by a group of experts—scientists and managers—from NOAA and local jurisdictional agencies. The references are developed to be specific to each jurisdiction so that indicator scores are representative of the coral reef system for that specific jurisdiction.

The data used in this status report effort are predominantly NCRMP data. Localized data, such as those collected by jurisdictional agencies, were included where practicable and feasible based on statistical comparability (See Section IV). In the absence of a targeted calibration exercise that would allow for integrating disparate datasets, we focus here on the NCRMP data that is designed to monitor coral reefs at a jurisdictional scale and those monitoring programs that use the same or similar methodologies as NCRMP. It is a goal of future efforts to include other data in indicator scoring. However, local long-term data products are included when possible as a time-series or highlight story. Highlight stories are meant to message locally relevant information.

I.II Create a conceptual framework

The first step in developing a status report is to conceptualize the ecosystem by determining the threats to that system and the parts of the system that people value. A stakeholder engagement workshop, which includes not only decision makers and managers of the systems but also the scientists that gather and analyze data in the region, is critical to creating buy-in and support for the assessment process and final product. The USVI, Puerto Rico, and Florida workshops took place in May 2019 in St. Thomas, San Juan, and Miami, respectively. The Flower Garden Banks workshop took place in June 2019 at NOAA headquarters in Silver Spring, MD. These workshops brought together scientists and managers to determine the conceptual framework, potential indicators and thresholds, and draft layout of the final product.



The 5-Step Report Card process was used to create the Atlantic status reports.

II. ATLANTIC JURISDICTIONS WITH REEF AREAS

II.I. Florida's Coral Reef

Florida's Coral Reef extends from Martin County on the Atlantic Coast of Florida through the Keys to the Dry Tortugas in the Gulf of Mexico. Florida's Coral Reef is the only coral reef found along the coast of the continental United States. Florida's Coral Reef was divided into three sub-regions to evaluate the condition. The three regions are Southeast Florida, Florida Keys, and Dry Tortugas.

Florida's Coral Reef status report regions and areas. Note that the total area for each reporting region is the hardbottom forereef habitat less than 30 meters in depth:

Region	Area (km^2)
Southeast Florida	221
Florida Keys	669
Dry Tortugas	300

II.II United States Virgin Islands (USVI)

The Virgin Islands of the United States are an unincorporated Territory located southeast of Florida between the Atlantic Ocean and Caribbean Sea. The Territory consists of three major islands and many smaller islands, all surrounded by fringing coral reefs. The U.S. Virgin Islands were divided into two sub-regions to evaluate condition. The two regions are St. Thomas & St. John and St. Croix.

U.S. Virgin Islands status report regions and areas. Note that the total area for each reporting region is hardbottom habitat less than 30 meters in depth:

Region	Area (km^2)
St. Thomas & St. John	126.61
St. Croix	231.74

II. III Puerto Rico

Puerto Rico is a volcanic island in the Greater Antilles located in the north central Caribbean between the U.S. Virgin Islands to the east and the island of Hispaniola to the west. In addition to the main island, the islands of Mona, Monito, Desecheo, Caja de Muertos, Vieques, and Culebra make up the Commonwealth of Puerto Rico. Puerto Rico was not divided into sub-regions. The total coral reef hardbottom habitat less than 30 meters in depth that was monitored is 994.5 square kilometers.

II.IV Flower Garden Banks

The East and West Flower Garden Banks are submerged topographic features off the shores of Texas and Louisiana in the Gulf of Mexico. Rising from over 150 m depth to 17 m below the sea surface, they harbor relatively deep coral reef ecosystems. They were first discovered in the early 1900s and designated as part of the Flower Garden Banks National Marine Sanctuary in 1992. Flower Garden Banks combines data collected from both East and West Flower Garden Banks into one region. The total coral reef hardbottom habitat less than 30 meters in depth that was monitored for Flower Garden Banks is 0.898 square kilometers.

III. INDICATOR DEVELOPMENT

NOAA's National Coral Reef Monitoring Program defines four main monitoring data themes in its monitoring plan (NOAA, 2014). The four monitoring themes are fish, coral and algae, climate, and human connections, and each has associated indicators. During the initial workshop, presentations of available data were given by experts followed by breakout sessions to determine appropriate indicators for this product within each theme (fish, coral and algae, climate, and human connections). The criteria which experts used to choose indicators were: 1) data availability, 2) sufficient understanding of reference conditions, and 3) importance to overall ecosystem health. These indicators were refined over months of discussion between different groups, jurisdictions, and NOAA headquarters.

Coral reef status report indicators, indicator categories, and scoring system.

<table>
<tr><th>Indicators</th><th colspan="2">Indicator categories</th><th>Scoring system for all indicators</th></tr>
<tr><td>Coral cover</td><td rowspan="6">Coral and algae</td><td rowspan="6"></td><td rowspan="15">What do the scores mean?

90–100% Very Good
All or almost all indicators meet reference values. Conditions in these locations are unimpacted, or minimally impacted or have not declined. Human connections are very high.

60–69% Impaired
Few indicators meet reference values. Conditions in these locations are very impacted or have declined considerably. Human connections are lacking.

70–79% Fair
Some indicators meet reference values. Conditions in these locations are moderately impacted or have declined moderately. Human connections are moderate.

80–89% Good
Most indicators meet reference values. Conditions in these locations are lightly impacted or have lightly declined. Human connections are high.

0–59% Critical
Very few or no indicators meet reference values. Conditions in these locations are severely impacted or have declined substantially. Human connections are severely lacking.

Insufficient Data
Not scored.</td></tr>
<tr><td>Macroalgae and CCA cover</td></tr>
<tr><td>Adult coral (density)</td></tr>
<tr><td>Herbivory</td></tr>
<tr><td>Mortality</td></tr>
<tr><td>Diversity</td></tr>
<tr><td>Reef fish</td><td rowspan="3">Fish</td><td rowspan="3"></td></tr>
<tr><td>Sustainability</td></tr>
<tr><td>Diversity</td></tr>
<tr><td>Temperature stress</td><td rowspan="3">Climate</td><td rowspan="3"></td></tr>
<tr><td>Ocean acidification</td></tr>
<tr><td>Reef material growth</td></tr>
<tr><td>Awareness</td><td rowspan="3">Human Connections</td><td rowspan="3"></td></tr>
<tr><td>Support for management actions</td></tr>
<tr><td>Pro-environmental behavior</td></tr>
</table>

III.I Define reference data

The reference data (or baseline) are the values against which the current data are evaluated. The reference data for all climate indicators were chosen to represent a historical or pre-human impact condition. For benthic and fish indicators, the reference data were based on representative habitats, published literature, and the best available data. Human Connection references were chosen differently – please refer to that section for more information. References can be determined in several ways, including using regulatory criteria assessment, established management goals, literature reviews of best practices, and expert opinions. At each of the workshops, breakout groups proposed potential ideas for references for NCRMP's indicators. Most of the reference data were determined through a series of analyses with input from a variety of stakeholders in each jurisdiction. Please see each indicator section for more details.

IV. INDICATORS AND SCORING PROCESS

The following sections detail the process by which individual indicators for each Atlantic jurisdiction were scored. The sections are organized by theme: coral and algae (benthos), fish, climate, and human connections. Scores are calculated on a 0-100% scale, with descriptive words and narrative text accompanying each score.

IV. I Corals and Algae (Benthos)

IV.I.I Indicators overview

Corals & algae make up the base of the coral reef ecosystem, providing food and shelter for fish, shellfish, and many other marine organisms. The following indicators were selected to assess the benthic communities of the Atlantic jurisdictions: coral cover, crustose coralline algae (CCA) cover, macroalgae cover, adult coral density (>=4 cm), old mortality, herbivory, and diversity. Coral cover is a measure of the percentage of the reef (benthos) that is hard coral and was collected using a line-point intercept method. Macroalgae cover is a measure of the percentage of the reef (benthos) that is macroalgae and was collected in conjuction with coral cover. Crustose coralline algae (CCA) cover is a measure of the percentage of the reef (benthos) that is crustose coralline algae and was collected in conjuction with coral cover. Adult coral density is a measure of the density of corals, by species, that are greater than or equal to 4 cm in maximum size, which is considered of reproductive age for many coral species. All coral colonies were included in the coral demographic surveys that were 1.) within the survey transect area, 2.) had visible living tissue, and 3.) were greater than or equal to 4 cm in maximum dimension with any part of the living colony or skeletal unit affixed to the substrate. Adult colonies were identified to genus or species and measured (maximum diameter, perpendicular diameter, and height) to the nearest cm. Mortality is a measure of old dead coral skeleton exposed as scars on live coral colonies and was collected during the coral demographic surveys. Old mortality is defined as the non-living surface of a colony where the skeletal structures have been either eroded or colonized by organisms that are not easily removed. This serves as a proxy for loss of reproductive biomass within coral populations. Herbivory is a measure of the level of grazing pressure by fish on corals and algae. Diversity is a measure of the number of different species coral present. These indicators were selected because they represent the major components of coral community status and can be measured over time using the NCRMP field methodologies. Survey sites were identified by using stratified random sampling to select either 50 m x 50 m primary sample units (PSUs) in the Caribbean and Gulf of Mexico (GOM) or 100 m x 100 m PSUs in Florida. All survey sites were on hardbottom habitats between 0 and 30 m depths. See individual regions for the number of sites surveyed for each jurisdiction during each NCRMP mission. Field and sampling methodologies can be found here: https://coastalscience.noaa.gov/project/national-coral-reef-monitoring-program-biological-socioeconomic/

IV.I.II Scoring methods overview

A standardized approach using Z-scores values was used to compare the most recent NCRMP domain estimates to indicator- and region-specific reference values. Site level status values were first transformed to Z scores using the following equation:

Z score = (status value - reference value)/ standard deviation of reference value

Status values represent the most current NCRMP data completed prior to this status report. For sampling regions with a total of three completed NCRMP missions (FGBNMS, St. Thomas & St. John, Southeast Florida, Florida Keys, and the Dry Tortugas), status values were calculated as follows: the two most recent years of data were combined, weighted by reef area, and then used to calculate the domain estimate. For sampling regions where only two NCRMP missions were completed prior to this status report (Puerto Rico and St. Croix), the most recent sampling year domain estimate was used as the status value.

Reference values were calculated as the mean and variance of a dataset derived from one or more of the following: long-term monitoring data, historic survey data from peer-reviewed scientific literature, or in the absence of either, domain estimates from the first year of NCRMP sampling for the region. Reference values were then assigned a score ranging from Very Good to Critical. Reference data and scores were based on the available data and included jurisdictional partners' expertise on current and historic conditions. Therefore, reference datasets differed by indicator and by region. An ideal reference area would encompass representative and comparable habitats and depths, have sufficient sampling for statistical power, and, perhaps most importantly, be from a time period or a geographic area unaffected by anthropogenic stressors, including fishing pressure and land-based sources of pollution or runoff, among other factors. However, the availability of ideal reference data within each region for each indicator was limited, and the best possible alternative had to be selected instead. For each metric within each region, careful consideration was given to reference data selection and the sensitivity of the final score (for non-significance).

The Z score domain estimate was calculated as the sum of the weighted means and variances (stratum weights) of Z score data aggregated at the strata-level. A reef area weighting scheme was applied where applicable. The status Z score value was then compared to the reference Z score value (zero) using a Student's T-test. A scoring rubric based on p values was created by first assigning the previously determined reference score to p values > 0.05, indicating no change. The other four categorical scores were assigned to the remaining p values based on rank (table below).

See individual jurisdictions sections for specific methods, datasets used and results. See https://github.com/shgroves/NCRMP.benthics.statusreport for the NCRMP status report benthic R package for all the data and R functions used to calculate the benthic scores.

Example scoring rubric where the reference value has been determined to be in Fair condition. The indicator score is based on the statistical comparison of the reference value (mean) to the status value (deviation from the mean) using standardized z-scores.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Inclusion of regional long-term monitoring data

Inclusion of data from regional long-term monitoring (LTM) programs was a common request throughout the jurisdictions. Often these datasets preceded NCRMP by almost two decades and therefore provide data for reef communities prior to high impact disturbance events such as the 2005 bleaching event in the Caribbean. For this reason, they were meaningful baselines or reference values for comparison to status NCRMP data.

Regions and programs that provided long-term monitoring data for this effort include the Territorial Coral Reef Monitoring Program in the USVI (TCRMP; https://sites.google.com/site/usvitcrmp/), the Virgin Islands National Park Inventory and Monitoring Program (https://www.nps.gov/im/sfcn/coral-reefs.htm), the Florida Coral Reef Evaluation and Monitoring Project (CREMP; http://ocean.floridamarine.org/FKNMS_WQPP/coral.htm), the Puerto Rico Coral Reef Monitoring Program (PRCRMP; http://www.drna.pr.gov/programas-y-proyectos/arrecifes-monitoreo/) and the FGBNMS long-term monitoring program (https://flowergarden.noaa.gov/science/monitor.html). All of these LTM programs monitor fixed sites with multiple stations or transects per site. To reduce the likelihood that differences in indicator values were due to survey design rather than ecological change, pairwise comparisons of indicator yearly means for contemporaneous sampling years were conducted between NCRMP and LTM data. LTM data were only included in the NCRMP status report if the results of the pairwise test were not significant. With this assumption, any changes in indicator status values from the reference value were considered actual changes in the metric (i.e., a decrease in coral cover) rather than due to survey design. See individual regions for results of statistical tests.

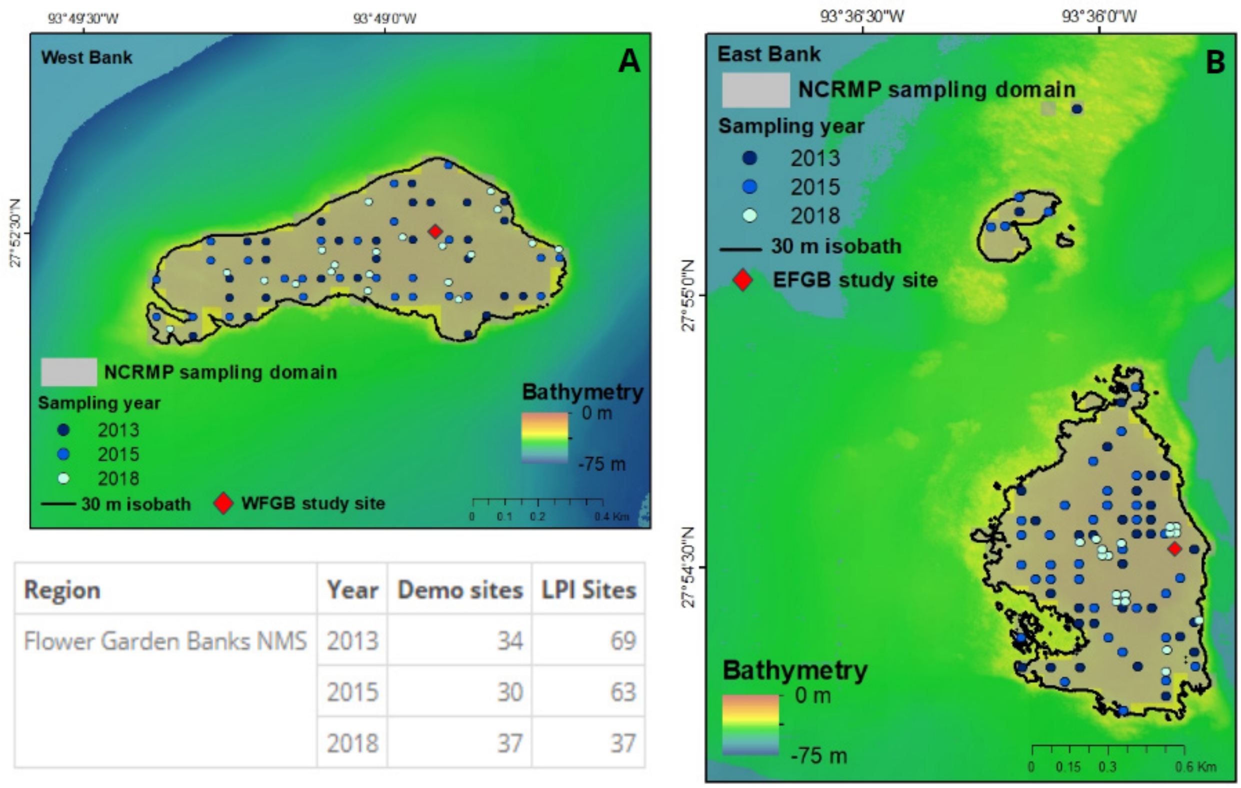
In addition to the monitoring programs listed above, the Disturbance Response Monitoring Program (DRM; http://ocean.floridamarine.org/FRRP/) has conducted stratified, random surveys in all three Florida regions (Southeast Florida, the Florida Keys and the Dry Tortugas) each year since 2005. The NCRMP and DRM programs use the same stratified random sampling design in Florida, although note that the DRM survey domain extends to 20m depth and NCRMP extends to 30m depth and DRM only conducts coral demographic surveys and not benthic assessment surveys. Because the sampling designs are the same, NCRMP and DRM data from contemporaneous years have been combined for analyses.

Inclusion of historic literature-based data

When regional long-term monitoring efforts did not precede major disturbance events (e.g., the emergence of white band disease or pre-*Diadema antillarum* die off) and peer-reviewed literature was available, data values were aggregated from multiple sources to form more ecologically meaningful baselines than LTM data alone. Historic data was identified from an extensive literature review and consultation with local experts in each jurisdiction. For the three Florida regions, Southeast Florida, the Florida Keys, and the Dry Tortugas, there were sufficient literature-sourced values to create baselines for the coral cover indicator ranging from 1974 to 1999 with the inclusion of early CREMP monitoring efforts from 1996-1999. In the absence of information describing site level replication, all reported values were treated as individual sites. In the Florida Keys and the Dry Tortugas, literature-based values were assigned broad habitat types that corresponded to current NCRMP strata definitions. Status NCRMP site level data were classified by reef type and scored separately to acknowledge ecological differences in habitat types. The habitat level scores were reef area weighted and combined to get the final indicator score. For Southeast Florida, literature-based values were uniformly classified as hardbottom so coral cover was scored at the regional level and not by habitat type. See Florida section for more information on habitat type classification and see Florida References for publications used for baseline data.

IV.I.III Flower Garden Banks

NCRMP missions were completed in the Flower Garden Banks (FGB) in 2013, 2015, and 2018 (see figure below). In addition, long-term monitoring (LTM) of the East and West Flower Garden Banks has been ongoing at one 100 m x 100 m site per bank since 1989 and has been led by Flower Garden Banks National Marine Sanctuary (FGBNMS) since 2009 (Johnson et al. 2017). For all cover indicators, FGBNMS LTM data were used in the analyses in combination with NCRMP data. A comparison of NCRMP domain estimates and FGBNMS LTM yearly means for concurrent years showed no significant difference between indicator values for each program (pairwise t-test with Bonferroni correction, $p > 0.05$). Although differences in sampling methods exist between NCRMP and FGBNMS LTM benthic cover field data collection methodologies, previous studies have shown that no significant difference exists in cover values when calculating percent cover when using digital or point-intercept collection methods in either line or belt transects (Jokiel et al. 2015, Nadon & Stirling 2006). See table below for a list of specific datasets used for each indicator and see Johnston et al. (2017) for the most recent monitoring report from the FGBNMS.



Region	Year	Demo sites	LPI Sites
Flower Garden Banks NMS	2013	34	69
	2015	30	63
	2018	37	37

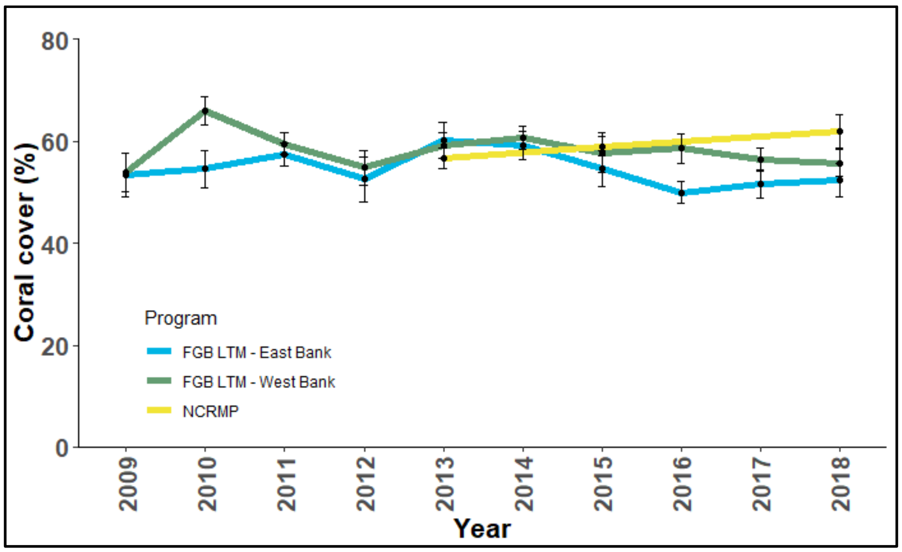
Maps of sampling locations for all NCRMP sampling years (shades of blue) and Flower Garden Banks National Marine Sanctuary (FGBNMS) long-term monitoring sites (red) on both the West Flower Garden Bank (A) and East Flower Garden Bank (B). The table inset indicates the years that NCRMP missions were completed and the number of coral demographic (Demo) and benthic assessment (LPI) survey sites each year.

Datasets used to determine reference values and status values for the Flower Garden Banks.

Indicator	Reference data	Status data
Coral density	NCRMP 2013	NCRMP 2015+2018; FGB LTM 2017
Old mortality	NCRMP 2013	NCRMP 2015+2018; FGB LTM 2017
Coral cover	FGB LTM 2009-2013; NCRMP 2013	NCRMP 2015+2018; FGB LTM 2015-2017
Macroalgae cover	FGB LTM 1992-2013; NCRMP 2013	NCRMP 2015+2018; FGB LTM 2015-2017
CCA cover	FGB LTM 2009-2013; NCRMP 2013	NCRMP 2015+2018; FGB LTM 2015-2017

Coral cover

The status value for FGB coral cover was calculated by combining the site level means from NCRMP site level data (2015, 2018) with data for the two FGBNMS LTM sites (2015-2018). The coral cover reference values for the FGB included data from NCRMP (2013) and FGBNMS LTM (2009-2013). For each of the two FGBNMS LTM sites, site level means for the years of interest were calculated and added as two additional sites to the NCRMP site level data. Coral cover on the East and West banks has remained relatively constant since LTM began in 1989 (Johnston et al. 2017). For that reason, the authors and jurisdictional partners agreed to use only FGBNMS LTM going back to 2009, when the Sanctuary began directly leading the LTM program. The reference value and standard deviation were calculated as the mean and standard deviation of all sites.



Mean coral cover (± SE) for the NCRMP Flower Garden Banks sampling missions (2013, 2015, 2018; yellow) and the FGBNMS long-term monitoring East Bank (blue) and West Bank (green) sites.

Scoring rubric based on p-values for coral cover in the Flower Garden Banks.

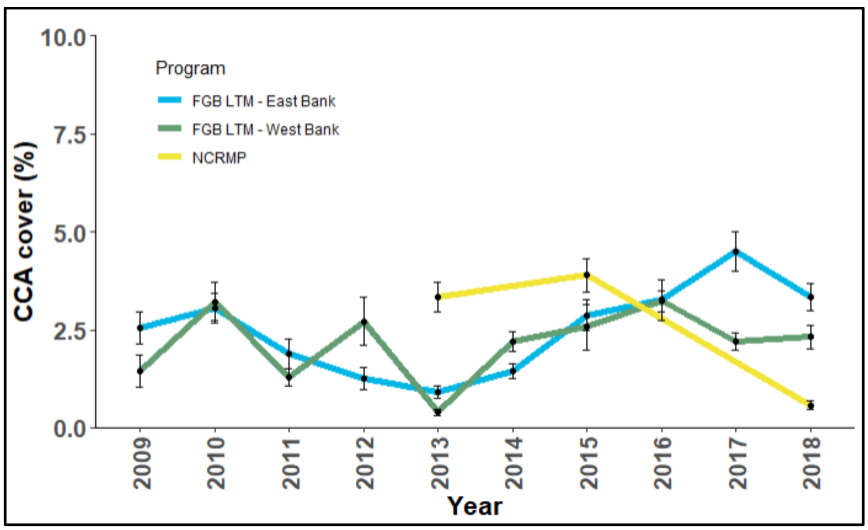
Status Z score domain estimate in relation to zero	**P value**	**Score**
= 0	p > 0.05, not significant	Very good
< 0	p < 0.05	Good
< 0	p < 0.01	Fair
< 0	p < 0.001	Impaired
< 0	p < 0.0001	Critical

Macroalgae cover-not scored

When macroalgae monitoring began on the East and West Flower Garden Banks in 1992, macroalgal cover was low, estimated at less than 5%. Macroalgal cover has since risen to about 30% and has remained relatively consistent since 2009 (Gittings et al. 1992, Johnston et al. 2017). While this change in cover has been well-documented, the authors and jurisdictional representatives were unable to set a meaningful reference value for this indicator that would both represent the pre-increase levels and contain sufficient sampling sites for statistical power. Therefore, we were unable to score this indicator. More information on macroalgae in the FGBNMS can be found in the Sanctuary Monitoring Reports (https://flowergarden.noaa.gov/science/monitor.html) and through NOAA's National Coral Reef Monitoring Program (https://coastalscience.noaa.gov/project/national-coral-reef-monitoring-program-biological-socioeconomic/).

CCA cover

Analyses of the CCA cover status indicator were conducted consistently with analyses of the coral cover status indicator for FGB.



Mean CCA cover (±SE) for the NCRMP Flower Garden Banks sampling missions (2013, 2015, 2018; yellow) and the FGBNMS long-term monitoring East (blue) and West (green) Bank sites from 2009-2018.

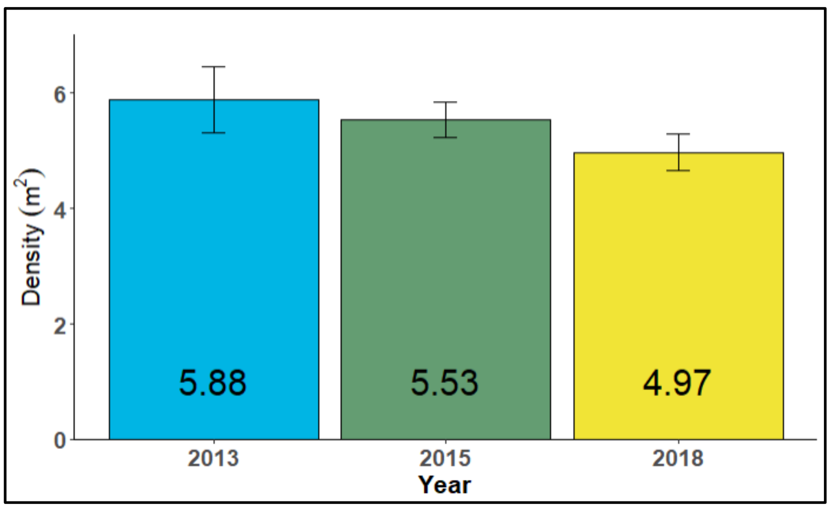
Scoring rubric based on p-values for CCA cover in the Flower Garden Banks.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.05	Very good
= 0	p > 0.05, not significant	Good
< 0	p < 0.01	Fair
< 0	p < 0.001	Impaired

< 0	p < 0.0001	Critical

Adult coral density

NCRMP 2013 data were used as the reference for FGB coral density. The reference value and standard deviation were calculated as the mean and standard deviation of all NCRMP 2013 sites. The status value for coral density was calculated by combining the site level means from the NCRMP data (2015, 2018) with the two FGBNMS LTM sites (2017). FGBNMS LTM began including adult coral density data in 2015; therefore, LTM data were not included in the reference value. Adult coral density values focused on the density of species considered to have high ecological value by jurisdictional stakeholders in this sampling region. Selected coral species included the Endangered Species Act (ESA)-listed and reef building corals *Orbicella annularis, O. faveolata,* and *O. franksi*; selected from Johnston et al. 2017 for high abundance, as well as the following additional coral species: *Agaricia agaricites, Colpophyllia natans, Montastraea cavernosa*, *Madracis auretenra, M. decactis, Porites astreoides, Pseudodiploria strigosa, Siderastrea siderea,* and *Stephanocoenia intersepta.*



Mean adult coral density (±SE) for the NCRMP Flower Garden Banks sampling missions (2013, 2015, 2018).

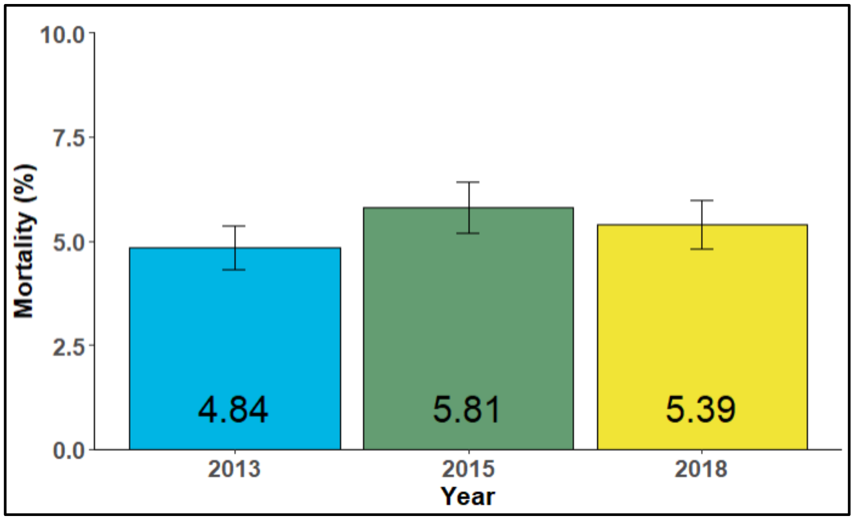
Scoring rubric based on p-values for coral density in the Flower Garden Banks.

Status Z score domain estimate in relation to zero	**P value**	**Score**
= 0	p > 0.05, not significant	Very good
< 0	p < 0.05	Good
< 0	p < 0.01	Fair
< 0	p < 0.001	Impaired

< 0	p < 0.0001	Critical

Old mortality

The same subset of species used for coral density was used for old mortality, as was the same analytic approach.



Mean old mortality (±SE) for the NCRMP Flower Garden Banks sampling missions.

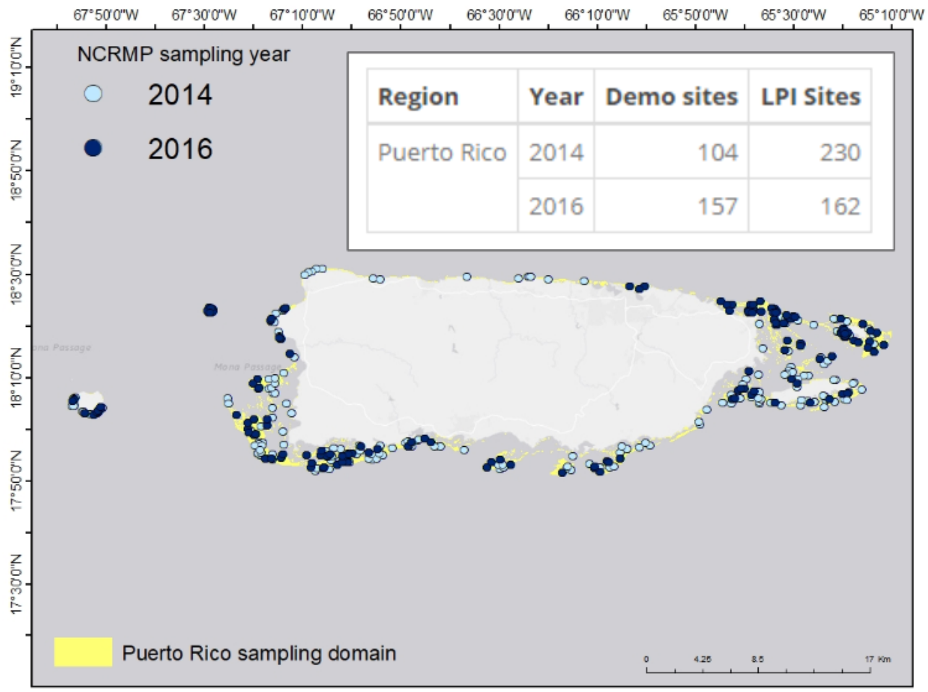
Scoring rubric based on p-values for old mortality in the Flower Garden Banks.

Status Z score domain estimate in relation to zero	P value	Score
= 0	p > 0.05, not significant	Very good
> 0	p < 0.05	Good
> 0	p < 0.01	Fair
> 0	p < 0.001	Impaired
> 0	p < 0.0001	Critical

IV.I.IV Puerto Rico

NCRMP missions were completed in Puerto Rico in 2014 and 2016 (see figure below). The 2019 sampling mission was ongoing at the time of status report development. Long-term monitoring has been conducted by the Department of Natural and Environmental Resources in Puerto Rico since 1999; however, this LTM data was not incorporated into the status report due to statistically significant differences in indicator values between the Puerto Rico Coral Reef Monitoring Program sites and NCRMP yearly domain values potentially due to differences in experimental design and site selection.

Therefore, NCRMP data were the sole dataset used to evaluate all indicators. NCRMP 2014 data were used for reference and NCRMP 2016 data was used for the status assessment for all indicators.

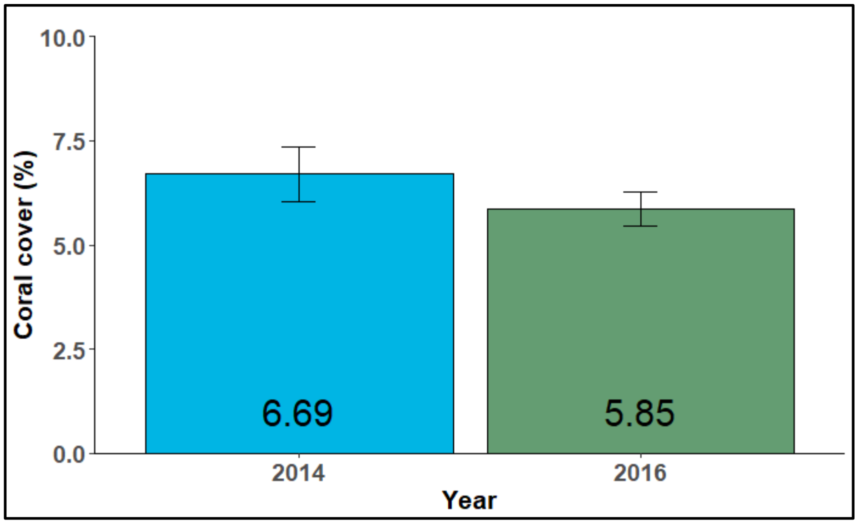


Map of sampling locations for all NCRMP sampling years (shades of blue). Table inset indicates the years missions were completed in Puerto Rico and the number of coral demographic (Demo) and benthic assessment (LPI) sampling survey sites each year.

Scoring rubric based on p-values for coral cover, CCA cover, macroalgal cover, coral density and old mortality in Puerto Rico.

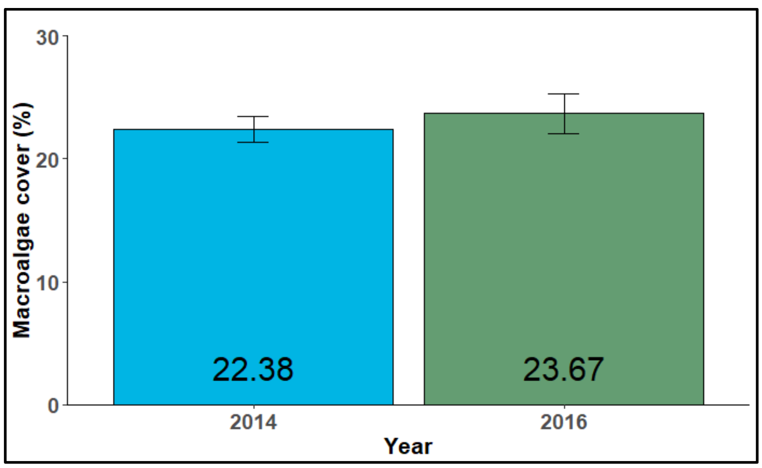
Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Coral cover



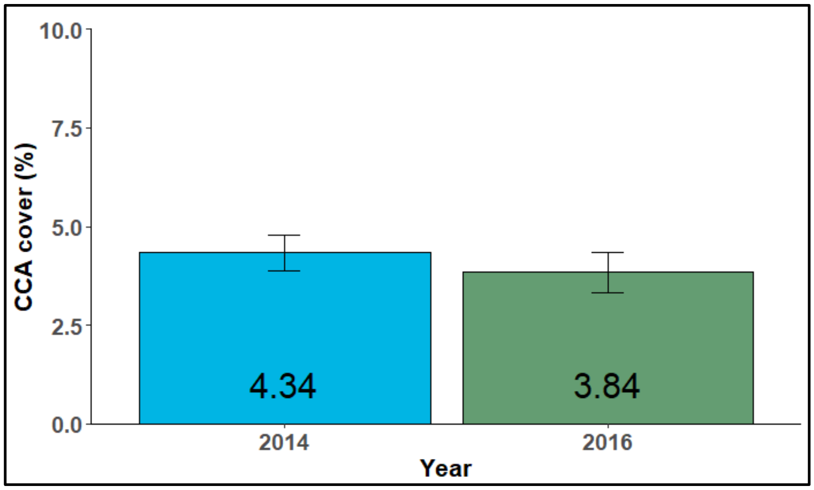
Mean coral cover (± SE) for the NCRMP Puerto Rico sampling missions.

Macroalgae cover



Mean macroalgae cover (±SE) for the NCRMP Puerto Rico sampling missions.

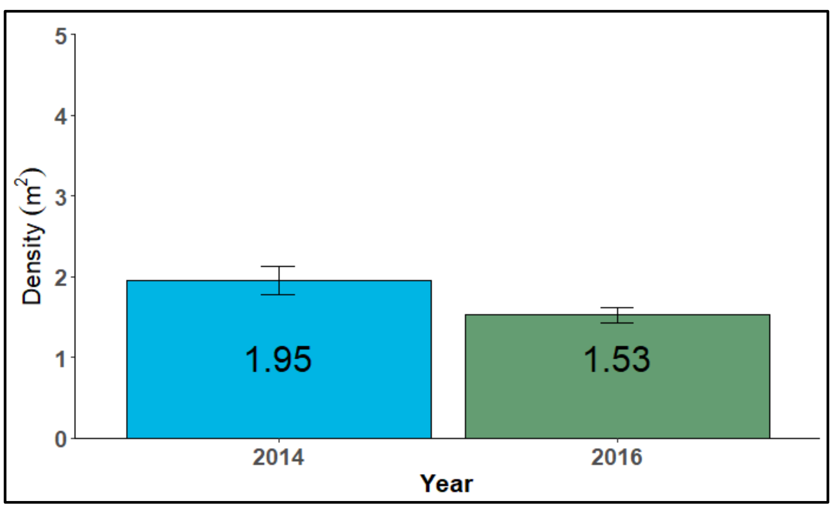
CCA cover



Mean crustose coralline algae (CCA) cover (±SE) for the NCRMP Puerto Rico sampling missions.

Adult coral density

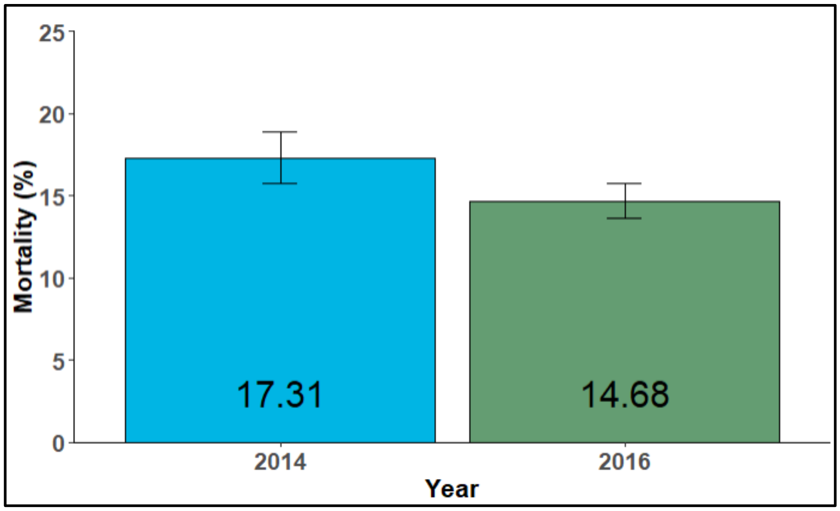
For both the reference and status values, a subset of species was used to focus on the density of species considered to have high ecological value. The species were selected with input from jurisdictional stakeholders and included the Endangered Species Act (ESA) listed corals: *Acropora cervicornis, A. palmata, Dendrogyra cylindrus, Orbicella annularis, O. faveolata,* and *O. franksi*, as well as the following additional coral species: *Agaricia agaricites, A. lamarcki, Colpophyllia natans, Diploria labyrinthiformis, Montastraea cavernosa, Porites porites, Pseudodiploria strigosa and Siderastrea siderea.*



Mean coral density (±SE) for the NCRMP Puerto Rico sampling missions.

Old mortality

The same subset of species used for coral density was used for old mortality, as was the same analytic approach.

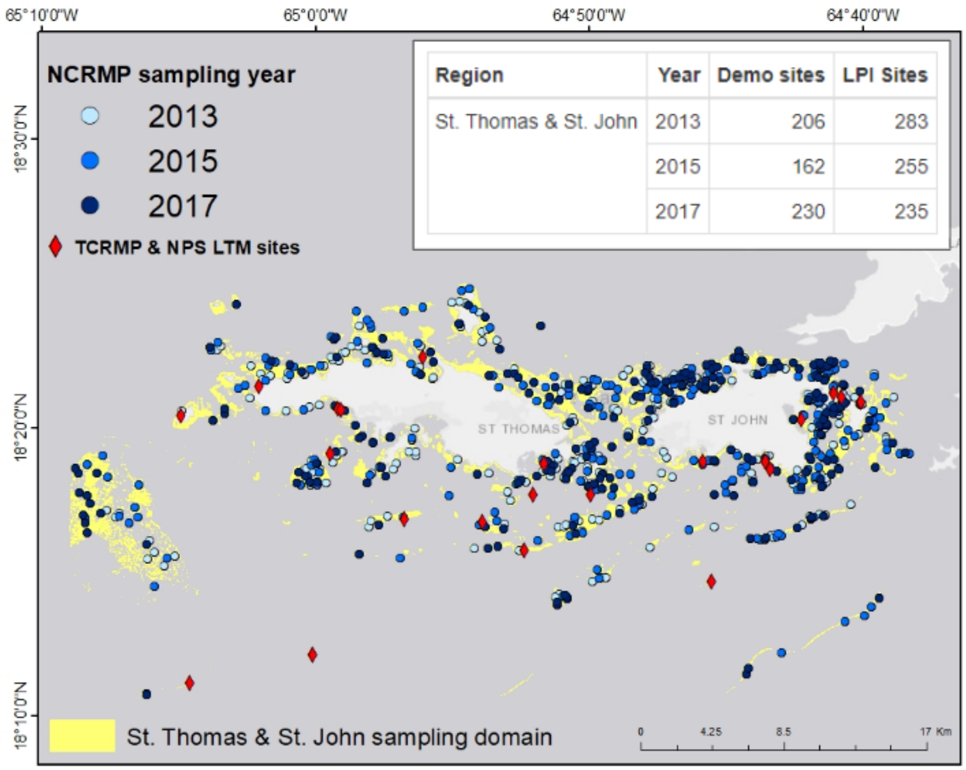


Mean old mortality (±SE) for the NCRMP Puerto Rico sampling missions.

IV.I.V U. S. Virgin Islands

U.S. Virgin Islands (USVI) NCRMP missions occurred in St. Thomas and St. John in 2013, 2015 and 2017 and in St. Croix in 2015 and 2017. See below for locations and number of benthic sampling sites per year. Long-term monitoring (LTM) in the USVI has been conducted since 1999 at permanent sites surrounding all three major islands. The Territorial Coral Reef Monitoring Program (TCRMP) managed by the University of the Virgin Islands (UVI) in partnership with the Virgin Islands Department of Planning and Natural Resources (VI DPNR) currently monitors 33 sites surrounding St. Thomas, St. John and St. Croix in water depths from 6 to 65 m on a yearly basis. The Virgin Islands National Park Service (VI NPS) currently monitors 12 sites surrounding St. John and St. Croix in depths from 6 to 34 m on a yearly basis. For all cover indicators, LTM data for sites up to 30 m depths from 1999-2005 were used to create the reference values after it was determined that there was no significant difference in indicator values between NCRMP domain estimates and TCRMP and NPS LTM yearly means in comparable habitats for concurrent years (2013, 2015, 2017; pairwise t-test with Bonferroni correction, $p > 0.05$). The date range of 1999-2005 was selected to provide reference values that were prior to the 2005 Caribbean mass coral bleaching event (see Woody et al. 2008 and Eakin et al. 2011). LTM sites below 30 m were excluded as NCRMP does not sample depths below 30 m. While differences in sampling methods exist between NCRMP, TCRMP, and NPS benthic cover protocols, studies have shown that no significant difference exists in cover values when calculating percent cover when using digital or point-intercept collection methods in either line or belt transects (Nadon & Stirling 2006, Jokiel et al. 2015). To account for differences in habitat types sampled between NCRMP and the TCRMP and NPS LTM program, all LTM sites were reviewed and classified into NCRMP habitat categories (aggregate reef, patch reef, bedrock, pavement or scattered coral and rock in sand). As the majority (~ 75%) of TCRMP and NPS LTM sites fell into the high-coral, high-relief habitats of aggregate reef, patch reef, or bedrock, only NCRMP sites in the same habitat classifications were selected for comparison to the LTM sites. These sites were given the habitat type classification of high coral (HC). The remaining NCRMP sites which were in the low-coral, low-relief habitats, pavement and scattered coral and rock in sand, were only compared to other NCRMP sites in the same habitats as there was an insufficient number of LTM sites in these habitats to create a reference. These sites were given the habitat type classification of low coral (LC). For the adult density and old mortality indicators, LTM data were not available, so only NCRMP data were used. See table below for a list of specific datasets used for the reference and status values of each indicator.

St. Thomas & St. John



Maps of sampling locations for all NCRMP sampling years (shades of blue) and TCRMP and NPS long-term monitoring (LTM) sites (red) surrounding St. Thomas and St. John. The table inset indicates the years NCRMP missions were completed and the number of coral demographic and line-point intercept (LPI) sampling survey sites each year. TCRMP and NPS LTM sites below 30 m depths are not shown as they were not included in the data analysis.

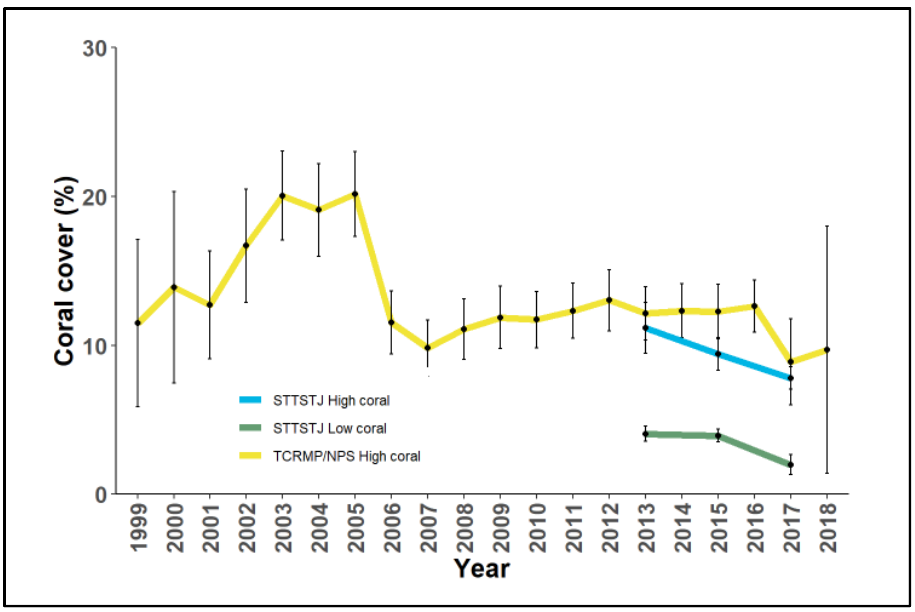
Datasets used to determine reference values and status values for St. Thomas and St. John.

Indicator	Habitat type	Reference data	Status data
Density	High coral	NCRMP 2013	NCRMP 2015 + 2017
	Low coral	NCRMP 2013	NCRMP 2015 + 2017
Old mortality	High coral	NCRMP 2013	NCRMP 2015 + 2017
	Low coral	NCRMP 2013	NCRMP 2015 + 2017

Coral cover	High coral	TCRMP & NPS LTM 1999-2005	NCRMP 2015 + 2017
	Low coral	NCRMP 2013	NCRMP 2015 + 2017
Macroalgae cover	High coral	TCRMP & NPS LTM 1999-2005	NCRMP 2015 + 2017
	Low coral	NCRMP 2013	NCRMP 2015 + 2017
CCA cover	High coral	TCRMP & NPS LTM 1999-2005	NCRMP 2015 + 2017
	Low coral	NCRMP 2013	NCRMP 2015 + 2017

Coral cover

For high coral (HC) habitats, TCRMP and NPS long-term monitoring data were used to create the reference value for coral cover. Site level means of coral cover for LTM years 1999 to 2005 were calculated for each of the long-term monitoring sites. For low coral (LC) habitats, the NCRMP 2013 data were used to create the reference value. For each habitat type, HC or LC, the reference value and reference standard deviation were calculated as the mean and standard deviation of all sites. The NCRMP 2015 and 2017 data were used to create the status values for coral cover.



Mean coral cover (±SE) for the 3 St. Thomas and St. John NCRMP sampling missions (2013, 2015, 2017) for both high coral (HC, blue) and low coral (LC, green) habitats. The combined TCRMP and NPS long-term monitoring yearly means from 1999-2018 are shown in yellow.

High coral (HC) habitat type scoring rubric based on p-values for coral cover in St. Thomas and St. John.

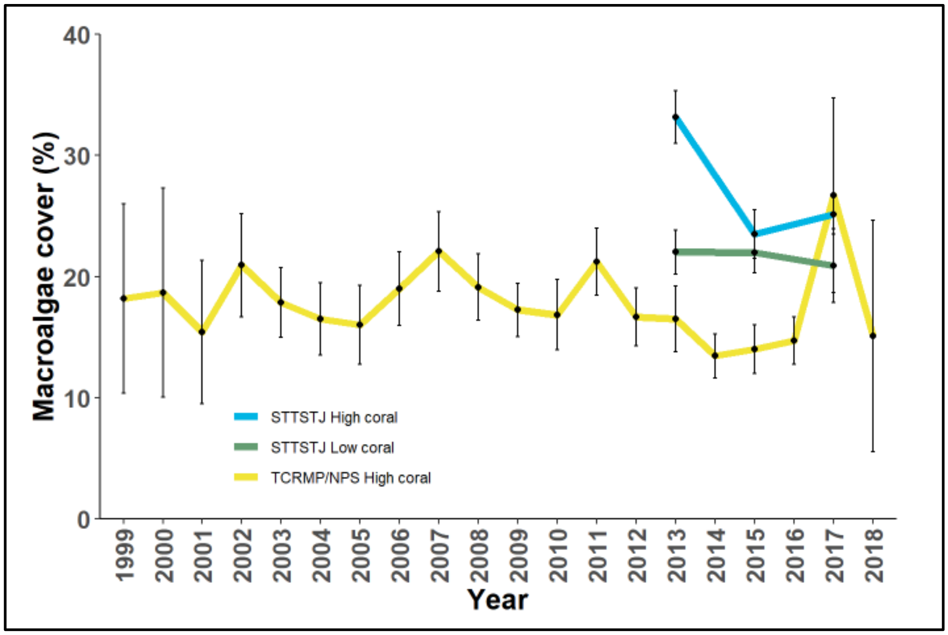
Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	$p < 0.05$	Very good
= 0	$p > 0.05$, not significant	Good
< 0	$p < 0.01$	Fair
< 0	$p < 0.05$	Impaired
< 0	$p < 0.001$	Critical

Low coral (LC) habitat type scoring rubric based on p-values for coral cover in St. Thomas and St. John.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	$p < 0.01$	Very good
> 0	$p < 0.05$	Good
= 0	$p > 0.05$, not significant	Fair
< 0	$p < 0.05$	Impaired
< 0	$p < 0.01$	Critical

Macroalgae cover

Analyses of the macrolagae cover status indicator were conducted consistently with analyses of the coral cover status indicator for St. Thomas and St. John.



Mean macroalgae cover (±SE) for the 3 St. Thomas and St. John (STTSTJ) NCRMP sampling missions (2013, 2015, 2017) for both high coral (HC, blue) and low coral (LC, green) habitats. The combined TCRMP and NPS long-term monitoring yearly means from 1999-2018 are shown in yellow.

High coral habitat scoring rubric based on p-values for macroalgae cover in St. Thomas and St. John.

Status Z score domain estimate in relation to zero	**P value**	**Score**
< 0	p < 0.05	Very good
< 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
> 0	p < 0.05	Impaired
> 0	p < 0.001	Critical

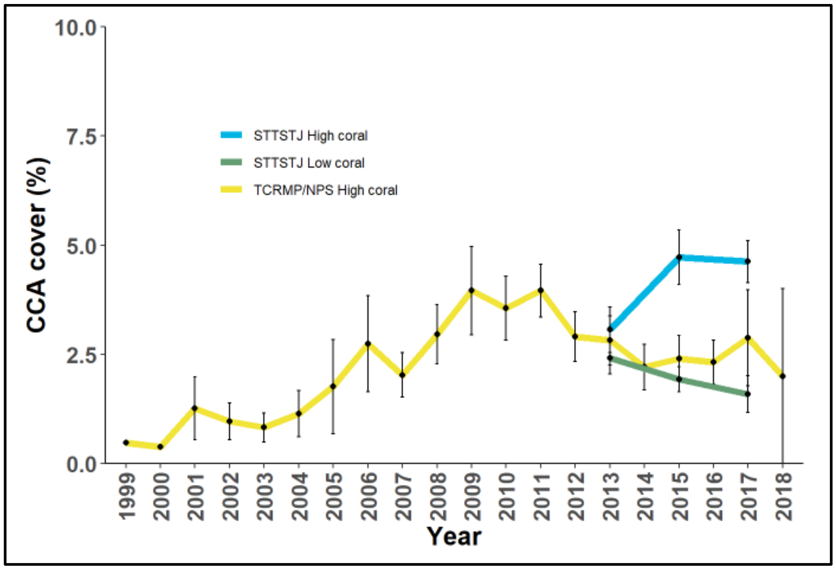
Low coral habitat scoring rubric based on p-values for macroalgae cover in St. Thomas and St. John.

Status Z score domain estimate in relation to zero	**P value**	**Score**
< 0	p < 0.01	Very good
< 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair

> 0	p < 0.05	Impaired
> 0	p < 0.01	Critical

CCA cover

Analyses of the CCA cover status indicator were conducted consistently with analyses of the coral cover status indicator for St. Thomas and St. John.



Mean CCA cover (±SE) for the 3 St. Thomas and St. John NCRMP sampling missions (2013, 2015, 2017) for both high coral (HC, blue) and low coral (LC, green) habitats. Mean CCA cover (±SE) for TCRMP and NPS long-term monitoring sites from 1999-2018 are shown in yellow.

High coral and low coral habitat scoring rubric based on p-values for CCA cover in St. Thomas and St. John.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.05	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.001	Critical

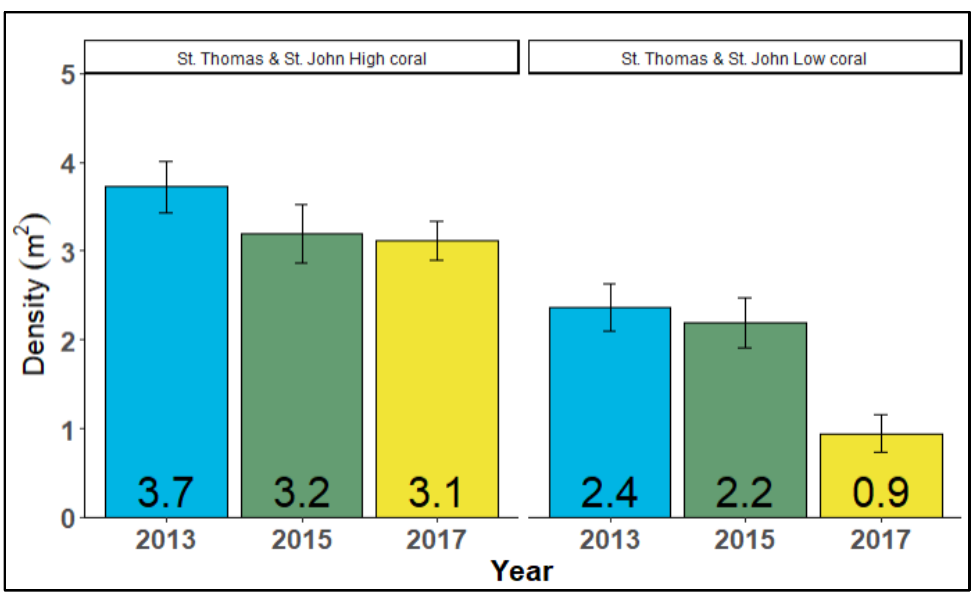
Low coral habitat scoring rubric based on p-values for CCA cover in St. Thomas and St. John.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Coral density

The NCRMP 2013 data were used to create the reference values for coral density. To identify potential differences in change between HC and LC habitats, the data were divided into these two categories and scored separately even though LTM data were not available. The reference values and reference standard deviation were calculated as the mean and standard deviation of all sites. The combined NCRMP 2015 and 2017 data were used to create the status value for coral density, again being divided into HC and LC habitats.

For both the reference and status values, a subset of species was used to focus on the density of species with high ecological value and remove weedy species. The species selected were determined with input from jurisdictional stakeholders and included the Endangered Species Act (ESA) listed corals: *Acropora cervicornis, Acropora palmata, Orbicella annularis, Orbicella franksi,* and *Orbicella faveolata*, as well as the following additional coral species: *Colpophyllia natans, Diploria labyrinthiformis, Montastraea cavernosa, Porites porites, Pseudodiploria strigosa, Pseudodiploria clivosa, Siderastrea siderea, Agaricia agaricites, Agaricia lamarcki, Meandrina meandrites* and *Stephanocoenia intersepta.*



Mean coral density (±SE) for select species in both high coral (left) and low coral (right) habitats for the St. Thomas and St. John NCRMP sampling missions (2013, 2015, and 2017).

Scoring rubric based on p-values for coral density in high coral (HC) habitats in the St. Thomas and. St. John.

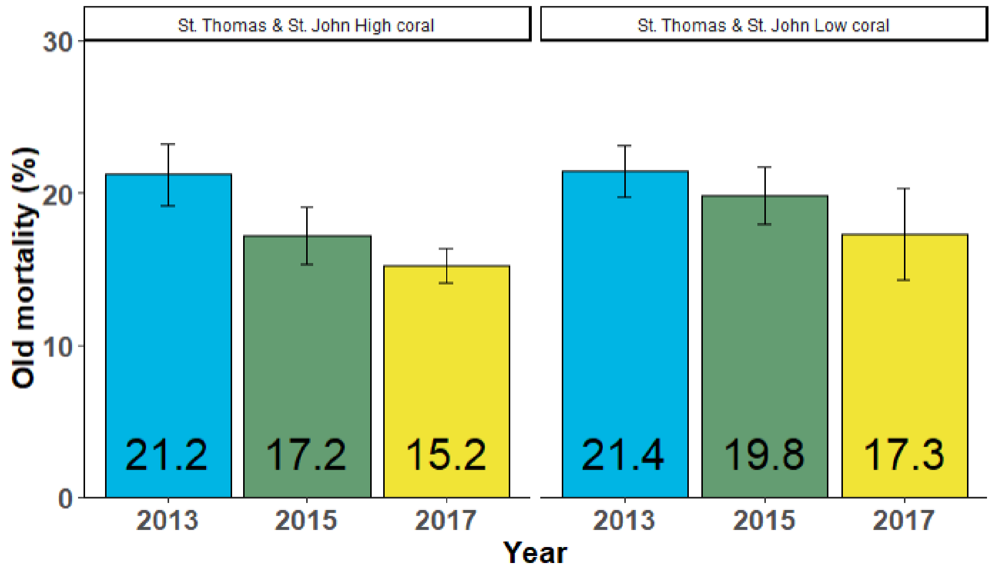
Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Scoring rubric based on p-values for coral density in low coral (LC) habitats in the St. Thomas and. St. John.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Old mortality

The same subset of species used for coral density was used for old mortality, as was the same analytic approach.

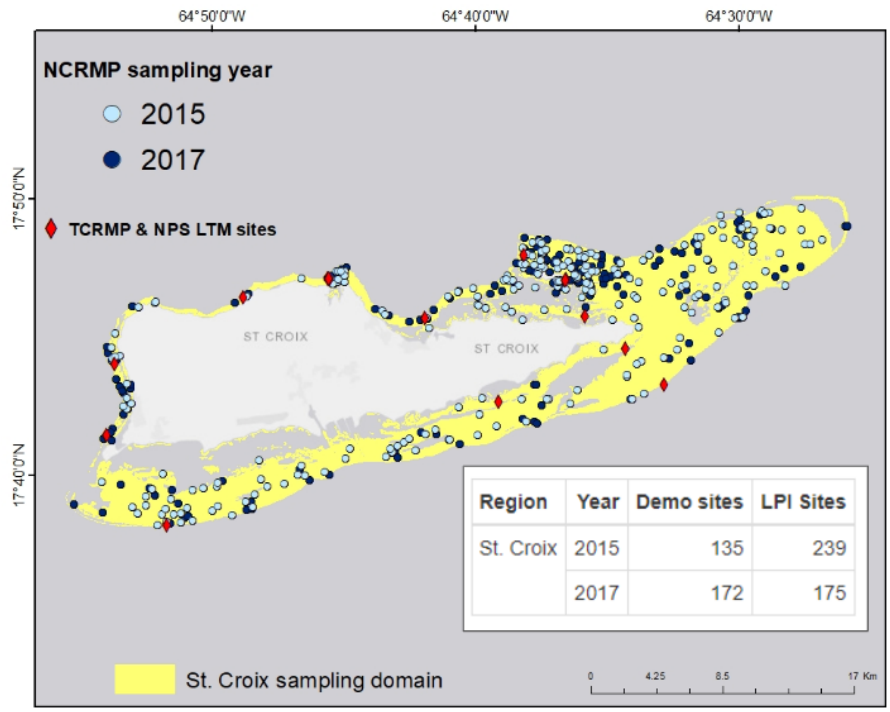


Mean old mortality (±SE) for select species in high coral (left) and low coral (right) habitats for the St. Thomas and St. John NCRMP sampling missions (2013, 2015, and 2017).

Scoring rubric based on p-values for old mortality in high coral (HC) and low coral (LC) habitats in the St. Thomas and. St. John.

Status Z score domain estimate in relation to zero	**P value**	**Score**
< 0	$p < 0.01$	Very good
< 0	$p < 0.05$	Good
= 0	$p > 0.05$, not significant	Fair
> 0	$p < 0.05$	Impaired
> 0	$p < 0.01$	Critical

St. Croix



Map of sampling locations for all St. Croix NCRMP missions (shades of blue) and TCRMP and NPS long-term monitoring (LTM) sites (red). The table inset indicates the years NCRMP missions were completed and the number of coral demographic (Demo) and line-point intercept (LPI) sampling survey sites each year. TCRMP and NPS LTM sites below 30 m depths are not shown as they were not included in the data analysis.

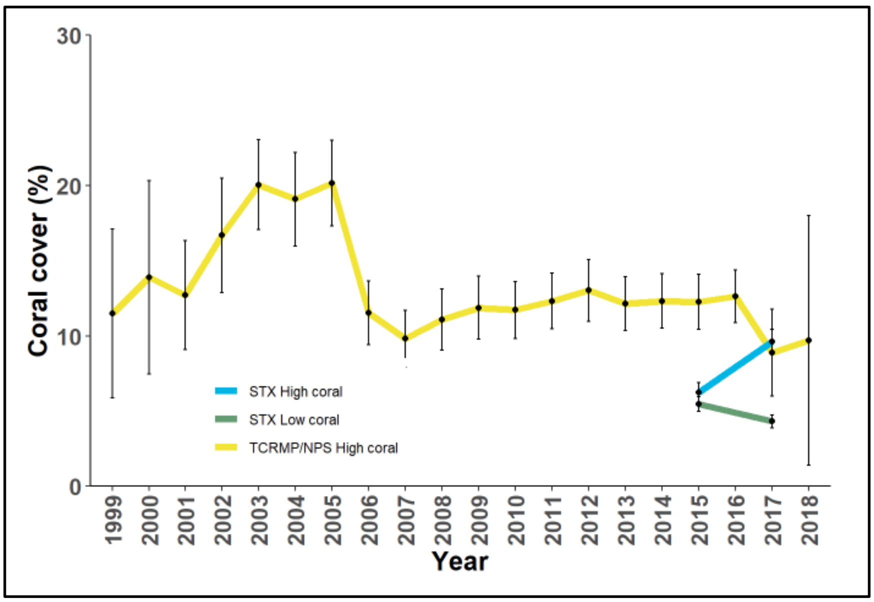
Datasets used to determine reference values and status values for St. Croix.

Indicator	Habitat type	Reference data	Status data
Density	High coral	NCRMP 2015	NCRMP 2017
	Low coral	NCRMP 2015	NCRMP 2017
Old mortality	High coral	NCRMP 2015	NCRMP 2017
	Low coral	NCRMP 2015	NCRMP 2017
Coral cover	High coral	TCRMP & NPS LTM 1999-2005	NCRMP 2017
	Low coral	NCRMP 2013	NCRMP 2017

Macroalgae cover	High coral	TCRMP & NPS LTM 1999-2005	NCRMP 2017
	Low coral	NCRMP 2013	NCRMP 2017
CCA cover	High coral	TCRMP & NPS LTM 1999-2005	NCRMP 2017
	Low coral	NCRMP 2013	NCRMP 2017

Coral cover

For high coral (HC) habitats, TCRMP and NPS long-term monitoring data were used to create the reference value for coral cover. Site level means of coral cover for years 1999 to 2005 were calculated for each of the long-term monitoring sites. For low coral (LC) habitats, the NCRMP 2015 data were used to create the reference value. For each Habitat type, HC or LC, the reference value and reference standard deviation were calculated as the mean and standard deviation of all sites.



Mean coral cover (±SE) for the 3 St. Croix NCRMP sampling missions (2013, 2015, 2017) for both high coral (HC, blue) and low coral (LC, green) habitats and the combined TCRMP and NPS long-term monitoring yearly means (yellow) from 1999-2018.

High coral (HC) habitat type scoring rubric based on p-values for coral cover in St. Croix.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.05	Very good
= 0	p > 0.05, not significant	Good
< 0	p < 0.01	Fair

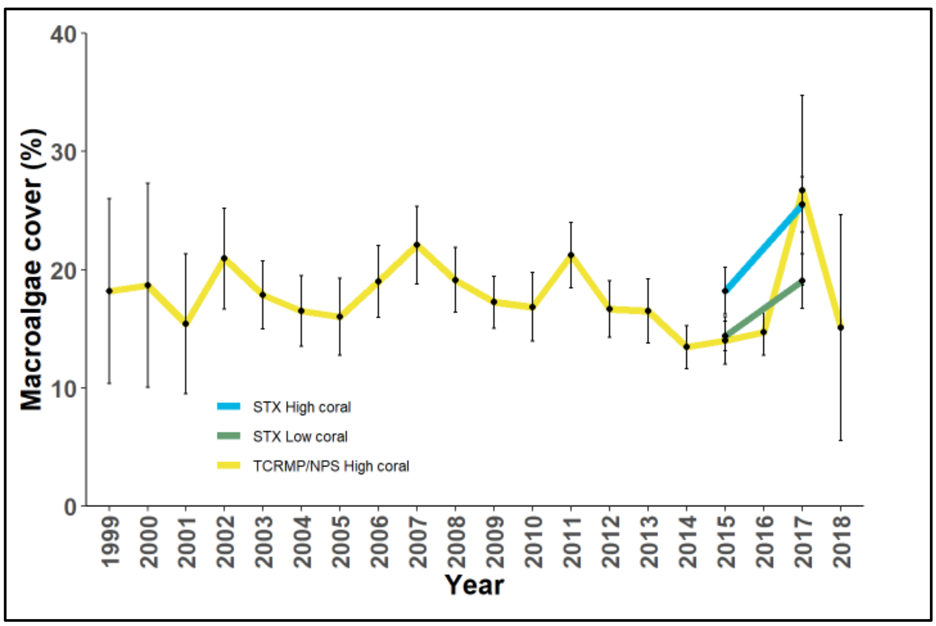
< 0	p < 0.05	Impaired
< 0	p < 0.001	Critical

Low coral (LC) habitat type scoring rubric based on p-values for coral cover in St. Croix.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Macroalgae cover

Analyses of the macroalgae cover status indicator were conducted consistently with analyses of the coral cover status indicator for St. Croix.



Mean macroalgae cover (±SE) for the 2 St. Croix (STX) NCRMP sampling missions (2015, 2017) for sites in both high coral (HC, blue) and low coral (LC, green) habitats. Combined TCRMP and NPS long-term monitoring yearly means from 1999-2018 are shown in yellow.

High coral (HC) habitat type scoring rubric based on p-values for macroalgae cover in St. Croix.

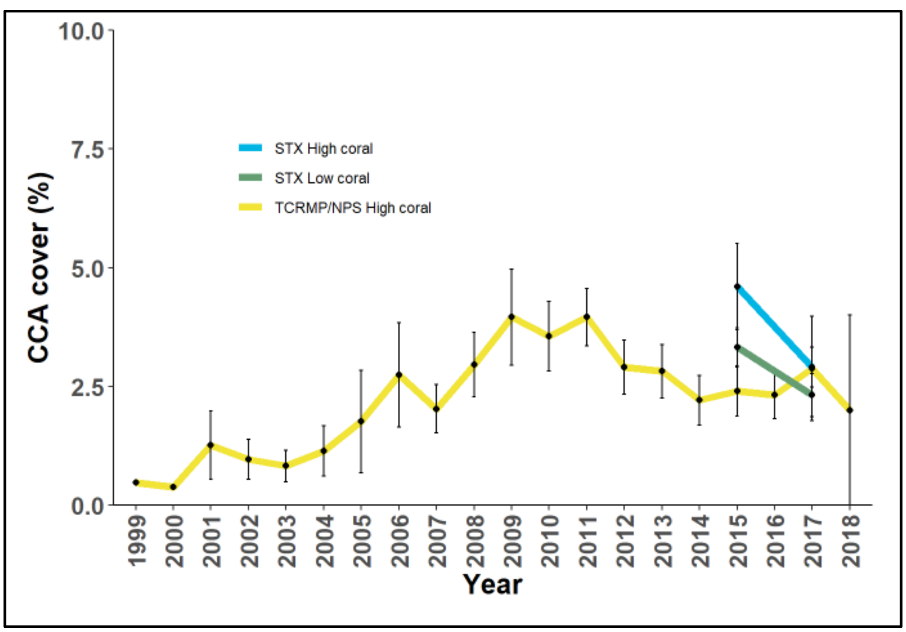
Status Z score domain estimate in relation to zero	P value	Score
< 0	p < 0.05	Very good
< 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
> 0	p < 0.05	Impaired
> 0	p < 0.001	Critical

Low coral (LC) habitat type scoring rubric based on p-values for macroalgae cover in St. Croix.

Status Z score domain estimate in relation to zero	P value	Score
< 0	p < 0.01	Very good
< 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
> 0	p < 0.05	Impaired
> 0	p < 0.01	Critical

CCA cover

Analyses of the CCA cover status indicator were conducted consistently with analyses of the coral cover status indicator for St. Croix.



Mean CCA cover (±SE) for the 2 St. Croix (STX) NCRMP sampling missions (2015, 2017) for both high coral (HC, blue) and low coral (LC, green) habitats. Combined TCRMP and NPS long-term monitoring yearly means from 1999-2018 are shown in yellow.

High coral (HC) habitat type scoring rubric based on p-values for CCA cover in St. Croix.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.05	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.001	Critical

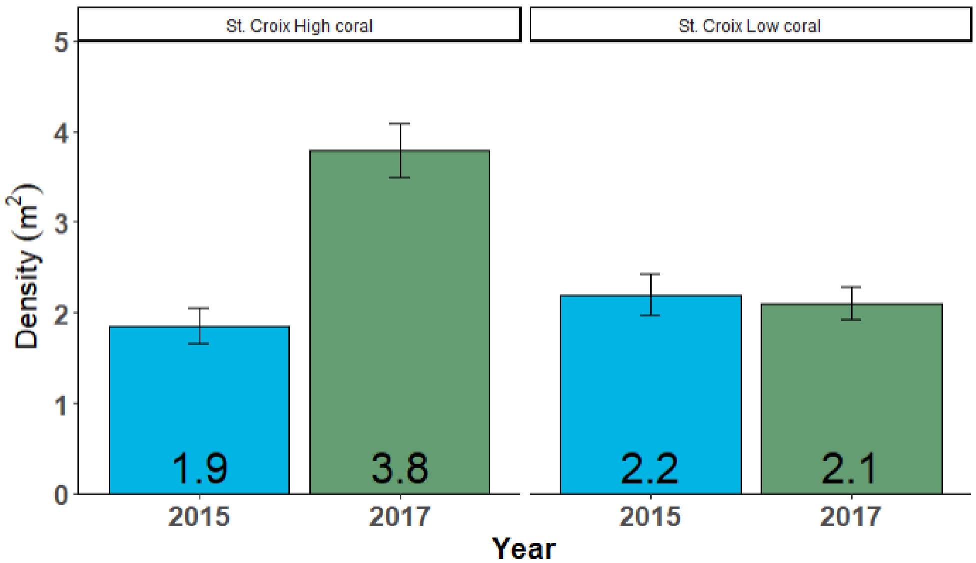
Low coral (LC) habitat type scoring rubric based on p-values for CCA cover in St. Croix.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Coral density

The NCRMP 2015 data were used to create the reference values for coral density. To identify potential differences in change between HC and LC habitats, the data were divided into these two categories and scored separately even though LTM data were not available. The reference values and reference standard deviation were calculated as the mean and standard deviation of all sites.

For both the reference and status values, a subset set of species was used to focus on the density of species with high ecological value and remove weedy species. The species selected were determined with input from jurisdictional stakeholders and included the Endangered Species Act (ESA) listed corals *Acropora cervicornis, Acropora palmata, Orbicella annularis, Orbicella franksi,* and *Orbicella faveolata*, as well as the following additional coral species: *Colpophyllia natans, Diploria labyrinthiformis, Montastraea cavernosa, Porites porites, Pseudodiploria strigosa, Pseudodiploria clivosa, Siderastrea siderea, Agaricia agaricites, Agaricia lamarcki, Meandrina meandrites* and *Stephanocoenia intersepta.*



Mean coral density (±SE) for select species in both high coral (left) and low coral (right) habitats for the St. Croix NCRMP sampling missions (2015 and 2017).

Scoring rubric based on p-values for coral density in high coral (HC) habitats in St. Croix.

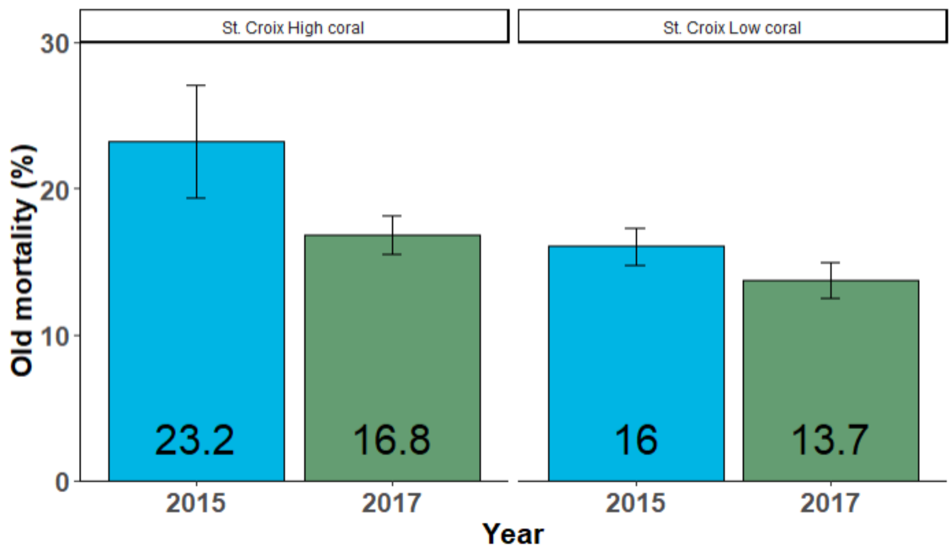
Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.001	Very good
> 0	p < 0.01	Good
= 0	p < 0.05	Fair
< 0	p > 0.05, not significant	Impaired
< 0	p < 0.05	Critical

Scoring rubric based on p-values for coral density in low coral (LC) habitats in St. Croix.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Old mortality

The same subset of species used for coral density was used for old mortality, as was the same analytic approach.



Mean old mortality (±SE) for select species in high coral (left) and low coral (right) habitats for the St. Croix NCRMP sampling missions (2015 and 2017).

Scoring rubric based on p-values for old mortality in high coral (HC) habitats in St. Croix.

Status Z score domain estimate in relation to zero	P value	Score
< 0	p < 0.01	Very good
< 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
> 0	p < 0.05	Impaired
> 0	p < 0.01	Critical

Scoring rubric based on p-values for old mortality in low coral (LC) habitats in St. Croix.

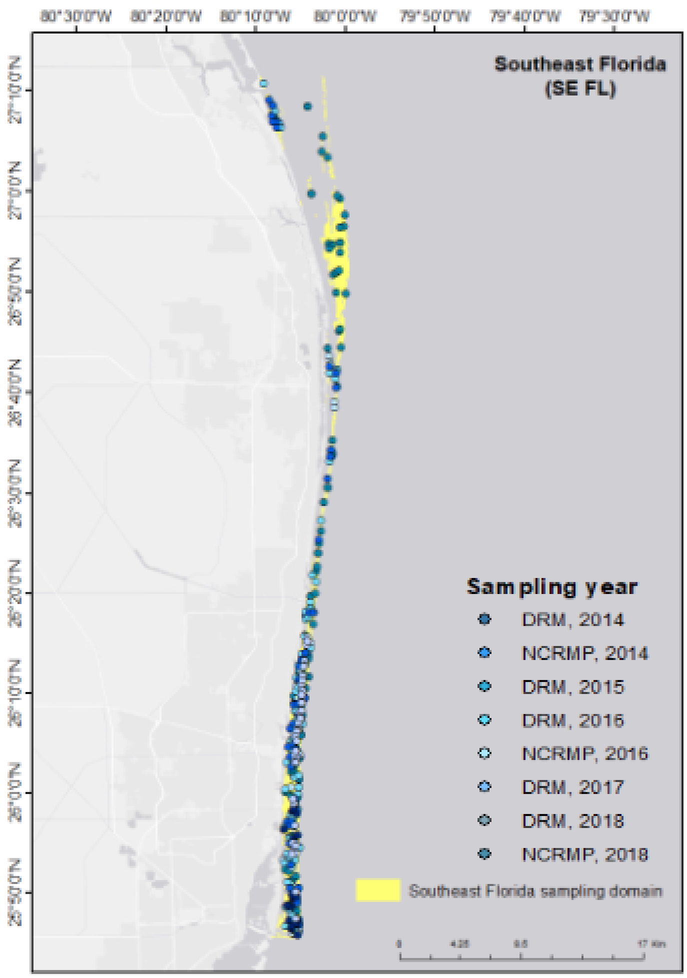
Status Z score domain estimate in relation to zero	P value	Score
< 0	p < 0.01	Very good
< 0	p < 0.05	Good

= 0	$p > 0.05$, not significant	Fair
> 0	$p < 0.05$	Impaired
> 0	$p < 0.01$	Critical

IV.I.VI Florida

NCRMP missions occurred in all three Florida regions (Southeast Florida, the Florida Keys, and the Dry Tortugas) in 2014, 2016, and 2018. See figures and tables for locations and number of benthic sampling sites per year. Long-term monitoring (LTM) in Florida has been conducted since 1996 by the Florida Coral Reef Evaluation and Monitoring Project (CREMP) at permanent sites in all three regions. In addition, the Disturbance Response Monitoring Program (DRM; http://ocean.floridamarine.org/FRRP/) has conducted stratified random surveys in all three regions each year since 2005. The multiple monitoring efforts in Florida were included in the analyses for this report. However, authors and jurisdictional partners recognized that the LTM data were not representative of the reef state prior to human impacts. An extensive literature review was conducted to identify the most historic monitoring information for the benthic indicators. The combination of literature-based historical data and coral cover data from the Florida Coral Reef Evaluation and Monitoring Program (CREMP) 1996-1999 allowed for more historically representative baselines for coral cover than only long-term monitoring data. The CREMP LTM data met the requirements for inclusion with NCRMP: there was no significant difference in coral cover and macroalgae cover indicator values between NCRMP domain estimates and CREMP yearly means for concurrent years for each region (pairwise t-tests with Bonferroni correction, all $p > 0.05$). Because the NCRMP and DRM programs use the same stratified random sampling design in Florida, no statistical tests were conducted to compare NCRMP and DRM.

Southeast Florida



Map of sampling locations for all NCRMP and DRM missions 2014 - 2018 (shades of blue).

NCRMP and DRM sampling effort in Southeast Florida for coral demographic and benthic assessment (LPI) surveys from 2014-2018.

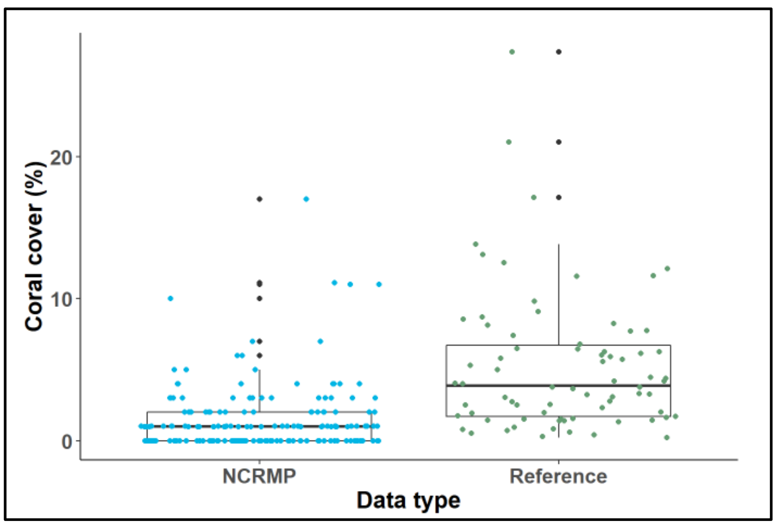
Region	Year	NCRMP Demo Sites	DRM Demo Sites	NCRMP LPI Sites
Southeast Florida	2014	49	41	49
	2015	NA	100	NA
	2016	93	48	98
	2017	NA	23	NA
	2018	70	49	77

Datasets used to determine reference values and status values in Southeast Florida.

Indicator	Reference	Status
Coral cover	Historic data (1979-1992)	NCRMP 2016 + 2018
Macroalgae cover	SE-CREMP 2003-2005	NCRMP 2016 + 2018
CCA cover	NCRMP 2014	NCRMP 2016 + 2018
Density	DRM 2005-2007	NCRMP/DRM 2016-2018
Old mortality	DRM 2005-2007	NCRMP/DRM 2016-2018

Coral cover

For the Southeast Florida coral cover reference value, coral cover values were used from Blair & Flynn 1989 and Hocevar 1993, which included a total of 74 sites on hardbottom habitat. The reference value and standard deviation were calculated as the mean and standard deviation of all sites. The NCRMP 2016 and 2018 data were used to create the status value for coral cover.



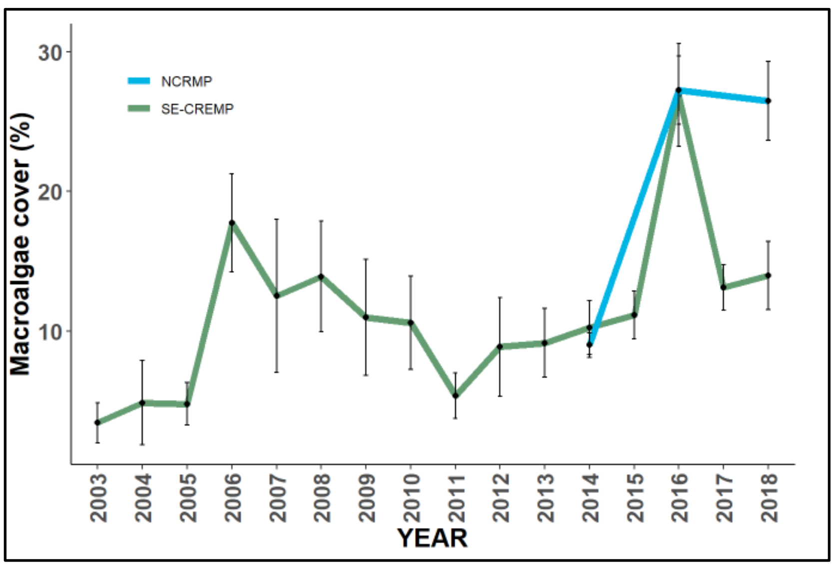
Box plots of the status NCRMP site level coral cover data (blue) and the literature-based reference data used for comparison (green). Upper and lower hinges correspond to the first and third quartiles, horizontal bars correspond to medians and whiskers extend to the highest and lowest values within 1.5 IQR (interquartile range). Data beyond whiskers are outliers represented as black dots.

Scoring rubric based on p-values for coral cover in Southeast Florida.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Macroalgae cover

The SE-CREMP long-term monitoring data were used to create the reference value for macroalgae in Southeast Florida. Site level means of macroalgae for years 2003-2005 were calculated for each of the long-term monitoring sites. The reference value and reference standard deviation were calculated as the mean and standard deviation of all sites. The NCRMP 2016 and 2018 data were used to create the status values for macroalgae cover.



Mean macroalgae cover (±SE) for the NCRMP Southeast Florida sampling years (blue; 2014, 2016, 2018) and SE-CREMP (green) since 2003.

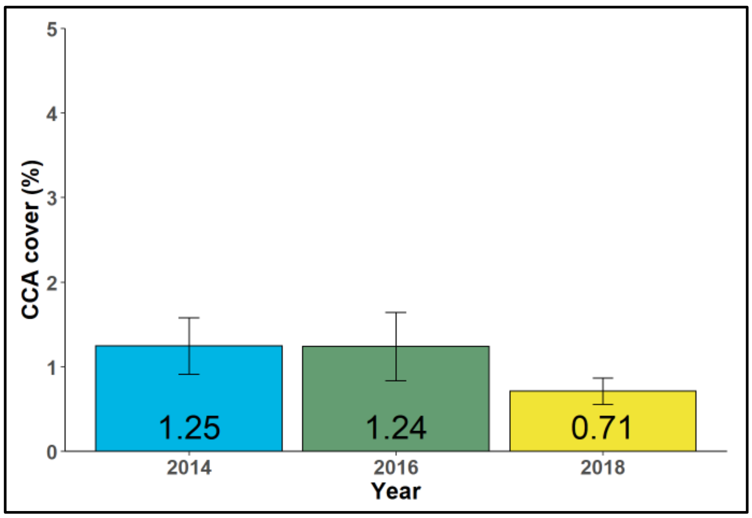
Scoring rubric based on p-values for macroalgae cover in Southeast Florida.

Status Z score domain estimate in relation to zero	P value	Score
< 0	p < 0.05	Very good

< 0	p > 0.05, not significant	Good
= 0	P < 0.05	Fair
> 0	p < 0.01	Impaired
> 0	p < 0.001	Critical

CCA cover

In the absence of available historic literature or long-term monitoring data for the CCA cover indicator, the NCRMP 2014 data were used to create the reference value. The reference value and standard deviation were calculated as the mean and standard deviation of all sites. The NCRMP 2016 and 2018 data were used to create the status values for CCA cover.



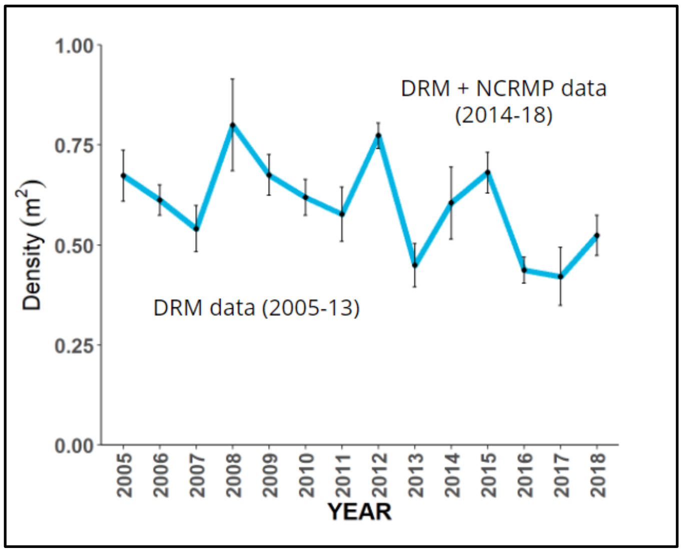
Mean CCA cover (±SE) in for the NCRMP Southeast Florida sampling years (2014, 2016, 2018).

Scoring rubric based on p-values for macroalgae cover in Southeast Florida.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.001	Very good
> 0	p > 0.01	Good
> 0	P < 0.05	Fair
= 0	p > 0.05, not significant	Impaired
< 0	p < 0.05	Critical

Adult coral density

DRM data from 2005-2007 were used to create the reference values for coral density. These years were selected because 2005 was the earliest DRM sampling year and including 3 years provided a comparable sample size to the status value. The reference values and standard deviation were calculated as the mean and standard deviation of all sites. The combined NCRMP 2016 and 2018 data were used to create the status value for coral density. For both the reference and status values, a subset of coral species was used to focus on the density of species considered by jurisdictional stakeholders to have high ecological value. Selected coral species included the Endangered Species Act (ESA) listed corals: *Acropora cervicornis, A. palmata, Orbicella annularis, O. faveolata,* and *O. franksi*, as well as the following additional coral species: *Colpophyllia natans, Diploria labyrinthiformis, Meandrina meandrites, Montastraea cavernosa, Porites porites, Pseudodiploria clivosa, P. strigosa, Siderastrea siderea,* and *Stephanocoenia intersepta.*



Mean coral density (±SE) for select species from DRM and NCRMP sampling efforts in Southeast Florida.

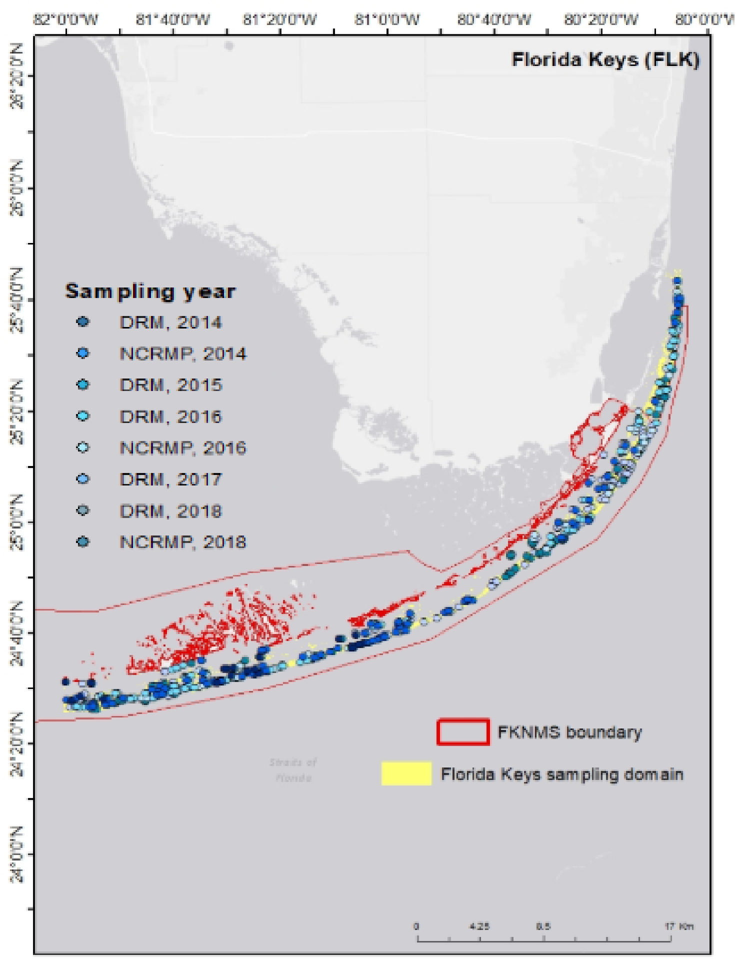
Scoring rubric based on p-values for coral density in Southeast Florida.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.001	Very good
> 0	p < 0.01	Good
> 0	p < 0.05	Fair
= 0	p > 0.05, not significant	Impaired
< 0	p < 0.05	Critical

Old mortality – not scored

Very low coral cover and adult coral density equates to a limited coral population; in this scenario the potential is limited for coral mortality to be representative. From an ecological perspective, low coral mortality is a positive reef attribute which, in this application relates to a favorable score. However, the combination of low coral mortality, low coral cover, and low coral densities can be indicative of a highly impacted coral community in which individual colonies may be dying and leaving the population, potentially rapidly rather than persisting with a "scar" of old partial colony mortality from a disturbance event such as bleaching, coral disease or a hurricane. All three of these disturbance events have impacted Southeast Florida's reefs repeatedly, most recently Hurricane Irma in 2017 and the Stony Coral Tissue Loss Disease (SCTLD), which was first reported off the coast of Miami-Dade County in 2014. Because of the limited coral population in the Southeast Florida region, the authors and jurisdictional representatives decided that old mortality did not accurately indicate coral population status.

The Florida Keys



Map of sampling locations for all NCRMP and DRM missions 2014-2018 (shades of blue).

NCRMP and DRM sampling effort in the Florida Keys for coral demographic (Demo) and benthic assessment (LPI) surveys from 2014-2018.

Region	Year	NCRMP Demo Sites	DRM Demo Sites	NCRMP LPI Sites
The Florida Keys	2014	314	86	349
	2015	NA	129	NA
	2016	92	107	93
	2017	NA	18	NA
	2018	86	94	90

Datasets used to determine reference values and status values in the Florida Keys.

Indicator	Habitat type	Reference	Status
Coral cover	Patch reef	Historic data (1974-1999)	NCRMP 2018
	Bank reef	Historic data (1974-1999)	NCRMP 2016 + 2018
Macroalgae cover	Patch reef	CREMP 1996-1999	NCRMP 2016 + 2018
	Bank reef	CREMP 1996-1999	
CCA cover	NA	NCRMP 2014	NCRMP 2016 + 2018
Density	NA	DRM 2005-2007	NCRMP/DRM 2016-2018
Old mortality	NA	DRM 2005-2007	NCRMP/DRM 2016-2018

Coral cover

To create the coral cover reference value for the Florida Keys (FLK), coral cover values were included from 17 peer reviewed publications and the Florida CREMP data from 1996-1999 (see references). A total of 138 bank reef sites and 37 patch reef sites were reported.

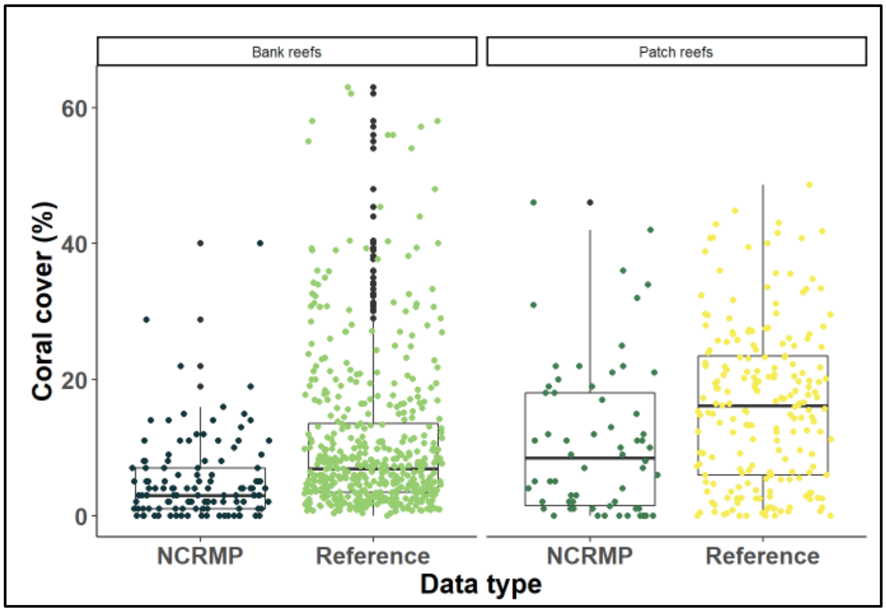
Survey sites from the scientific literature were assigned broad habitat categories that are consistent with the finer scale strata classifications used in Florida for the NCRMP years included in this status report. In the Florida Keys, 19 different habitats or reef zones were described, with patch reef, bank reef, deep reef, reef flat, and hardbottom as the most common. From these, it was determined that patch reef and bank reef were the most similar to the current strata used to classify the Florida Keys region. Reef imagery, habitat maps, and local expertise were consulted for classifications. To address both ecological differences and differences in anthropogenic stressors based on location along the Florida Reef Tract (FRT), the status NCRMP site level data were classified as either patch reef or bank reef based on their strata classification. All inshore, mid-channel and offshore patch reef sites were classified as patch reef and all shallow, medium depth, and deep linear forereefs as well as high relief reefs were classified as bank reefs (see table below). Patch and bank reefs were then scored separately and only compared to reference sites with the same habitat type classification. The scores for the habitat types were weighted by reef area and combined to produce the final indicator score for the region. This classification system was used for both coral cover and macroalgae cover in the FLK due to the data available.

Literature derived habitat classification for current NCRMP strata in the Florida Keys.

Literature derived habitat	**Current Florida Keys strata**
Hardbottom	Not applicable
Patch Reefs	Inshore patch reef (INPR) Mid channel patch reef (MCPR) Offshore patch reef (OFPR)
Reef flat	Not applicable
Bank reefs	Fore reef deep low relief (FDLR) Fore reef mid-channel linear relief (FMLR) Fore reef shallow linear reef (FSLR) High relief reef (HRRF; spur and groove)

Site level means of coral cover were calculated for each of the CREMP LTM sites. The reference value for each habitat type (bank reef or patch reef) was calculated as the mean and standard deviation of all sites. The combined NCRMP 2016 and 2018 data were used to create the status value for bank reefs, and the NCRMP 2018 data only were used to create the status values for patch reefs. While bank reefs in the Florida Keys experienced substantial declines in coral cover beginning in the late 1980s to early 1990s (Porter and Meier 1992, Ogden et al. 1994), up until recently patch reefs, particularly those offshore, have maintained a consistent coral cover. Between the 2016 to 2018 NCRMP sampling seasons, coral cover on patch reef habitats declined from 17% to 9%, potentially due to Stony Coral

Tissue Loss Disease (SCTLD). To capture this impact on the reef community, the authors used the 2018 data only to evaluate patch reefs.



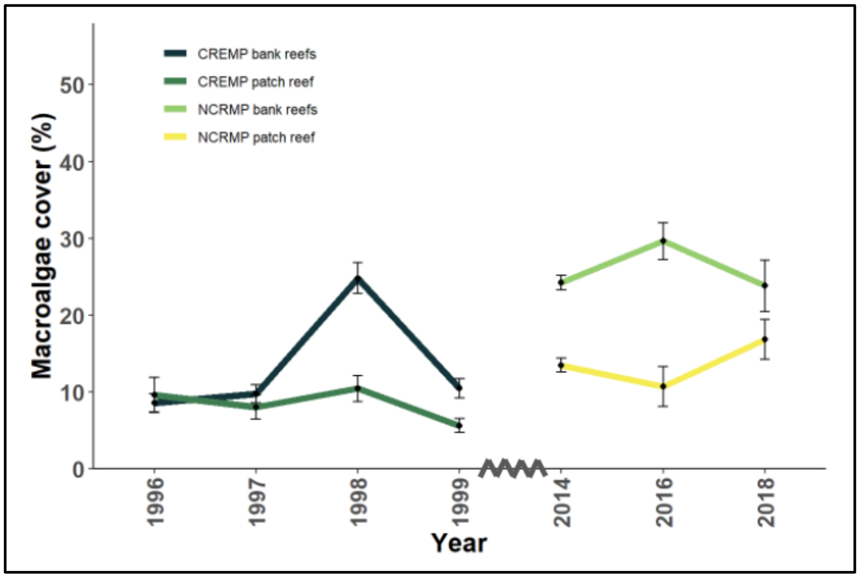
Box plots of the status NCRMP site level coral cover data and the literature-based reference data used for comparison for both bank reefs (left) and patch reefs (right). Upper and lower hinges correspond to the first and third quartiles, horizontal bars correspond to medians and whiskers extend to the highest and lowest values within 1.5 IQR (interquartile range). Data beyond whiskers are outliers represented as black dots.

Bank reef and patch reef scoring rubric based on p-values for coral cover in the Florida Keys.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.05	Very good
= 0	p > 0.05, not significant	Good
< 0	p < 0.05	Fair
< 0	p < 0.01	Impaired
< 0	p < 0.001	Critical

Macroalgae cover

The Florida CREMP data from 1996-1999 was used to create the macroalgae reference values for the Florida Keys. For each of the long-term monitoring sites, site level means from 1996-1999 were calculated. The reference values for each habitat type (bank reef or patch reef as described in the coral cover section) were calculated as the mean and standard deviation of all sites. The NCRMP 2016 and 2018 data were used to create the status values for macroalgae cover.



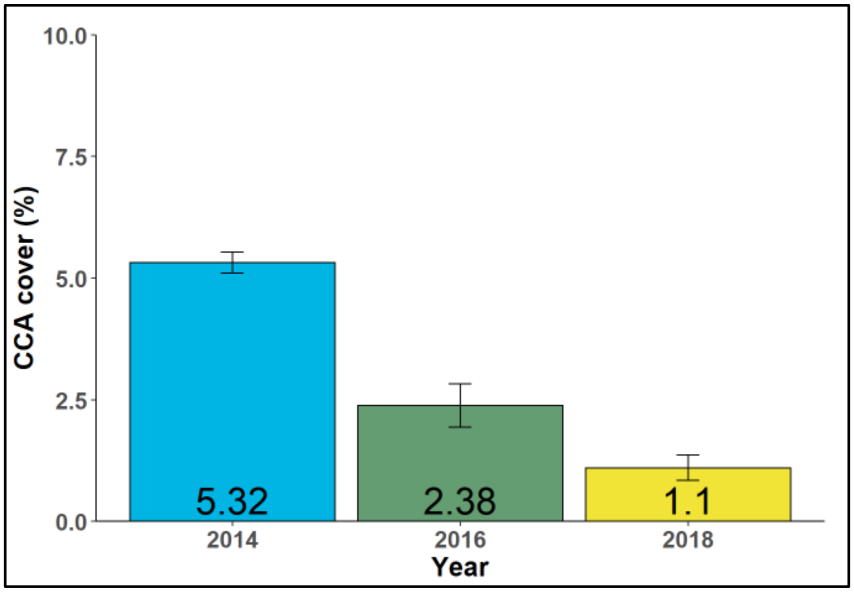
Mean macroalgae cover (±SE) for bank reefs (light green) and patch reefs (yellow) for the 3 NCRMP Florida Keys sampling missions and CREMP from 1996-1999 (patch reefs dark green, bank reefs black).

Bank reef and patch reef scoring rubric based on p-values for macroalgae cover in the Florida Keys.

Status Z score domain estimate in relation to zero	P value	Score
< 0	$p < 0.05$	Very good
= 0	$p > 0.05$, not significant	Good
> 0	$p < 0.05$	Fair
> 0	$p < 0.01$	Impaired
> 0	$p < 0.001$	Critical

CCA cover

In the absence of available historic literature or long-term monitoring data for the CCA cover indicator, the NCRMP 2014 data were used to create the reference value for CCA cover. The reference value and reference standard deviation were calculated as the mean and standard deviation of all sites. As there were no distinct trends in CCA cover between bank reefs and patch reefs and only NCRMP data were used for the analyses, the data were not broken into reef type categories. The NCRMP 2016 and 2018 data were used to create the status value for CCA cover.



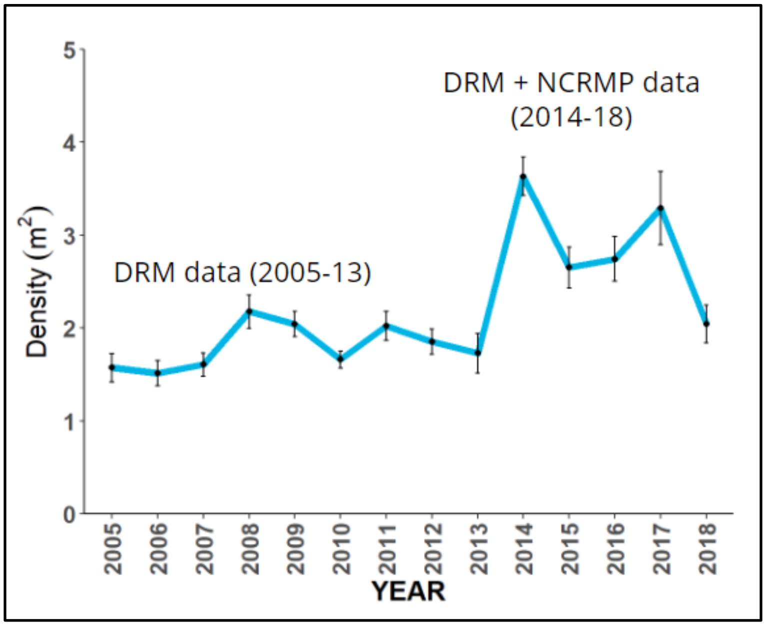
Mean CCA cover (±SE) for the 3 NCRMP Florida Keys sampling missions.

Scoring rubric based on p-values for CCA cover in the Florida Keys.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	$p < 0.05$	Very good
= 0	$p > 0.05$, not significant	Good
< 0	$p < 0.05$	Fair
< 0	$p < 0.01$	Impaired
< 0	$p < 0.001$	Critical

Adult coral density

DRM data from 2005-2007 were used to create the reference values for coral density. These years were selected because 2005 was the earliest sampling year and including 3 years gave a comparable sample size to the status value. The reference values and reference standard deviation were calculated as the mean and standard deviation of all sites. The combined NCRMP 2016 and 2018 data were used to create the status value for coral density. For both the reference and status values, a subset of coral species was used to focus on the density of species considered to have high ecological value by jurisdictional stakeholders. Selected coral species included the Endangered Species Act (ESA) listed corals *Acropora cervicornis, A. palmata, Orbicella annularis, O. faveolata,* and *O. franksi*, as well as the following additional coral species: *Colpophyllia natans, Diploria labyrinthiformis, Meandrina meandrites, Montastraea cavernosa, Porites porites, Pseudodiploria clivosa, P. strigosa, Siderastrea siderea,* and *Stephanocoenia intersepta.*



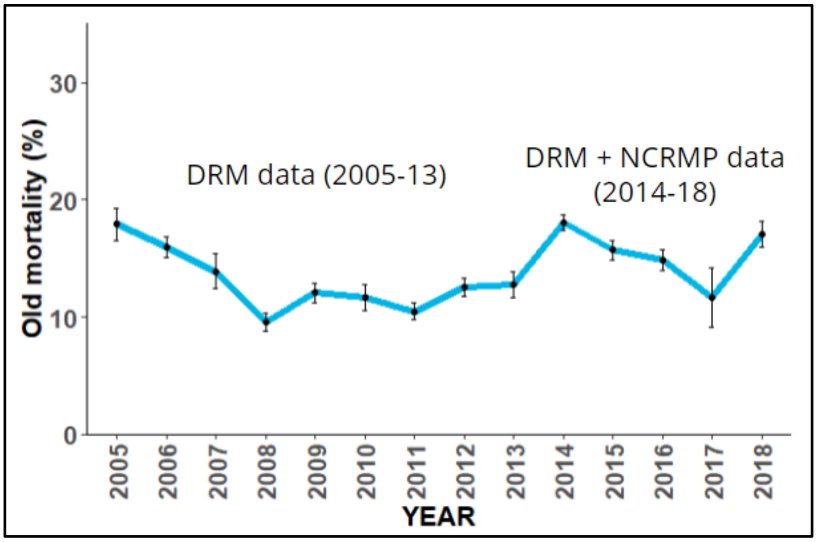
Mean coral density (∓SE) for select species from both DRM and NCRMP sampling efforts in the Florida Keys.

Scoring rubric based on p-values for coral density in Southeast Florida.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.001	Very good
> 0	p < 0.01	Good
> 0	p < 0.05	Fair
= 0	p > 0.05, not significant	Impaired
< 0	p < 0.05	Critical

Old mortality

The same subset of species used for coral density was used for old mortality, as was the same analytic approach.

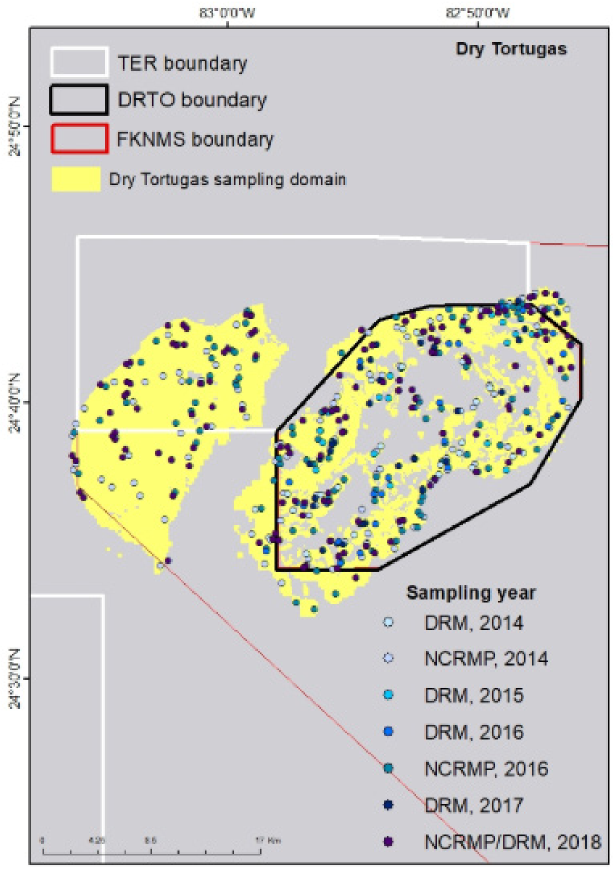


Mean old mortality (∓SE) for select species from both DRM and NCRMP sampling efforts.

Scoring rubric based on p-values for old mortality in the Florida Keys.

Status Z score domain estimate in relation to zero	**P value**	**Score**
< 0	$p < 0.01$	Very good
< 0	$p < 0.05$	Good
= 0	$p > 0.05$, not significant	Fair
> 0	$p < 0.05$	Impaired
> 0	$p < 0.01$	Critical

The Dry Tortugas



Map of sampling locations for all NCRMP and DRM missions 2014-2018 (shades of blue). Boundaries of the Florida Keys National Marine Sanctuary (FKNMS; red), the Tortugas Ecological Reserve (TER; white), and the Dry Tortugas National Park (DRTO; black).

NCRMP and DRM sampling effort in the Dry Tortugas for coral demographic (Demo) and benthic assessment (LPI) surveys. 2018 was a joint sampling year between NCRMP and DRM.

Year	NCRMP Demo Sites	DRM Demo Sites	NCRMP LPI sites
2014	105	29	106
2015	NA	20	NA
2016	98	29	98
2017	NA	31	NA
2018	139	NA	139

Datasets used to determine reference values and status values in the Dry Tortugas.

Indicator	Habitat type	Reference	Current
Coral cover	Mid-high relief reef	Historic data (1975-1999)	NCRMP 2016 + 2018
	Low relief reef	Historic data (1975-1999)	
Macroalgae cover	NA	NCRMP 2014	NCRMP 2016 + 2018
CCA cover	NA	NCRMP 2014	NCRMP 2016 + 2018
Density	NA	DRM 2007 + 2009	NCRMP/DRM 2016-2018
Old mortality	NA	DRM 2007 + 2009	NCRMP/DRM 2016-2018

Coral cover

To create the coral cover reference value for the Dry Tortugas, coral cover values were garnered from 4 peer reviewed publications and the Florida CREMP data from 1996-1999 (see references). A total of 47 mid to high relief reef sites and 31 low relief reef sites were reported.

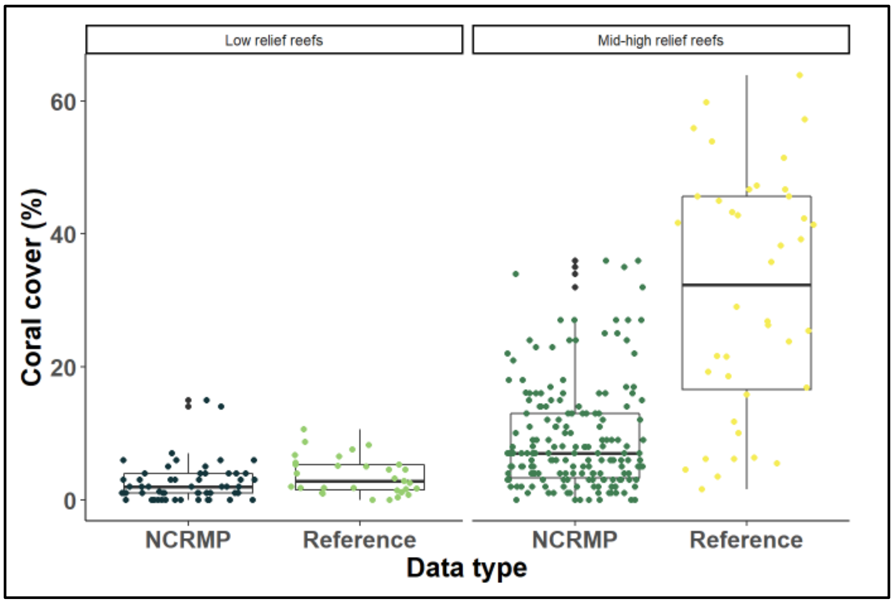
In the Dry Tortugas, a similar classification scheme as the Flordia Keys was used, however, the predominant habitat types in the historic scientific literature were based on reef relief. Status NCRMP site level data with the NCRMP strata classifications of mid or high relief contiguous reef, mid or high relief isolated patch reef, or high relief spur and groove reef were given the habitat classification of mid-high relief, while sites with the NCRMP strata classifications of low relief contiguous reef, low relief isolated patch reefs or low relief spur and groove reef were given the habitat classification of low relief (see table below). High relief reefs and low relief reefs were scored separately and only compared to reference sites with the same habitat type classification. The scores for the habitat types were weighted by reef area and combined to produce the final indicator score for the region. This classification system was used for the coral cover only in the Dry Tortugas based on data available.

Literature derived habitat classification for current NCRMP strata in the Dry Tortugas.

Literature derived habitat	**Current Dry Tortugas strata**
High/Mid/Mixed	Continuous high relief reef (CONT_HR) Continuous mid-relief reef (CONT_MR) Isolated high relief reef (ISOL_HR)

	Isolated mid relief reef (ISOL_MR) Spur and groove high relief reef (SPGR_HR)
Low	Continuous low relief reef (CONT_LR) Isolated low relief reef (ISOL_LR) Spur and groove low relief reef (SPGR_LR)

Site level means of coral cover were calculated for each of the CREMP LTM sites. The reference value for each habitat type (mid-high relief or low relief) was calculated as the mean and standard deviation of all sites. The combined NCRMP 2016 and 2018 data were used to create the status values for coral cover.



Box plots of the status NCRMP site level coral cover data and the literature-based reference data used for comparison for both low relief reefs (left) and high relief reefs (right). Upper and lower hinges correspond to the first and third quartiles, horizontal bars correspond to medians and whiskers extend to the highest and lowest values within 1.5 IQR (interquartile range). Data beyond whiskers are outliers represented as black dots.

Mid-high relief reefs scoring rubric based on p-values for coral cover in the Dry Tortugas.

Status Z score domain estimate in relation to zero	P value	Score
= 0	p > 0.05, not significant	Very good
< 0	p < 0.05	Good
< 0	p < 0.01	Fair

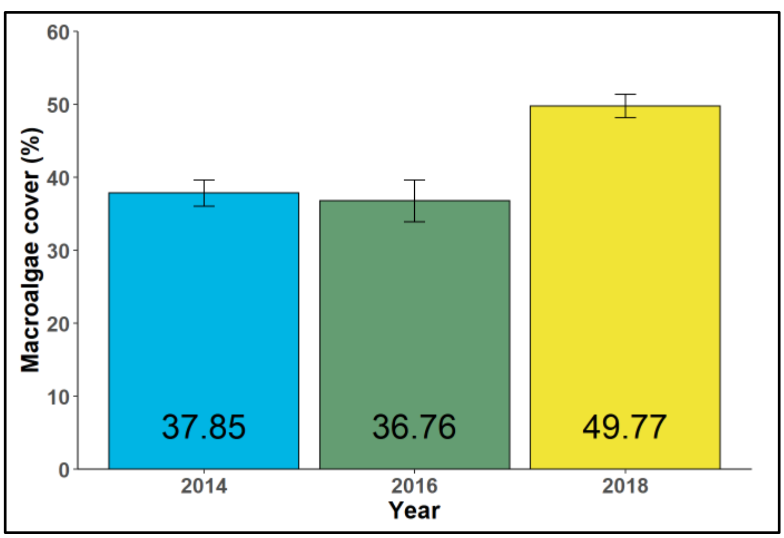
< 0	p < 0.001	Impaired
< 0	p < 0.0001	Critical

Low relief reefs scoring rubric based on p-values for coral cover in the Dry Tortugas.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.05	Very good
= 0	p > 0.05, not significant	Good
< 0	p < 0.05	Fair
< 0	p < 0.01	Impaired
< 0	p < 0.001	Critical

Macroalgae cover

In the absence of available historic literature or long-term monitoring data for the CCA cover indicator, the NCRMP 2014 data were used to create the reference value for macroalgae cover. The reference value and reference standard deviation were calculated as the mean and standard deviation of all sites. As there were no distinct trend in macroalgae cover between mid-high relief reefs and low relief reefs and only NCRMP data were used for the analyses, the data were not broken into reef type categories. The NCRMP 2016 and 2018 data were used to create the status value for macroalgae cover.



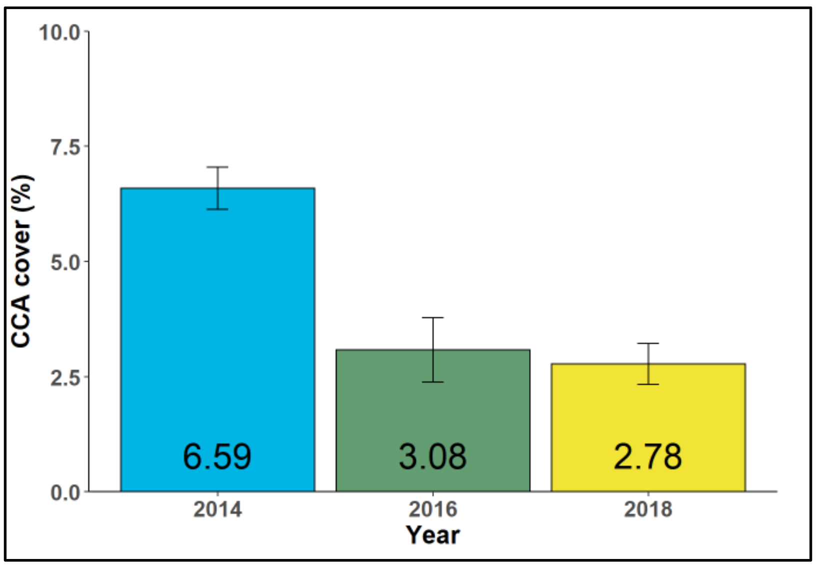
Mean macroalgae cover (∓SE) for the NCRMP Dry Tortugas sampling missions.

Scoring rubric based on p-values for macroalgae cover in the Dry Tortugas.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.001	Very good
> 0	p < 0.01	Good
> 0	p < 0.05	Fair
= 0	p > 0.05, not significant	Impaired
< 0	p < 0.05	Critical

CCA cover

Analyses of the CCA cover status indicator were conducted consistently with analyses of the macroalgae cover status indicator for the Dry Tortugas.



Mean CCA cover (±SE) for the NCRMP Dry Tortugas sampling missions.

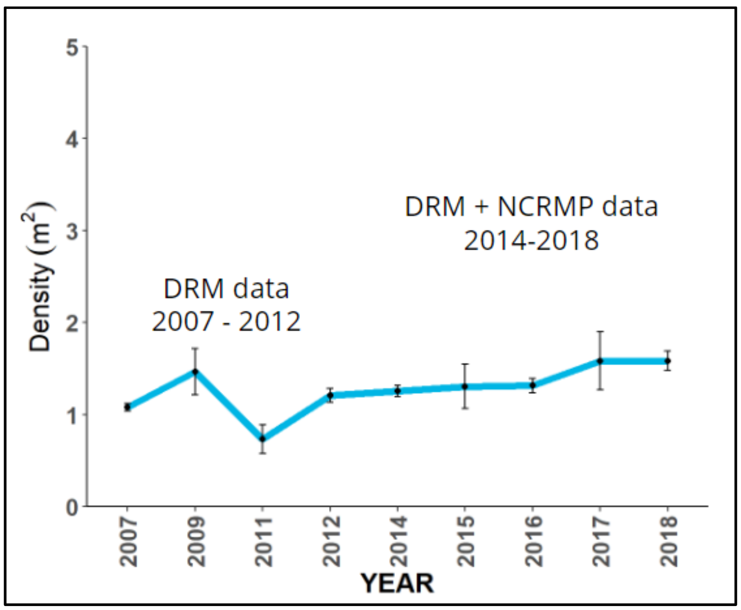
Scoring rubric based on p-values for CCA cover in the Dry Tortugas.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.05	Very good
= 0	p > 0.05, not significant	Good
< 0	p < 0.05	Fair

< 0	p < 0.01	Impaired
< 0	p < 0.001	Critical

Adult coral density

DRM data from 2007 and 2009 were used to create the reference values for coral density. These years were selected because 2009 was the earliest sampling year and including 2 years gave a comparable sample size to the status value. The reference values and reference standard deviation were calculated as the mean and standard deviation of all sites. The combined NCRMP 2016 and 2018 data were used to create the status value for coral density. For both the reference and status values, a subset of species was used to focus on the density of species with high ecological value and remove weedy species. The species selected were determined with input from jurisdictional stakeholders and included the Endangered Species Act (ESA) listed corals: *Acropora cervicornis, A. palmata, Orbicella annularis, O. faveolata,* and *O. franksi*, as well as the following additional coral species: *Colpophyllia natans, Diploria labyrinthiformis, Meandrina meandrites, Montastraea cavernosa, Porites porites, Pseudodiploria clivosa, P. strigosa, Siderastrea siderea,* and *Stephanocoenia intersepta.*



Mean coral density (∓SE) for select species from both DRM and NCRMP sampling efforts in the Dry Tortugas.

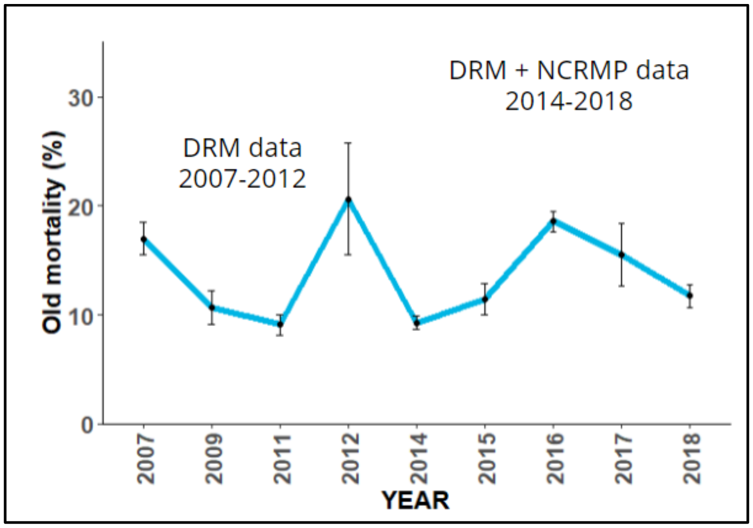
Scoring rubric based on p-values for coral density in the Dry Tortugas.

Status Z score domain estimate in relation to zero	**P value**	**Score**
> 0	p < 0.01	Very good
> 0	p < 0.05	Good

= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Old mortality

The same subset of species and analytic approach used for coral density was used for old mortality.



Mean old mortality (∓SE) for select species from both DRM and NCRMP sampling efforts in the Dry Tortugas.

Scoring rubric based on p-values for old mortality in the Dry Tortugas.

Status Z score domain estimate in relation to zero	**P value**	**Score**
< 0	p < 0.01	Very good
< 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
> 0	p < 0.05	Impaired
> 0	p < 0.01	Critical

References used to create the cover indicator baselines in Florida (see Florida references for full citations).

Reference	**Florida region(s)**
Alevizon and Porter 2014	Florida Keys
Antonius et al. 1978	Florida Keys
Aronson et al. 1994	Florida Keys
Blair and Flynn 1989	Southeast Florida
Bohnsack et al. 2002	Florida Keys
Burns 1985	Florida Keys
Dustan 1985	Dry Tortugas
Dustan and Halas 1987	Florida Keys
Glynn et al. 1989	Florida Keys
Hocevar 1993	Southeast Florida
Jaap 1978	Florida Keys
Jaap et al. 1989	Dry Tortugas
Murdoch and Aronson 1999	Florida Keys, Dry Tortugas
Porter et al. 1982	Dry Tortugas
Porter and Meier 1992	Florida Keys
Voss 2002	Florida Keys
White and Porter 1985	Florida Keys

IV.II Fish indicators

IV.II.I Indicators overview

The following indicators were selected to assess the fish communities of the Atlantic jurisdictions: reef fish (fishery target juvenile density, fishery target adult density, regionally specific fish density subset), diversity (richness), and sustainability. These indicators were selected because they represent the major components of fish community status and can be reliably measured over time using the NCRMP field methodologies. Individual diver reef fish data were averaged at each survey site, which were weighted to produce domain wide fish metric estimates.

Detailed field and sampling methodologies can be found here: https://coastalscience.noaa.gov/project/national-coral-reef-monitoring-program-biological-socioeconomic/

IV.II.II Reef fish

The reef fish indicator is a measure of amount of the fish present. The metric measured for this indicator was fish density. Fish density was defined as number of individuals per belt-transect (Gulf of Mexico) or average number of individuals per unit area (SSU) for RVC surveys (all other jurisdictions). In each sampling domain, fish densities were estimated for three fish species subsets: 1.) fishery target adult density; 2.) fishery target juvenile density, and, 3.) an additional fish density that varied by jurisdiction (ornamentals, herbivores, or parrotfishes; table below). Targeted fishery adults and juveniles were separated based on regionally published length-at-maturity (L_m) data and the additional density category was selected based on either published reports, regional management, or input from fish experts during the in-person status report meetings. Further descriptions of subset compositions are in the jurisdictional sections below.

Fish subset types used for density calculations for each sampling domain in the four Atlantic basin jurisdictions.

Jurisdiction	**Sampling Domain**	**Subset 1**	**Subset 2**	**Subset 3**
Florida	Dry Tortugas	fishery target adults	fishery target juveniles	ornamentals
Florida	Florida Keys	fishery target adults	fishery target juveniles	ornamentals
Florida	Southeast Florida	fishery target adults	fishery target juveniles	ornamentals
Gulf of Mexico	Flower Garden Banks	fishery target adults	fishery target juveniles	herbivores
Puerto Rico	Puerto Rico	fishery target adults	fishery target juveniles	parrotfishes

US Virgin Islands	St. John/St. Thomas	fishery target adults	fishery target juveniles	parrotfishes
US Virgin Islands	St. Croix	fishery target adults	fishery target juveniles	parrotfishes

IV.II.III Diversity

Species richness, or alpha diversity, is defined as the average number of unique fish species observed in each SSU in each sampling domain between reference and status years. This simple biodiversity metric does not consider abundance or species proportionality; it is, however, intuitive and easy to interpret. Small (i.e., gobies and blennies) and cryptic species were removed due to high levels of inconsistent reporting and potential misidentification amongst divers. If included, these fishes can result in a misrepresentation of the final score. All other community fish species were included. A complete list of species used in richness calculation can be found in Appendix A.

IV.II.IV Sustainability

Fisheries managers have defined sustainability in multiple ways. Generally, sustainability describes fish populations that remain constant over time (non-declining). Recreational and commercial fishers target sustainable fish populations, however, the fish landed are comprised of surplus production. As a result, fish are removed at a rate that ensures production levels and fisheries opportunities are maintained for the future. Calculated by sampling domain, sustainability was objectively defined using fisheries statistics where sustainability (*Sus*) equals the fishing mortality rate (*F*) divided by the natural mortality rate (*M*); *Sus = F/M*. Standard fisheries statistics used to derive estimates of survivorship included the Von Bertalanffy growth function, Beverton-Holt mean length mortality estimator, natural mortality estimator, and fishing mortality estimator (see below). To mitigate any *Z* biases that can be produced by Beverton-Holt (Ehrhardt and Ault, 1992) the selected fish species were restricted to <5% difference between L_λ and L_∞ (Vaughan, 2016).

Von Bertalanffy growth function $$L = L_\infty\left(1 - exp^{-K(a-a_0)}\right)$$

Beverton-Holt mean length mortality estimator $$Z = \frac{K(L_\infty - \bar{L})}{\bar{L} - L_c}$$

Lifespan based natural mortality estimator $$M = \frac{-\ln(0.05)}{a_\lambda}$$

Fishing mortality rate $$F = Z - M$$

Survivorship as ratio of fishing to natural mortality $$S = \frac{F}{M}$$

Species included in the sustainability metric varied by region and subregion. To be included in the calculation, a species had to have > 1% occurrence at the domain level (> 5% in Flower Garden Banks) and have published life history parameters and be part of the recreational or commercial fishery. A sustainability metric is calculated for each species separately, and then all fish for that region averaged for a final value.

IV.II.V Methods overview

For diversity and reef fish metrics, site level means were aggregated into strata level means, weighted by strata area, and summed to calculate the sampling domain estimates (status area estimates, Smith et al. 2011). Sampling domain estimates were calculated for each of the three Florida regions (Dry Tortugas, Florida Keys, and Southeast Florida), each of the two U.S. Virgin Islands regions (St. Thomas/St. John and St. Croix) and for Puerto Rico. In the Gulf of Mexico, the Flower Garden Banks monitoring data only has one strata and as a result, weighting was not required to produce domain estimates and the standardization described below was unnecessary. All other Z-score calculations and comparisons are applicable.

A standardized approach using Z-scores values was used to compare NCRMP domain estimates (status values) to indicator- and region-specific reference values. All observations, at the SSU level, were standardized to into six categories that included two depths (< 12 m and ≥ 12 m) and three rugosities (< 0.3 m, ≥ 0.3 – 0.7 m, and ≥ 0.7 m). This standardization aimed to remove the effect of habitat on the fish indicator metrics between the reference area and sampling domain. As such, sampling domains were not penalized for having a different habitat composition compared to the selected reference area. Reference time periods and areas were selected with input from jurisdictional stakeholders and consisted of long-term National Centers for Coastal Ocean Science (NCCOS) and Southeast Fisheries Science Center (SEFSC) RVC monitoring data, or recent NCRMP sampling data. In most cases, status values were calculated by taking the combined strata area-weighted domain estimate for the one or two most recent sampling years. The site level status values were first transformed to Z scores using the following equation:

Z score = (status observation value - reference mean value)/ standard deviation of reference value

A domain estimate Z score was calculated by taking the mean of the site level Z scores. A reef area weighting scheme was applied where applicable. The status Z score value was then compared to the reference Z score value (zero) using a Student's T-test. A scoring rubric based on levels of significance (*p* values) was created to test statistical similarity for each metric between the reference area and sampling domain.

Why the different scores (Very good - Critical) for non-significance T-test

Generally, a non-significant Student's T-test (Reference Z = 0) was regionally and metric dependent, where a non-significant test was either scored as 'good' or 'fair'. In all Florida jurisdictions and Flower Garden Banks, a non-significant T-test was considered 'good', while in the U.S. Virgin Islands and Puerto Rico, a non-significant T-test was considered 'fair'. These differences were due to the regionally specific chosen reference areas. The ideal reference area would be one that is large enough in spatial scale to encompass representative habitats and depths, have sufficient sampling, and, perhaps most importantly, an area that is unaffected by anthropogenic forces, including fishing pressure and land-based sources of pollution or runoff, among other factors. Most often, a region does not have an ideal reference area and therefore, expert opinion from NCRMP, jurisdictional scientists, and managers were used to choose the best possible reference area. This led to some subjectivity when determining the scoring rubric. Careful consideration was given to the reference area in each region, and for each metric, when determining the final score (for non-significance) and depended on how well the reference area fit our 'ideal'.

For sustainability ($Sus = F/M$), each sampling domain was scored on a 1 to 5 scale. A sustainability score of 1 was considered very good, and ≥ 5 was critical. These scores were assigned based on general fisheries statistics where if $F=M$ then the fishing mortality rate is approximately at maximum sustainable yield (MSY). Therefore, a ratio of 1 indicates that the fishing mortality or observed (F) is equal to the fishing mortality rate at maximum sustainable yield (F_{MSY}). A ratio above 1 indicates that $F > F_{MSY}$ which is not sustainable (Ault et al. 2014).

See individual jurisdictions sections for specific methods, datasets used, levels of significance (for Z scores), and results.

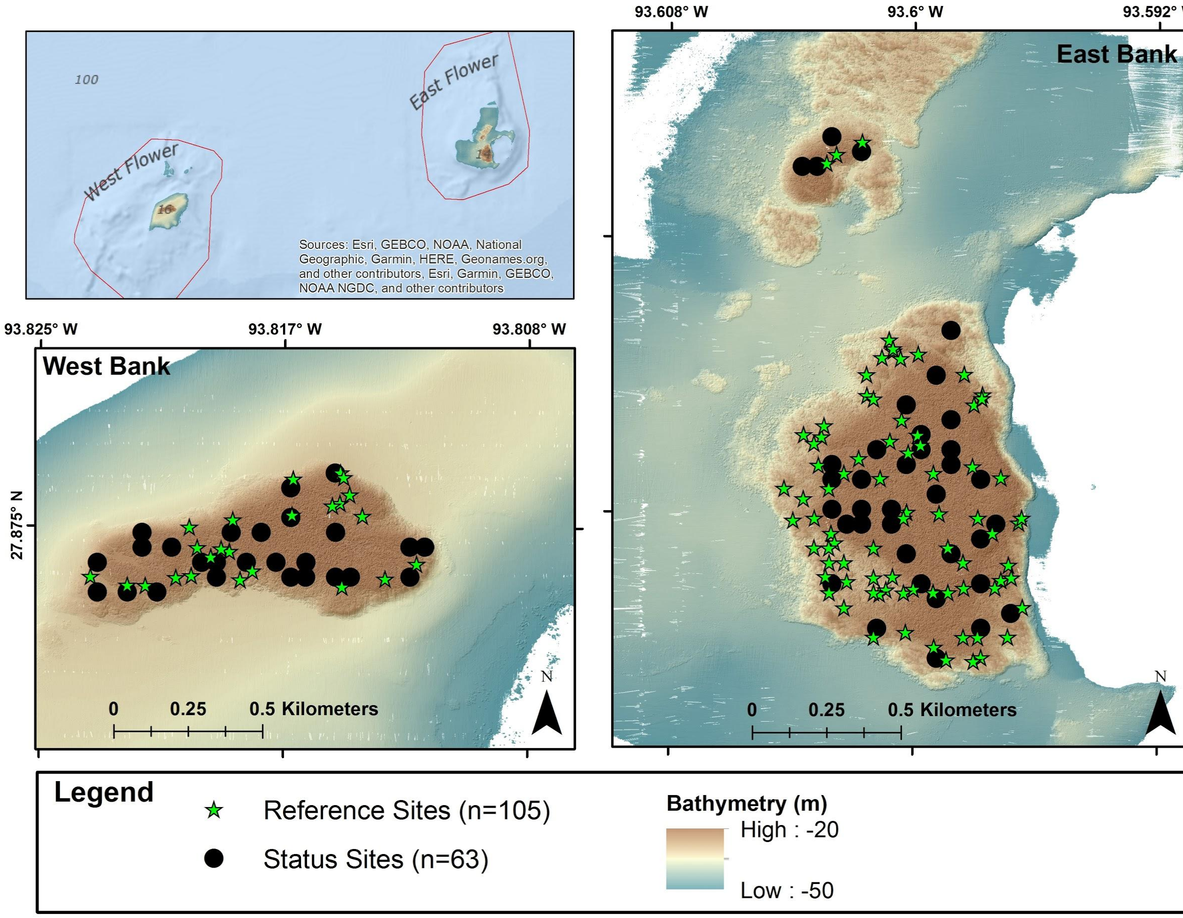
IV.II.VI Flower Garden Banks

Fish were surveyed throughout the East and West banks of the Flower Garden Banks National Marine Sanctuary (FGBNMS) from 2006 to 2012 by NCCOS and in 2013, 2015, and 2018 by NCRMP. All fish surveys were completed using the belt-transect methodology except for the most recent 2018 sampling year that used RVC methods. Future NCRMP surveys will continue to use RVC fish survey methods.

In FGBNMS, uniform habitat and low samples sizes by year prevented the selection of a discrete reference area within the larger FGBNMS (East and West banks). To address this issue, complete annual reef-wide surveys were compared between reference and status years to assess temporal change. A single year of RVC data in this region prevented the use of these data for richness and density indicator metrics; however, these most recent data were used to calculate a single year snapshot for the sustainability metric. The table below describes the reference and status years and the map shows the locations and number of fish sites for each of the years.

Datasets used to determine reference values and status values for the Flower Gardens Bank. Density indicator refers to targeted adult, targeted juvenile and herbivore species subsets.

Indicator	Reference Years	Reference Area	Status Year	Status Area	Survey Method
Density	2006 & 2007	East & West Bank	2015	East & West Bank	belt-transect
Richness	2006 & 2007	East & West Bank	2015	East & West Bank	belt-transect
Sustainability	n/a	n/a	2018	East & West Bank	RVC



Sampling locations of reference sites and status sites sampled on both East and West Flower Gardens Bank.

In the FGBNMS, fish experts and partners identified the reference years as 'good' based on CRCP's status metric definitions. The following rubric was used to compare Z-scores between the reference and status years.

Fish metric scoring rubric for Flower Gardens Bank.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.05	Very good
= 0	p > 0.05, not significant	Good
< 0	p < 0.05	Fair
< 0	p < 0.01	Impaired

< 0	$p < 0.001$	Critical

Reef fish

Three fish species subsets were used to calculate fish density: 1.) Fishery target adult density; 2.) Fishery target juvenile density; and, 3.) Herbivore density. Targeted fishery adults and juveniles used in Flower Garden Banks analyses are below. Juveniles were smaller than length-at-maturity (L_m) and adults were ≥ L_m. L_m is reported in cm.

Species list used in target density calculations for Flower Garden Banks. Length at maturity parameters (Stevens et al. 2019).

Common Name	*Scientific Name*	*Lm(cm)*
Gray triggerfish	*Balistes capriscus*	21
Mutton snapper	*Lutjanus analis*	32
Red snapper	*Lutjanus campechanus*	46
Cubera snapper	*Lutjanus cyanopterus*	54
Gray snapper	*Lutjanus griseus*	23
Dog Snapper	*Lutjanus jocu*	48
Black grouper	*Mycteroperca bonaci*	83
Yellowmouth grouper	*Mycteroperca interstitialis*	42
Scamp	*Mycteroperca phenax*	33
Tiger grouper	*Mycteroperca tigris*	34
Yellowfin grouper	*Mycteroperca venenosa*	54
Yellowtail snapper	*Ocyurus chrysurus*	23
Barracuda	*Sphyraena barracuda*	80

Herbivore density was selected as the indicator metric because it is was identified as valuable by partners and included in the FGBNMS annual monitoring reports (e.g., Johnston et al. 2018). The list of herbivores used in the analysis are below.

Species list used in Herbivore density calculations for Flower Garden Banks.

Common Name	**Scientific Name**
Doctorfish	*Acanthurus chirurgus*
Blue Tang	*Acanthurus coeruleus*
Ocean surgeonfish	*Acanthurus tractus*
Goldspot goby	*Gnatholepis thompsoni*
Yellow Chub	*Kyphosus incisor*
Bermuda Chub	*Kyphosus sectatrix*
Black Durgon	*Melichthys niger*
Yellowtail Damselfish	*Microspathodon chrysurus*
Redlip blenny	*Ophioblennius macclurei*
Striped Parrotfish	*Scarus iseri*

Princess parrotfish	*Scarus taeniopterus*
Queen Parrotfish	*Scarus vetula*
Greenblotch parrotfish	*Sparisoma atomarium*
Redband Parrotfish	*Sparisoma aurofrenatum*
Stoplight Parrotfish	*Sparisoma viride*
Dusky Damselfish	*Stegastes adustus*
Longfin Damselfish	*Stegastes diencaeus*
Bicolor Damselfish	*Stegastes partitus*
Cocoa Damselfish	*Stegastes variabilis*

Sustainability

All fish species included in the sustainability estimates are targeted fisheries species that have known length-at-capture (L_c) sizes reported as fork length in cm. To be included in the final sustainability analysis fish needed to have > 5% occurrence (equivalent of three individual fish).

Species list for sustainability calculations for Flower Garden Banks. Length at capture parameters (Stevens et al. 2019).

Common Name	**Scientific Name**	**Lc**
Gray snapper	*Lutjanus griseus*	24
Dog Snapper	*Lutjanus jocu*	29
Black grouper	*Mycteroperca bonaci*	60
Yellowmouth grouper	*Mycteroperca interstitialis*	47
Barracuda	*Sphyraena barracuda*	23

IV.II.VII Puerto Rico

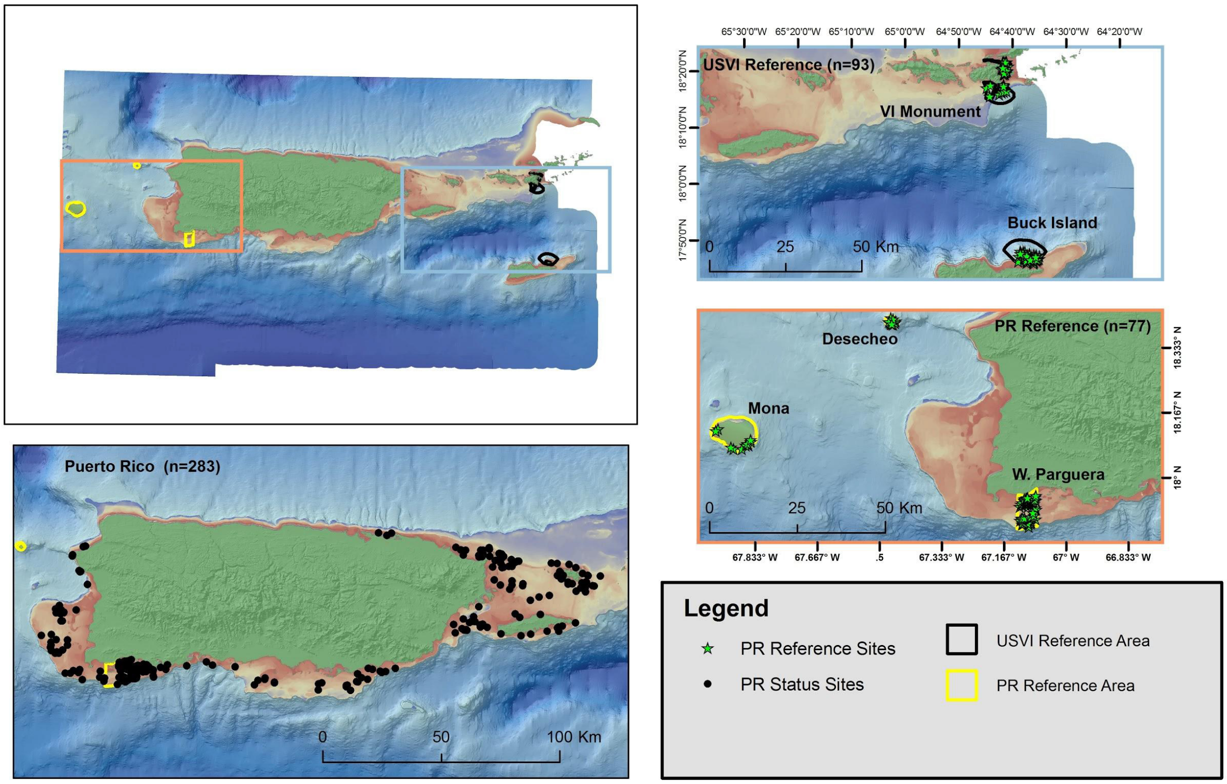
Fish were surveyed throughout Puerto Rico in 2016 as part of NCRMP. Prior to implementation of NCRMP, NCCOS surveyed targeted areas of Puerto Rico since 2000, using a different field sampling methodology (belt transects). In 2018, an additional project began to calibrate the historical belt transect data to the newer NCRMP method to allow for analysis of long-term trends. The calibration study sampled sites using both the belt transect and NCRMP stationary point count method simultaneously. This status report will include data collected in 2016 and only those samples collected in 2018 using the current NCRMP methodologies (RVC).

The reference area in Puerto Rico was initially selected by local stakeholders, partners, and fish experts in the region. A collection of smaller areas was chosen because Puerto Rico does not have a large, well-established and enforced marine protected area suitable for use as a reference. Originally, areas around the island of Mona and Desecheo and the western portion of La Parguera reserve were chosen because, together, they contain all the habitats and depths needed to properly compare against the status sites. Additionally, these areas had moderate levels of protection due to their relative remoteness or as a designated protected area. However, initial analysis showed these local reference areas were highly impacted by fishing (Smith TIPP report data) and may not have been the most representative habitat and depths needed to properly compare to the status sites. Following another discussion among experts and stakeholders, the decision was made to use the three reference areas in Puerto Rico (Mona, Desecheo, and W. La Parguera) as well as reference areas chosen for the U.S. Virgin Islands status report. In the U.S. Virgin Islands, two areas were chosen as the reference areas, Buck Island Reef National Monument in St. Croix and the Virgin Islands Coral Reef Monument in St. John. Both areas have been protected areas managed under the National Park system since 1983 and 2001, respectively. The final reference metrics were then calculated as averages between the Puerto Rican and Virgin Island reference areas. In the end, this approach allowed for local Puerto Rican areas to be included as part of the final reference, but also have long-standing, federally managed, and enforced reference areas included.

Status sites were used from data collected in the 2016 NCRMP mission (map and table). 283 sites were sampled in Puerto Rico from representative strata, consisting of a mix of habitat types and depths.

The table below describes the reference and status years. The figure below shows the locations and number of fish sites for each of the years. Puerto Rico reference refers to La Parguera, Mona, and Desecheo and U.S. Virgin Islands reference refers to Buck Island and VICR.

Indicator	**Reference Years**	**Reference Area**	**Status Year**	**Status Areas**
Density	2016 & 2018 2017	PR reference USVI reference	2016	PR domain-wide
Richness	2016 & 2018 2017	PR reference USVI reference	2016	PR domain-wide
Sustainability	n/a	n/a	2016	PR domain-wide



Sampling locations of reference sites and status sites sampled in Puerto Rico.

In Puerto Rico, fish experts and partners identified the reference years as 'fair' based on CRCP's status metric definitions. The following rubric was used to compare Z-scores between the reference and status years.

Fish metric scoring rubric for Puerto Rico.

Status Z score domain estimate in relation to zero	P value	Score
> 0	p < 0.01	Very good
> 0	p < 0.05	Good
= 0	p > 0.05, not significant	Fair
< 0	p < 0.05	Impaired
< 0	p < 0.01	Critical

Reef fish

Three fish species subsets were used to calculate fish density: 1.) Fishery target adult density; 2.) Fishery target juvenile density; and, 3.) Parrotfish density. Target species were selected based on multiple criteria, including commercial and local importance as well as published data on species specific life history parameters, specifically, length at maturity (Stevens et al. 2019). Juveniles were smaller than length-at-maturity (L_m) and adults were ≥ L_m. L_m is reported in cm. A subset of parrotfish species was selected as an indicator by fish experts, partners, and stakeholders during initial development of status metrics. Specifically, large-bodied parrotfish were used because of their role in the coral reef ecosystem and because they are targeted by both the commercial and recreational fishery.

Species list used in target density calculations for Puerto Rico. Length at maturity (L_m) parameters (Stevens et al. 2019).

Common Name	**Scientific Name**	**Lm**
Gray triggerfish	*Balistes capriscus*	21
Red grouper	*Epinephelus morio*	29
Hogfish	*Lachnolaimus maximus*	18
Mutton snapper	*Lutjanus analis*	32
Schoolmaster snapper	*Lutjanus apodus*	25
Blackfin snapper	*Lutjanus buccanella*	24
Cubera snapper	*Lutjanus cyanopterus*	54
Gray snapper	*Lutjanus griseus*	23
Dog Snapper	*Lutjanus jocu*	48
Lane snapper	*Lutjanus synagris*	24
Black grouper	*Mycteroperca bonaci*	83
Yellowmouth grouper	*Mycteroperca interstitialis*	42
Gag grouper	*Mycteroperca microlepis*	54
Scamp	*Mycteroperca phenax*	33
Yellowfin grouper	*Mycteroperca venenosa*	54
Yellowtail snapper	*Ocyurus chrysurus*	23
Red porgy	*Pagrus pagrus*	20
Great barracuda	*Sphyraena barracuda*	80

Parrotfish species list used in parrotfish density calculations for Puerto Rico.

Common Name	**Scientific Name**
Midnight	*Scarus coelestinus*
Blue	*Scarus coeruleus*
Rainbow	*Scarus guacamaia*
Striped	*Scarus iseri*
Princess	*Scarus taeniopterus*
Queen	*Scarus vetula*
Redband	*Sparisoma aurofrenatum*
Redtail	*Sparisoma chrysopterum*
Yellowtail	*Sparisoma rubripinne*

Stoplight	*Sparisoma viride*

Sustainability

All fish species included in the sustainability estimates are targeted fisheries species that have known length-at-capture (L_c) sizes reported as fork length in cm. All life history parameters came from Caribbean sampled species when possible; otherwise, Florida parameters were used as proxies. To be included in the final sustainability analysis, fish needed to have > 1% occurrence at the domain level.

Species list for sustainability calculations for Puerto Rico. Length at capture parameters (Stevens et al. 2019, Ault et al. 2008).

Region	**Common Name**	**Scientific Name**	**Lc**
Puerto Rico	Queen Triggerfish	*Balistes vetula*	29
Puerto Rico	Coney	*Cephalopholis fulva*	20
Puerto Rico	Red Hind	*Epinephelus guttatus*	21
Puerto Rico	White Grunt	*Haemulon plumierii*	17
Puerto Rico	Bluestriped Grunt	*Haemulon sciurus*	19
Puerto Rico	Hogfish	*Lachnolaimus maximus*	25
Puerto Rico	Mutton snapper	*Lutjanus analis*	22
Puerto Rico	Schoolmaster snapper	*Lutjanus apodus*	22
Puerto Rico	Gray snapper	*Lutjanus griseus*	23
Puerto Rico	Dog Snapper	*Lutjanus jocu*	23
Puerto Rico	Lane snapper	*Lutjanus synagris*	17
Puerto Rico	Yellowtail snapper	*Ocyurus chrysurus*	23

IV.II.VIII U.S. Virgin Islands

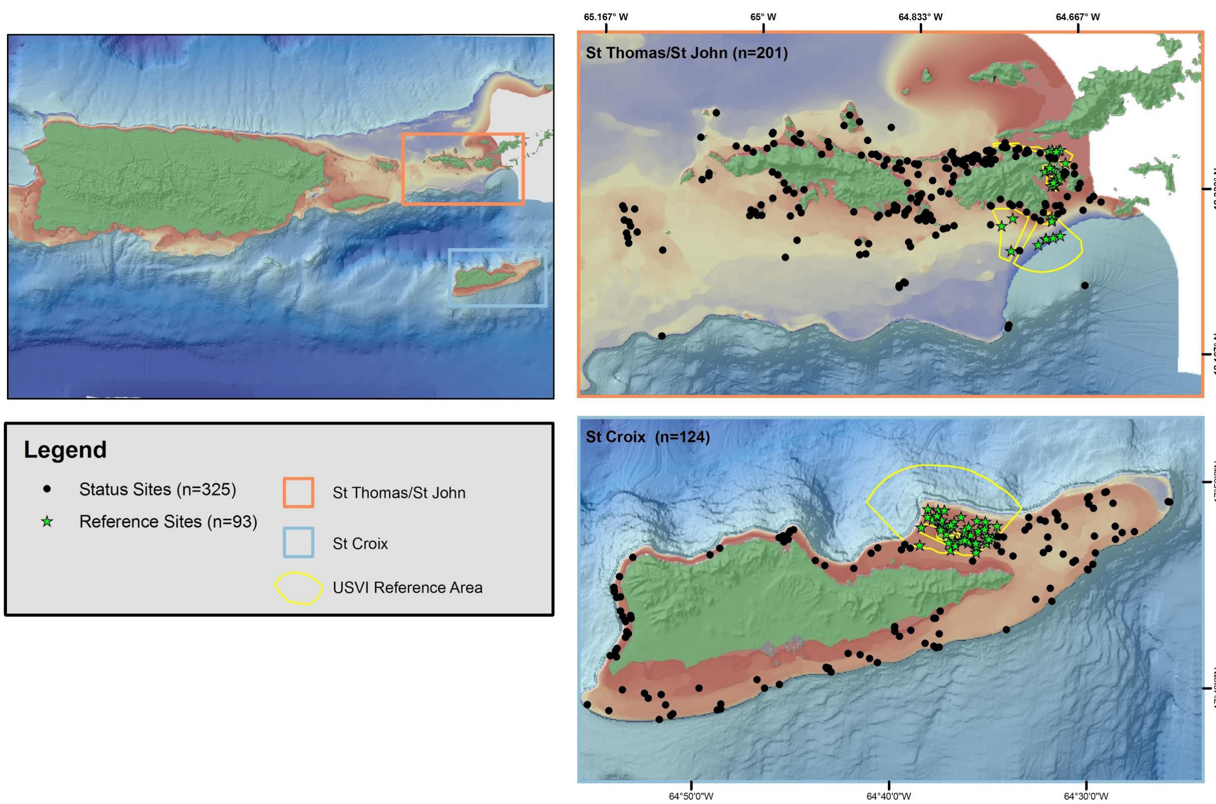
Fish were surveyed in both status and reference areas in 2017 using current NCRMP methodologies. Although, NCRMP officially began sampling in USVI in 2015 and NCCOS collected data earlier, this status report only uses RVC data collected in 2017 due to different sampling methods (belt transects) used prior to 2017. All data were collected prior to Hurricanes Irma and Maria, which devastated the U.S. Virgin Islands (USVI).

Local stakeholders, managers, and scientists selected reference areas in the USVI. A single, combined, reference area from both St Croix and St John was selected: in St. Croix, Buck Island Reef National Monument (BIRNM), and in St. John, the Virgin Islands Coral Reef National Monument (VICRNM). BIRNM is a federal national park that has been under protection since 1983 and the VICRNM is a federally managed marine area that has been under protection since 2001. Both BIRNM and the VICRNM are no-take reserves (with a small exception in the VICRNM), with no anchoring. Both reference areas contain all the habitats and depths needed to compare to the rest of the status sites on the Virgin Islands. St. Croix and St. Thomas/St. John regions were assessed against the reference separately then rolled up to the U.S. Virgin Island level.

Status sites were used from data collected in the 2017 NCRMP mission (map and table). 325 sites were sampled in the US Virgin Islands (STT/STJ = 201, STX = 124) from representative strata, consisting of a mix of habitat types and depths.

The table below describes the reference and status years and the figure shows the locations and number of fish sites for each of the years. Abbreviations include St. Thomas (STT), St. John (STJ), St. Croix (STX), Buck Island (BI), and Virgin Islands Coral Reef National Monument (VICR).

Indicator	Reference Years	Reference Area	Status Year	Status Areas
Density	2017	BI & VICR	2017	STT/STJ & STX
Richness	2017	BI & VICR	2017	STT/STJ & STX
Sustainability	n/a	n/a	2017	STT/STJ & STX



Sampling locations of reference sites and status sites sampled in U.S. Virgin Islands.

In the USVI, fish experts and partners identified the reference years as 'fair' based on CRCP's status metric definitions. The following rubric was used to compare Z-scores between the reference and status years.

Fish metric scoring rubric for U.S. Virgin Islands.

Status Z score domain estimate in relation to zero	P value	Score
> 0	$p < 0.01$	Very good
> 0	$p < 0.05$	Good
= 0	$p > 0.05$, not significant	Fair
< 0	$p < 0.05$	Impaired
< 0	$p < 0.01$	Critical

Reef fish

Three fish species subsets were used to calculate fish density: 1.) Fishery target adult density; 2.) Fishery target juvenile density; and, 3.) Parrotfish density. Target species were selected based on multiple criteria, including commercial and local importance as well as published data on species specific life history parameters, specifically, length at maturity (Stevens et al. 2019). Juveniles were smaller than length-at-maturity (L_m) and adults were ≥ L_m. L_m is reported in cm. A subset of parrotfish species was selected as an indicator by fish experts, partners, and stakeholders during initial development of status metrics (table below). Specifically, large-bodied parrotfish were used because of their role in the coral reef ecosystem and because they are targeted by both the commercial and recreational fishery.

Species list used in Target density calculations for U.S. Virgin Islands. Length at maturity (L_m) parameters (Stevens et al. 2019).

Common Name	Scientific Name	Lm
Ocean surgeon	*Acanthurus bahianus*	11
Doctorfish	*Acanthurus chirurgus*	17
Blue tang	*Acanthurus coeruleus*	13
Queen Triggerfish	*Balistes vetula*	21.5
Jolthead porgy	*Calamus bajonado*	30
Saucereye porgy	*Calamus calamus*	32.1
Graysby	*Cephalopholis cruentata*	16.5
Coney	*Cephalopholis fulva*	22
Rock Hind	*Epinephelus adscensionis*	32.9
Red Hind	*Epinephelus guttatus*	21.5
Nassau grouper	*Epinephelus striatus*	43.5
French grunt	*Haemulon flavolineatum*	16

Cottonwick	*Haemulon melanurum*	19
White Grunt	*Haemulon plumierii*	16.7
Bluestriped Grunt	*Haemulon sciurus*	20.5
Hogfish	*Lachnolaimus maximus*	18
Mutton snapper	*Lutjanus analis*	32.3
Schoolmaster snapper	*Lutjanus apodus*	20
Cubera snapper	*Lutjanus cyanopterus*	53.6
Gray snapper	*Lutjanus griseus*	23
Dog Snapper	*Lutjanus jocu*	47.6
Mahogany snapper	*Lutjanus mahogoni*	19.6
Lane snapper	*Lutjanus synagris*	24
Yellowtail snapper	*Ocyurus chrysurus*	23.2

Parrotfish species list used in parrotfish density calculations for U.S. Virgin Islands.

Common Name	**Scientific Name**
Midnight	*Scarus coelestinus*
Blue	*Scarus coeruleus*
Rainbow	*Scarus guacamaia*
Striped	*Scarus iseri*
Princess	*Scarus taeniopterus*
Queen	*Scarus vetula*
Redband	*Sparisoma aurofrenatum*
Redtail	*Sparisoma chrysopterum*
Yellowtail	*Sparisoma rubripinne*
Stoplight	*Sparisoma viride*

Sustainability

All fish species included in the sustainability estimates are targeted (commercial or recreational) fisheries species that have known length-at-capture (L_c) sizes reported as fork length in cm. All life history parameters came from Caribbean sampled species when possible; otherwise, Florida parameters were used as proxies. To be included in the final sustainability analysis, fish needed to have > 1% occurrence at the domain level.

Species list for sustainability calculations in each region of U.S. Virgin Islands. Length at capture parameters (Stevens et al. 2019, Ault et al. 2008).

Region	**Common Name**	**Scientific Name**	**Sustainability**
St. Croix	Queen Triggerfish	*Balistes vetula*	29
St. Croix	Coney	*Cephalopholis fulva*	20
St. Croix	Rock Hind	*Epinephelus adscensionis*	21

St. Croix	Red Hind	*Epinephelus guttatus*	21
St. Croix	White Grunt	*Haemulon plumierii*	17
St. Croix	Bluestriped Grunt	*Haemulon sciurus*	19
St. Croix	Mutton snapper	*Lutjanus analis*	22
St. Croix	Schoolmaster snapper	*Lutjanus apodus*	22
St. Croix	Gray snapper	*Lutjanus griseus*	23
St. Croix	Lane snapper	*Lutjanus synagris*	17
St. Croix	Yellowtail snapper	*Ocyurus chrysurus*	23
St. Thomas/St. John	Queen Triggerfish	*Balistes vetula*	29
St. Thomas/St. John	Coney	*Cephalopholis fulva*	20
St. Thomas/St. John	Red Hind	*Epinephelus guttatus*	21
St. Thomas/St. John	Nassau grouper	*Epinephelus striatus*	30
St. Thomas/St. John	White Grunt	*Haemulon plumierii*	17
St. Thomas/St. John	Bluestriped Grunt	*Haemulon sciurus*	19
St. Thomas/St. John	Hogfish	*Lachnolaimus maximus*	25
St. Thomas/St. John	Mutton snapper	*Lutjanus analis*	22
St. Thomas/St. John	Schoolmaster snapper	*Lutjanus apodus*	22
St. Thomas/St. John	Gray snapper	*Lutjanus griseus*	23
St. Thomas/St. John	Dog snapper	*Lutjanus jocu*	23
St. Thomas/St. John	Lane snapper	*Lutjanus synagris*	17
St. Thomas/St. John	Yellowtail snapper	*Ocyurus chrysurus*	23

IV.II.IX Florida's Coral Reef

Fish were surveyed in the Dry Tortugas and Florida Keys from 1999–2012 annually as part of a multi-partner effort led by the Southeast Fisheries Science Center (SEFSC). NCRMP surveys began in 2014 and occur every other year. In Southeast Florida, as part of a state-led initiative, the fish surveys were completed in 2012-2016 annually. NCRMP began fish surveys in Southeast Florida in 2018. All fish surveys were completed using RVC methods.

In Florida, many marine reserves have been established to spatially protect areas from fishing. The marine reserve known as the Research Natural Area (RNA) of the Dry Tortugas National Park was selected as the reference area for all Florida sampling domains for this status report. The RNA was selected as the reference area for multiple reasons:

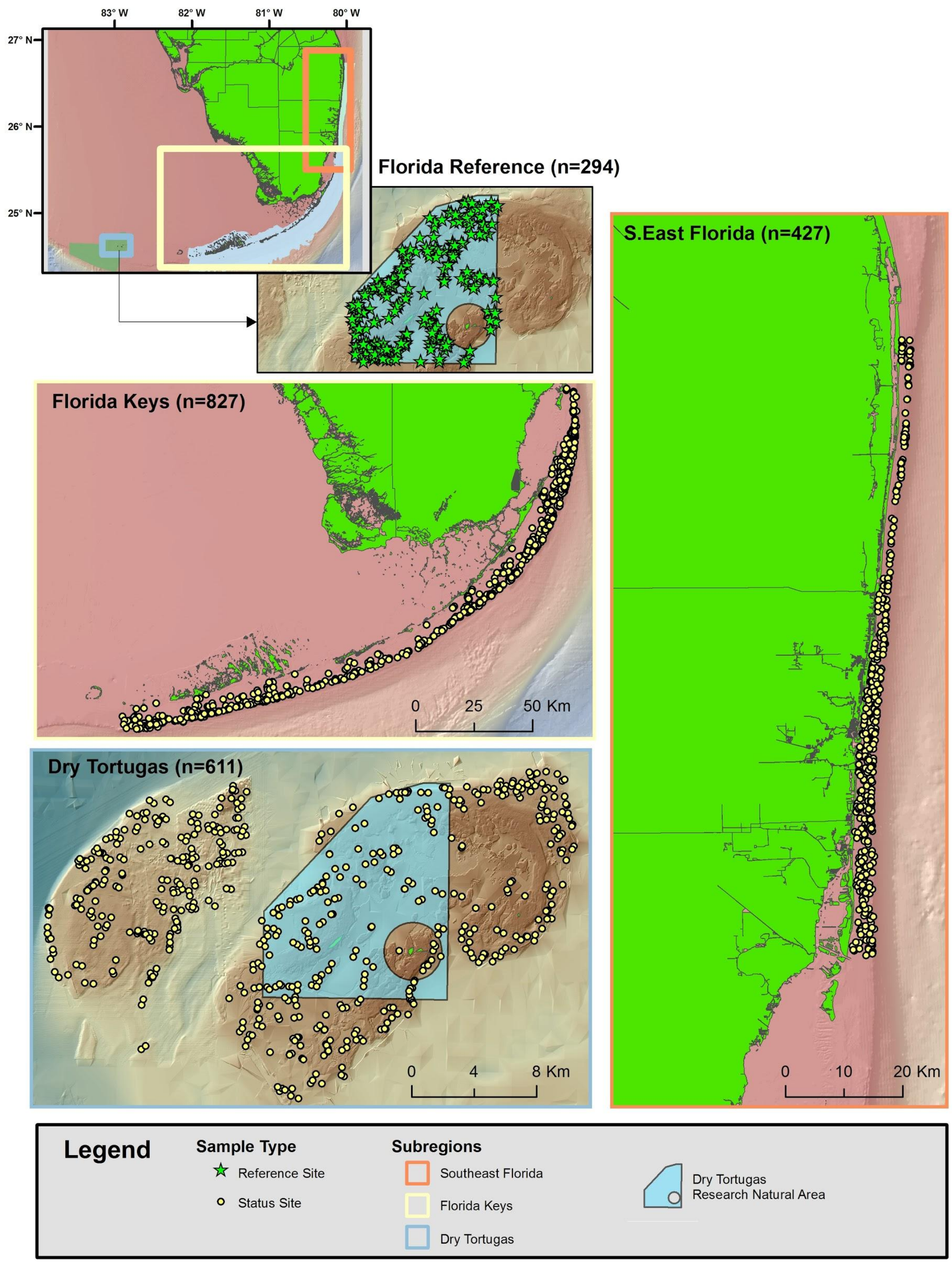
- Large size (46-square-miles) that offers greater protection to fisheries target species,
- Remote location in Dry Tortugas approximately 70 miles from Key West has historically lower fishing pressure than the mainland,
- Closed to recreational and commercial fishing,
- Generally healthier ecosystem (lower human interaction, less land-based pollution, etc.),
- Comprised of all habitats and depths found in Florida, and
- Reserve has been in place for > 10 years (established in 2007).

The reference years (2011–2014) were selected because the initially lower fish densities (in 2007 when established) had substantially improved and generally plateaued by 2011 (Ault et al. 2013).

The Florida Coral Reef is comprised of three status areas: 1.) Dry Tortugas; 2.) Florida Keys; and 3.) Southeast Florida. Each sampling domain was independently compared to the reference to obtain diversity and reef fish scores. Similarly, sustainability was assessed separately for each status area. The two most recent NCRMP sampling surveys were chosen as the status years (2016 & 2018) for all the fish indicators. Of note, the Southeast Florida analyses were limited to fish surveys from the southern portion of the reef tract (Miami-Dade, Broward, and South Palm Beach). This decision was made with input from partners and stakeholders to ensure a high level of reef fish assemblage comparability between Southeast Florida and the RNA reference area (Fisco, 2015).

The table below describes the reference and status years and the figure below shows the locations and number of fish sites for each of the years. Abbreviations for the Florida sampling areas are as follows: Dry Tortugas Research Natural Area (RNA), Dry Tortugas (DRTO), Florida Keys (FL Keys), and Southeast Florida (SE FL).

Indicator	**Reference Years**	**Reference Area**	**Status Year**	**Status Areas**
Density	2011–2014	RNA	2016 & 2018	DRTO, FL Keys, SE FL
Richness	2011–2014	RNA	2016 & 2018	DRTO, FL Keys, SE FL
Sustainability	n/a	n/a	2016 & 2018	DRTO, FL Keys, SE FL



Sampling locations of reference sites and status sites sampled in Florida.

In Florida, fish experts and partners identified the reference years as 'good' based on CRCP's status metric definitions. The following rubric was used to compare Z-scores between the reference and status years.

Fish metric scoring rubric for the Florida Coral Reef.

Status Z score domain estimate in relation to zero	P value	Score
> 0	$p < 0.05$	Very good
= 0	$p > 0.05$, not significant	Good
< 0	$p < 0.05$	Fair
< 0	$p < 0.01$	Impaired
< 0	$p < 0.001$	Critical

Reef fish

Three fish species subsets were used to calculate density: 1.) Fishery target adult density; 2.) Fishery target juvenile density; and 3.) Ornamental density. Targeted fishery adults and juveniles used in all three Florida status areas for the density analyses are below. Juveniles were smaller than length-at-maturity (L_m) and adults were ≥ L_m. L_m is reported in cm.

Species list used in target density calculations for the Florida Coral Reef. Length at maturity parameters (Stevens et al. 2019).

Common Name	Scientific Name	Lm
Gray triggerfish	*Balistes capriscus*	21
Red grouper	*Epinephelus morio*	29
Hogfish	*Lachnolaimus maximus*	18
Mutton snapper	*Lutjanus analis*	32
Schoolmaster snapper	*Lutjanus apodus*	25
Blackfin snapper	*Lutjanus buccanella*	24
Cubera snapper	*Lutjanus cyanopterus*	54
Gray snapper	*Lutjanus griseus*	23
Dog Snapper	*Lutjanus jocu*	48
Lane snapper	*Lutjanus synagris*	24
Black grouper	*Mycteroperca bonaci*	83
Yellowmouth grouper	*Mycteroperca interstitialis*	42
Gag grouper	*Mycteroperca microlepis*	54
Scamp	*Mycteroperca phenax*	33
Yellowfin grouper	*Mycteroperca venenosa*	54
Yellowtail snapper	*Ocyurus chrysurus*	23
Red porgy	*Pagrus*	20
Great barracuda	*Sphyraena barracuda*	80

Ornamental density was selected as the indicator metric because the management of these species is unique to Florida's reef tract. Fishers in other areas of their Caribbean distributions target many of these species; however, in Florida these species remain protected for portions of their life. As a result, they are common on Florida's coral reefs, many provide benthic ecosystem functions (herbivores or invertivores cleaning the benthos) and are valuable to the tourism industry due to their colorful patterns and docile behavior. The ornamental list used was taken from the Florida Fish and Wildlife Conservation Commission's (FWC) marine life list. The list of ornamental fishes used in the analysis can be found in Appendix B.

Sustainability

All fish species included in the sustainability estimates are targeted fisheries species that have known length-at-capture (L_c) sizes reported as fork length in cm. To be included in the final sustainability analysis, fish needed to have > 1% occurrence at the domain level.

Species list for sustainability calculations in each region of the Florida Coral Reef. Length at capture parameters (Stevens et al. 2019).

Region	**Common Name**	**Scientific Name**	**Lc**
Dry Tortugas	Red grouper	*Epinephelus morio*	44
Dry Tortugas	Hogfish	*Lachnolaimus maximus*	30
Dry Tortugas	Mutton snapper	*Lutjanus analis*	42
Dry Tortugas	Schoolmaster snapper	*Lutjanus apodus*	25
Dry Tortugas	Gray snapper	*Lutjanus griseus*	23
Dry Tortugas	Lane snapper	*Lutjanus synagris*	19
Dry Tortugas	Black grouper	*Mycteroperca bonaci*	60
Dry Tortugas	Scamp	*Mycteroperca phenax*	38
Dry Tortugas	Yellowtail snapper	*Ocyurus chrysurus*	25
Florida Keys	Gray triggerfish	*Balistes capriscus*	30
Florida Keys	Red grouper	*Epinephelus morio*	44
Florida Keys	Hogfish	*Lachnolaimus maximus*	30
Florida Keys	Mutton snapper	*Lutjanus analis*	42
Florida Keys	Schoolmaster snapper	*Lutjanus apodus*	25
Florida Keys	Gray snapper	*Lutjanus griseus*	23
Florida Keys	Dog snapper	*Lutjanus jocu*	29
Florida Keys	Lane snapper	*Lutjanus synagris*	19
Florida Keys	Black grouper	*Mycteroperca bonaci*	60
Florida Keys	Scamp	*Mycteroperca phenax*	38
Florida Keys	Yellowtail snapper	*Ocyurus chrysurus*	25
Southeast Florida	Gray triggerfish	*Balistes capriscus*	30
Southeast Florida	Red grouper	*Epinephelus morio*	44
Southeast Florida	Hogfish	*Lachnolaimus maximus*	30
Southeast Florida	Mutton snapper	*Lutjanus analis*	42
Southeast Florida	Schoolmaster snapper	*Lutjanus apodus*	25
Southeast Florida	Gray snapper	*Lutjanus griseus*	23

Southeast Florida	Lane snapper	*Lutjanus synagris*	19
Southeast Florida	Yellowtail snapper	*Ocyurus chrysurus*	25

IV.III Climate

The indicators for the climate theme are reef material growth, ocean acidification, and temperature stress. Each indicator has its own field methodology, which will be described in each section.

IV.III.I Reef material growth

Data were collected by a census-based method, termed *ReefBudget* (Perry et al. 2012). Surveys are first conducted to measure the abundances of the dominant calcifiers and bioeroders on a given reef. These abundance data are then used to estimate rates of calcium carbonate production and bioerosion based on published rate data for the various taxa. Thus, for each reef site we have a measure of carbonate production and bioerosion rates by taxa, as well as net reef production. The number of sites sampled, and years of data collection are listed below.

Years of collection and number of sites for each jurisdiction for reef material growth.

Jurisdiction	Years	# of sites
Flower Garden Banks	2015	6
Puerto Rico	2014	211
US Virgin Islands+	2015	242
Southeast Florida	2014	24
Florida Keys*	2010	34
Dry Tortugas*	2010	3

+-US Virgin Islands data are from sites in St. John and St. Thomas, and do not include St. Croix.
*-Data from Enochs et al. (2015).

To determine scores for reef material growth, we utilized the fact that historical net reef production in shallow water Caribbean reef environments (0-10m), prior to recent ecological degradation, was in the range of 10-17 kg $CaCO_3$ m^{-2} yr^{-1}, with values of 10 considered on the low end (Vecsei 2001; Perry et al. 2013). Thus, we set 10 kg $CaCO_3$ m^{-2} yr^{-1} as the lower bound of the “very good” score of 90% (Table 2). We considered a reef that was net erosional (net production negative) as “critical.” The full scoring scheme is provided in Table 2.

Net production values of reef accretion that correspond to grading scheme for Caribbean reef accretion.

Net Production (kg $CaCO_3$ m^{-2} yr^{-1})	Percent score
>10	90 – 100%, Very Good
6 - 10	80 – 90%, Good
3 – 6	70 – 80%, Fair
0 - 3	60 – 70%, Impaired
< 0	0 – 59%, Critical

Reef Accretion at the Flower Garden Banks

The reef growth metric for Flower Garden Banks (FGB) was calculated differently than the other sites because this site is a deep reef (transects range from 19-23m) and the grading system devised for the other NCRMP sites was based on shallower reef sites (0-10m, Perry et al. 2013). There are far fewer data on carbonate production from deeper reefs in the Atlantic and the known data are expressed as accretion rates (mm yr^{-1}). We converted our $CaCO_3$ production data from FGB to accretion rates using methods described in Perry et al. (2012), which yielded a mean accretion rate of 3.83 mm yr^{-1}. The historical mean accretion rate for Atlantic sites 20-25 m was 2.76 mm yr^{-1}; the maximum accretion rate for a reef site > 20m was 5.5 mm yr^{-1} (Hubbard 2009). We assumed that if a site was at or above the historical mean (2.75 mm yr^{-1}), it would receive 90% and above. A site with zero accretion or net erosion received was scored as ≤ 59% (i.e., reflective of a "critical" score). Perry et al. (2012) reported that, on average, carbonate production has declined by 50%, thus a value that was half of 2.75 was used as the cut off for a 70% score as this is the current norm for the Caribbean.

Modified scoring scheme for reef material growth at Flower Garden Banks given that this is a deep (> 20m) reef site and thus same grading scheme used elsewhere does not apply.

Reef Accretion (mm yr^{-1})	Percent score
> 2.75	90 – 100%, Very Good
2.06 – 2.75	80 – 90%, Good
1.38 – 2.06	70 – 80%, Fair
0 – 1.38	60 – 70%, Impaired
< 0	0 – 59%, Critical

IV.III.II Ocean Acidification

The ocean acidification indicator was calculated as previously described in Donovan et al. (2018). The number of sites sampled and years of data collection are listed below.

Years of collection and number of sites for each jurisdiction for ocean acidification

Jurisdiction	Years	# of sites
Flower Garden Banks	2013, 2015	45
Puerto Rico	2014, 2016	147
St. Croix	2015, 2017	69
St. John	2013	50
St. Thomas	2013, 2015	77
Southeast Florida	2014,2015	367
Florida Keys*	2009-2012	109
Dry Tortugas	2014	59

*-Data from Manzello et al. (2012)

IV.III.III Temperature stress

The temperature stress indicator grades coral health based on the occurrence and severity of coral bleaching thermal stress they have experienced during a 4-year evaluation period (2014-2017). Mass coral bleaching due to anomalously warm water temperatures has occurred with increasing frequency and severity in recent decades and is now the most significant single contributor to the decline of coral reef ecosystems on a global scale. Coral mortality and disease outbreak often follow massive bleaching events, along with significantly reduced coral growth rate both during and after the bleaching and ability to fight off other stresses. NOAA Coral Reef Watch (CRW) has been using NOAA's operational near-real-time satellite sea surface temperature data to detect and monitor thermal stress conducive to mass coral bleaching globally since 1997 (Liu et al. 2003, 2005, 2013, 2014). Monitoring data for the report card target regions were extracted from CRW's global products and then statistical analysis was performed on the data to generate a grade. Data analysis follows these steps:

1. Determine the reporting period based on available satellite data. Grading will be based on degree heating week event frequency and severity per 4-year period.
2. Define all the reef-containing data pixels for each area of interest and extract the daily time series of degree heating week values. For multi-pixel areas with 10 or more data pixels, the 90th percentile degree heating week value is chosen for each time step in the series. For multi-pixel areas with less than 10 data pixels, the maximum degree heating week value is used for each time step.
3. Take the maximum degree heating week value for each year in the 4-year time series.
4. Use these 4 values along with the grading chart and find the corresponding grade based on the frequency and severity values in the chart. The value resulting in the lowest grade becomes the overall grade for that reporting period.

The grading chart ranks thermal stress severity in 7 bins based on DHW ranges shown across the top of the chart. The frequency of events at these levels are shown below each bin and have varying distribution based on the relationship between DHW and coral bleaching and mortality. The corresponding grade and an interpretation of what that grade means are shown on the left-hand side of the chart. Counting the number of times a DHW level is reached in a 4-year period and matching it to the proper severity column and frequency row will result in the corresponding grade. The chart also considers consecutive years of high DHW events, which would have a greater impact on corals than non-consecutive events. These have their own frequency label of "2c". For example, during the period 2013-2016, if 2013 and 2015 saw DHW values of 9, the resulting grade would be 55%, but if 2013 and 2014 saw DHW values of 9 the resulting grade would be 45%.

Coral Reef Watch NCRMP Report Card Scoring Table for a Four-Year Evaluation Period									
%Bleached	%Dead	Grade	0<N<4	4≤N<8	8≤N<12	12≤N<16	16≤N<20	20≤N<32	32≤N
<1%		100%	0	0	0	0	0	0	
1%		95%	1-2						
10%		85%	3-4	1					
20%		75%		2					
40%		65%		3	1				
60%	10%	55%		4	2	1			
80%	20%	45%			2c	2	1		
90%	40%	35%			3	2c	2		
100%	60%	25%			4	3	2c	1	
	80%	15%				4	3		
	90%	5%					4	2	
	100%	0%						3-4	1

Key

DHW Severity Ranges (N = DHW value)

Number of DHW occurrences in 4-Year period (2c = 2 years are consecutive)

Corresponding Grade and Expected Impact on Corals

IV.IV Human connections

The human connections theme of the National Coral Reef Monitoring Program (NCRMP) gathers and monitors a collection of socioeconomic variables such as demographics in coral reef areas, human use of coral reef resources, as well as knowledge, attitudes, and perceptions of coral reefs and coral reef management. The overall goal of the human connections monitoring component is to track relevant information regarding each jurisdiction's population, social and economic structure, and interactions between coral reef ecosystems and adjacent human communities. The selection of indicators was determined through workshops and consultations with partners (local jurisdictions as well as federal agencies). The human connections indicators are: Awareness, Participation in Pro-Environmental Behavior, and Support for Management Actions. To operationalize these three indicators, secondary data collected from the jurisdiction and data collected from an NCRMP survey of jurisdictional residents were used. Threshold goals for these indicators were specific to each jurisdiction, and were established through consultation with coral reef managers, environmental education and outreach coordinators, and relevant federal, state, and local agency staff.

For more information on the human connections component of NCRMP, visit http://www.coris.noaa.gov/monitoring/socioeconomic.html.

IV.IV.I Puerto Rico

All indicators were evaluated at the jurisdictional level/reporting region level. Thus, the indicators for Awareness, Participation in Pro-Environmental Behavior, and Support for Management Actions reflect the status of Puerto Rico as a whole.

For more information about the Puerto Rico NCRMP survey, visit https://www.coris.noaa.gov/activities/ncrmp_puerto_rico/.

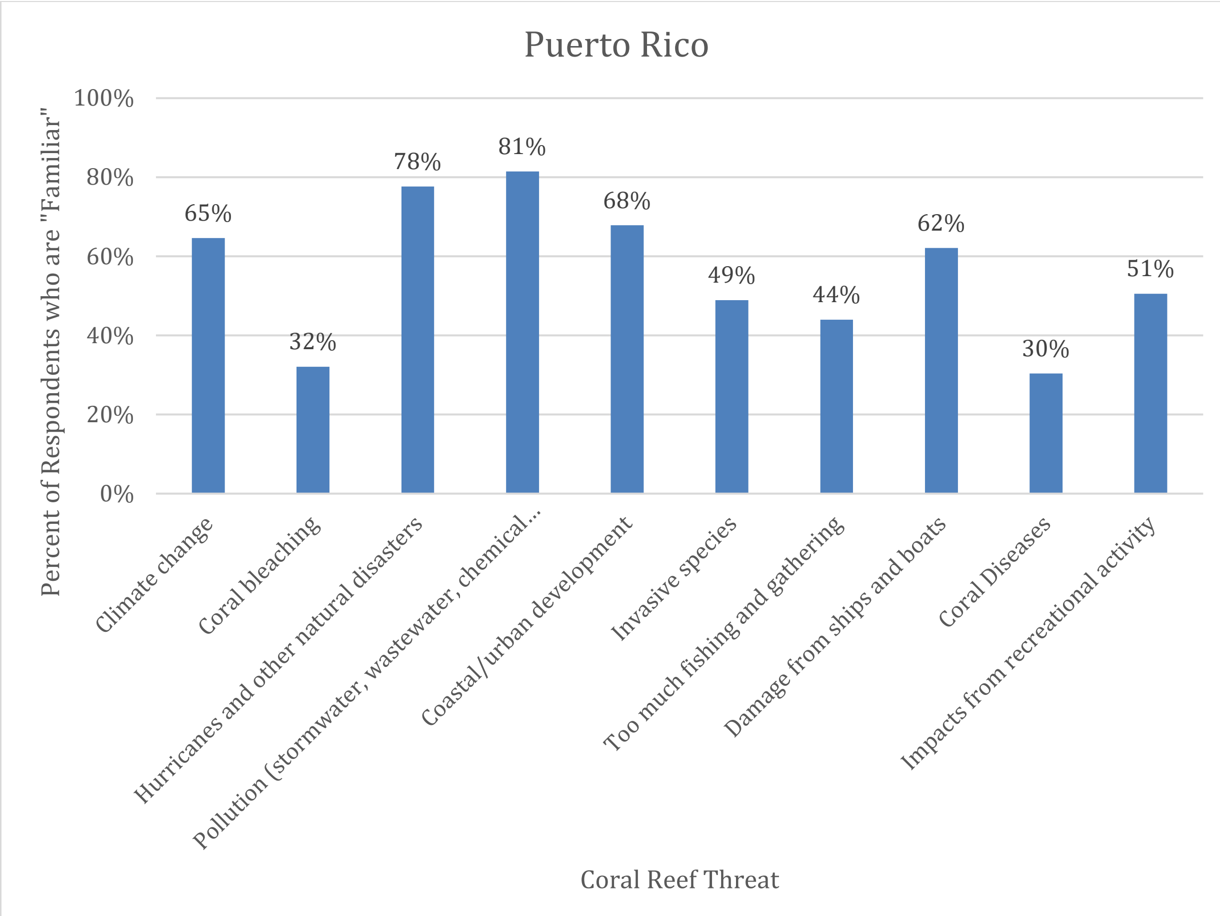
For an infographic depicting the results of the Puerto Rico NCRMP survey, visit https://www.coris.noaa.gov/monitoring/socioeconomic_PR.html. (For the Spanish translation, visit https://www.coris.noaa.gov/monitoring/resources/NCRMP_Infographic_Puerto_Rico_Espanol.pdf).

Awareness

The Awareness indicator is an indicator of residents' familiarity with threats to and the importance of reefs. Three awareness metrics were averaged into an overall Awareness indicator score. The three metrics for Puerto Rico are: familiarity with threats to coral reefs; familiarity with MPAs; and, the value or importance respondents place on coral reefs.

Familiarity with threats to coral reefs

Survey respondents in Puerto Rico were asked to rate their familiarity with various threats posed to coral reefs on a scale of "very unfamiliar" to "very familiar." Familiarity with threats indicates local awareness of the need for management action. The percentage of respondents that are at least "familiar" was calculated for each of the ten threats that were proposed in the Puerto Rico survey. A threshold of fifty percent was established (i.e., a goal that at least 50% of respondents were at least "familiar" with the threat). Coral reef managers in Puerto Rico confirmed that this goal was appropriate (i.e., professional judgement).

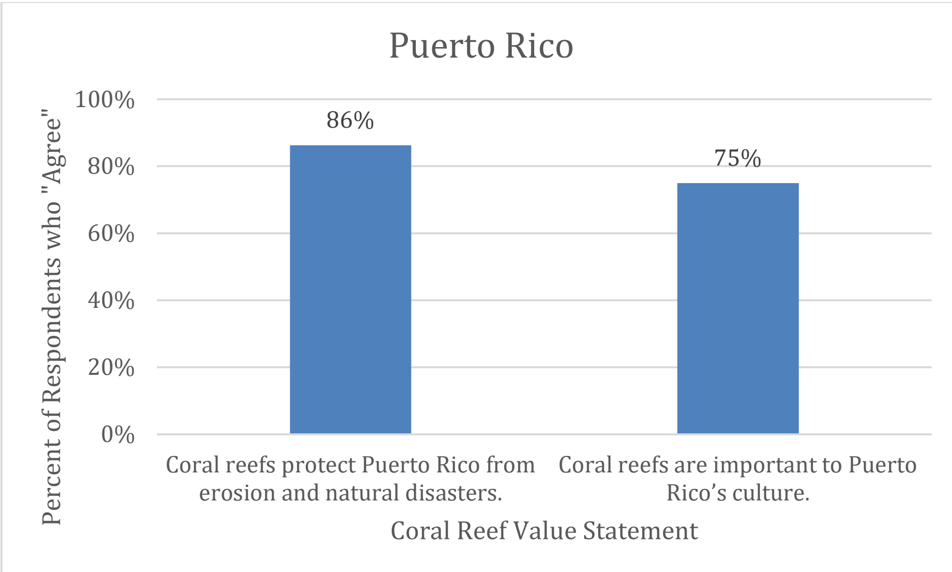


Familiarity with Marine Protected Areas

Survey respondents in Puerto Rico were asked to rate their familiarity with MPAs on a scale of "very unfamiliar" to "very familiar." Familiarity with MPAs indicates success of jurisdictional education and outreach campaigns and understanding of marine regulations. The percentage of respondents that are at least "familiar" with MPAs was calculated. A threshold of one third was established (i.e., a goal that at least 33% of respondents are at least "familiar" with MPAs). Coral reef managers in Puerto Rico confirmed that this goal was appropriate (i.e., professional judgement).

Value or Importance of coral reefs

The value or importance that respondents in Puerto Rico place on coral reefs was examined. This section of the survey contained four questions in which statements were proposed and respondents were asked to rate how much they "agree" with the statements on a scale of "strongly disagree" to "strongly agree." Two of these statements are ambiguous in their interpretation since an increase in agreement could be perceived as positive or negative by different stakeholders. As a result, they were omitted from analysis, and the other two statements in this section were analyzed. Agreement with these remaining statements can be interpreted as positive indicators. A threshold of two-thirds in agreement with the protection and culture statements was established after consultation with coral reef managers in Puerto Rico.



Pro-Environmental Behavior

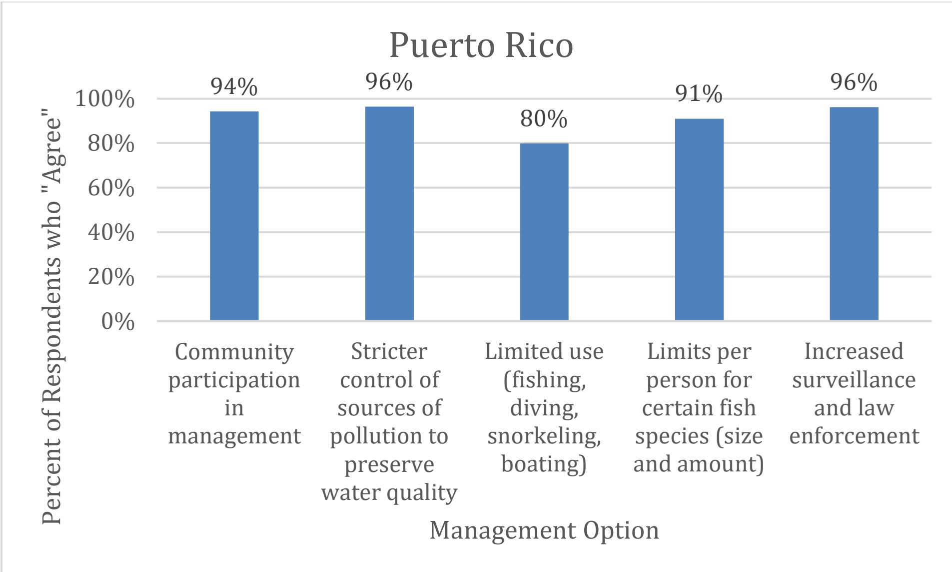
The Pro-Environmental Behavior indicator measures residents' (active) participation in activities that help the environment, such as beach clean-ups, volunteering with an environmental group, recycling, etc. NCRMP survey respondents in Puerto Rico were asked to rate their frequency of participation in pro-environmental behaviors on a scale of "not at all" to "several times a month or more." Through discussion with coral reef managers, a threshold of thirty-three percent participation several times a year was established (i.e., a goal of at least one third of respondents participating in any form of pro-environmental behavior at least several times a year).

Support for Management Actions

The Support for Management indicator measures the level of support that respondents to the NCRMP jurisdictional resident survey indicate for coral reef management activities. The Puerto Rico survey asked two sets of questions (agreement with coral reef management options and agreement with various Marine Protected Area functions). After consultation with local partners, the threshold for both indicators was set at two-thirds of the respondents in agreement.

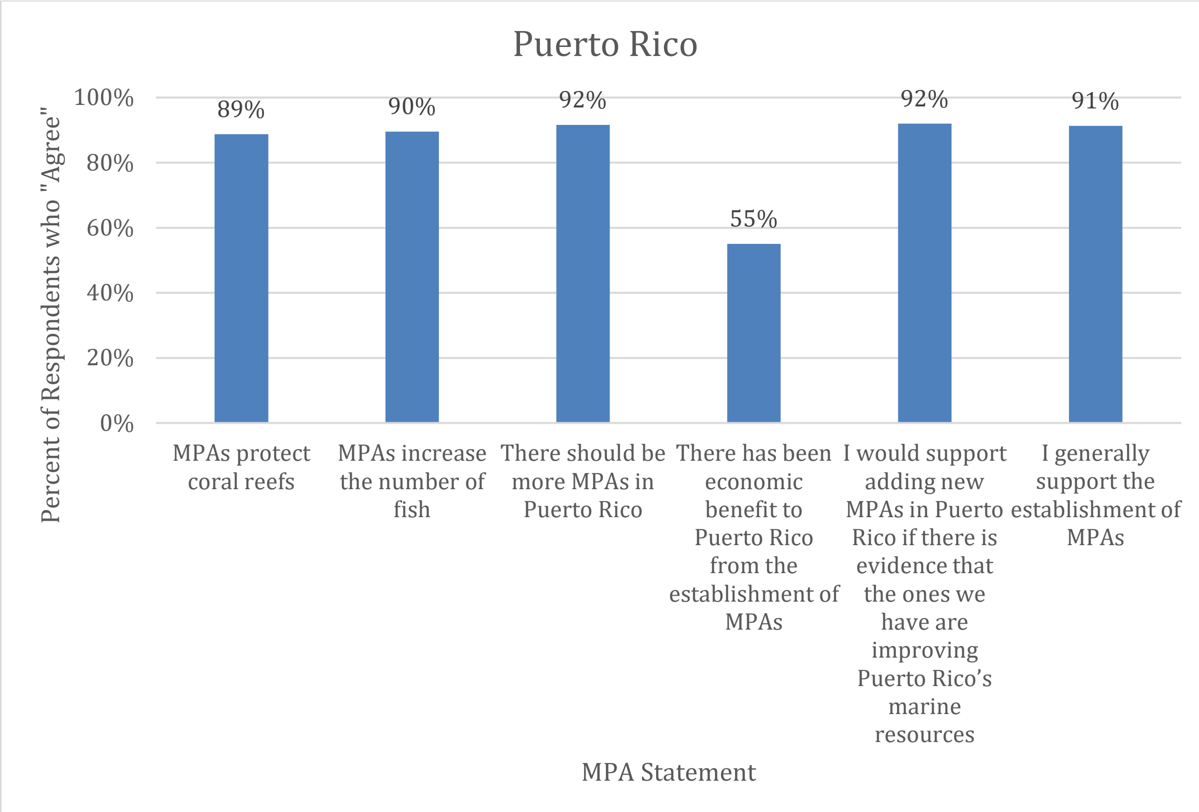
Support for coral reef management rules and regulations

Respondents were asked to rate their agreement with various management initiatives on a scale of "strongly disagree" to "strongly agree." The threshold goal of two-thirds of survey respondents in support with the proposed management initiatives was set after consultation with coral reef managers.



Agreement with marine protected area functions

The marine protected area question section contained ten statements, and respondents were asked to rate how much they "agree" with the statements on a scale of "strongly disagree" to "strongly agree." Four of these statements have either negative directionality or are ambiguous in their interpretation since an increase in agreement could be perceived as positive or negative by different stakeholders. As a result, they were omitted from analysis, and the other six statements in this section were analyzed. Agreement with these remaining statements can be interpreted as positive indicators. A threshold of two-thirds agreement was established for the "positive" statements after consultation with coral reef managers in Puerto Rico.



IV.IV.II U.S. Virgin Islands

All indicators were evaluated at the jurisdictional level, as well as the reporting region level. Thus, the indicators for Awareness, Participation in Pro-Environmental Behavior, and Support for Management Actions reflect the US Virgin Islands as a whole, as well as the island of St. Croix, and the combined islands of St. Thomas and St. John.

For more information about the USVI NCRMP survey, visit https://www.coris.noaa.gov/activities/ncrmp_usvi_socio/.

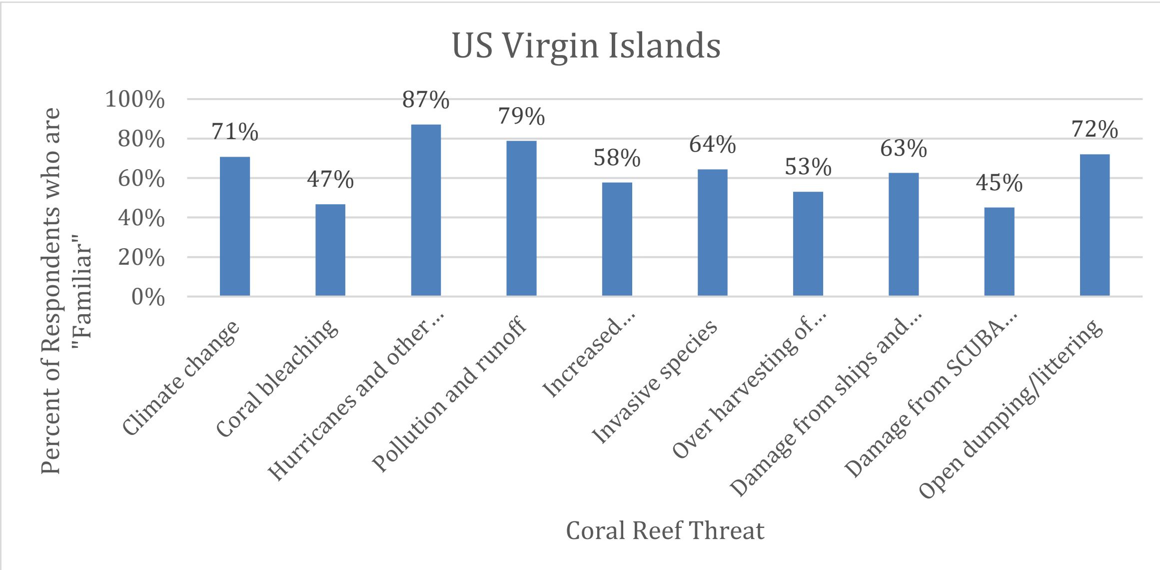
For an infographic depicting the results of the USVI NCRMP survey, visit https://www.coris.noaa.gov/monitoring/socioeconomic_USVI.html.

Awareness

The Awareness indicator is an indicator of residents' familiarity with threats to and the importance of reefs. Three awareness metrics were averaged into an overall Awareness indicator score. The three metrics for USVI are: familiarity with threats to coral reefs; familiarity with MPAs; and the value or importance respondents place on coral reefs.

Familiarity with threats to coral reefs

Survey respondents in USVI were asked to rate their familiarity with various threats posed to coral reefs on a scale of "very unfamiliar" to "very familiar." Familiarity with threats indicates local awareness of the need for management action. The percentage of respondents that are at least "familiar" was calculated for each of the ten threats that were proposed in the USVI survey. A threshold of two-thirds was established (i.e., a goal that at least two-thirds of respondents are at least "familiar" with the threat). Coral reef managers in USVI confirmed that this goal was appropriate (i.e., professional judgement).

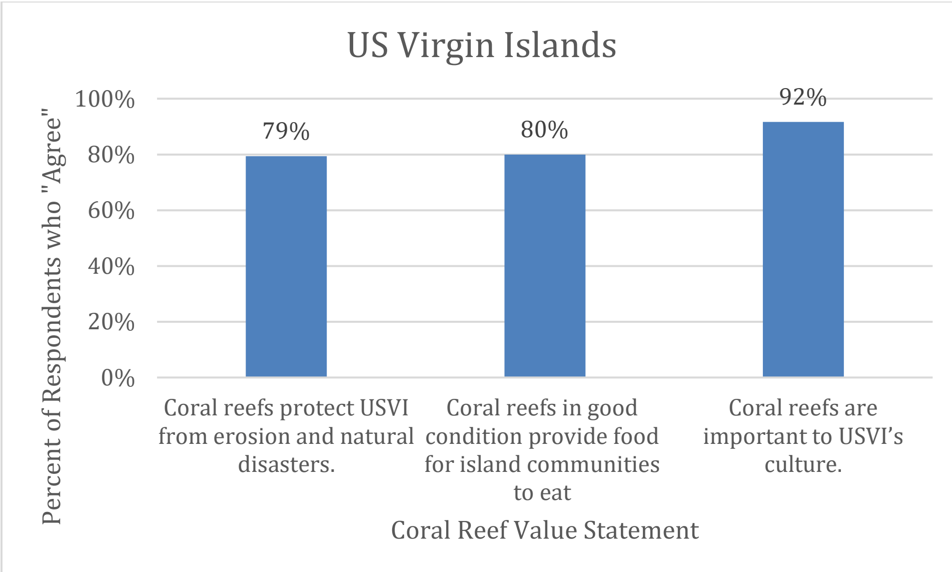


Familiarity with Marine Protected Areas

Survey respondents in USVI were asked to rate their familiarity with MPAs on a scale of "very unfamiliar" to "very familiar." Familiarity with MPAs indicates success of jurisdictional education and outreach campaigns and understanding of marine regulations. The percentage of respondents that are at least "familiar" with MPAs was calculated. A threshold of two-thirds was established (i.e., a goal that at least two-thirds of respondents are at least "familiar" with MPAs). Coral reef managers in USVI confirmed that this goal was appropriate (i.e., professional judgement).

Value or Importance of coral reefs

The value or importance that respondents in USVI place on coral reefs was examined. This section of the survey contained four questions in which statements were proposed and respondents were asked to rate how much they "agree" with the statements on a scale of "strongly disagree" to "strongly agree." One of these statements was ambiguous in its interpretation since an increase in agreement could be perceived as positive or negative by different stakeholders. As a result, it was omitted from analysis, and the other three questions in this section were analyzed. Agreement with these remaining statements can be interpreted as positive indicators. A threshold of two-thirds in agreement with the protection, culture, and provisioning statements was established after consultation with coral reef managers in USVI.



Pro-Environmental Behavior

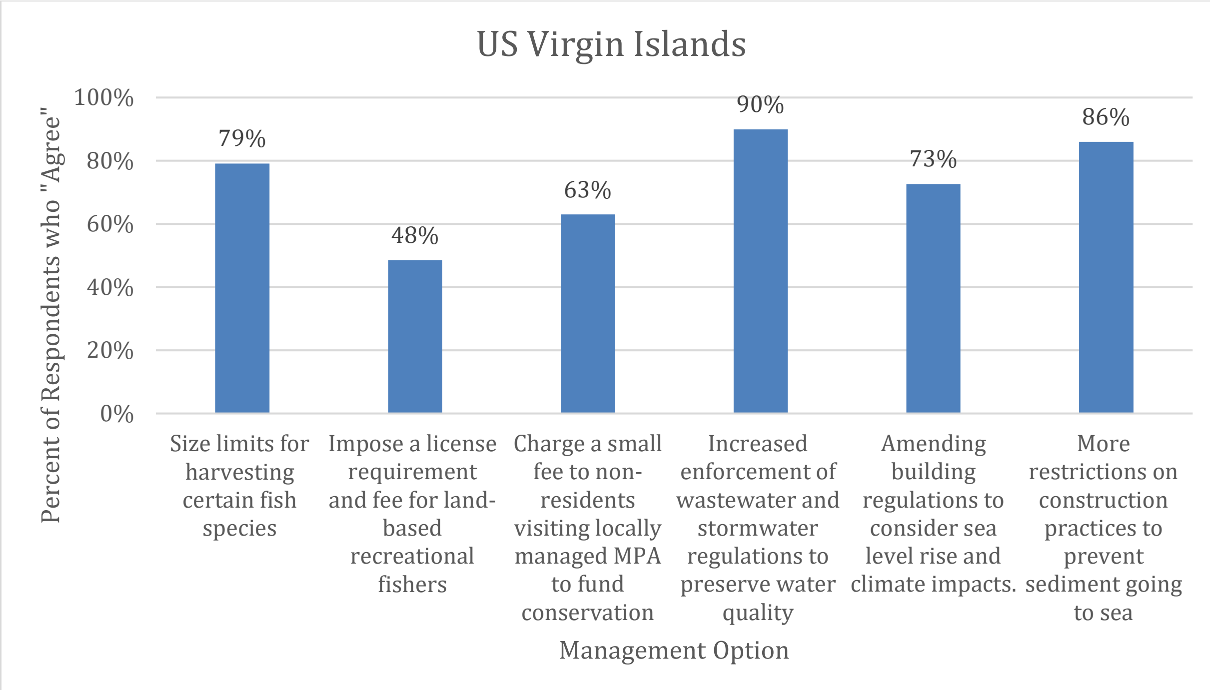
The Pro-Environmental Behavior indicator measures residents' (active) participation in activities that help the environment, such as beach clean-ups, volunteering with an environmental group, recycling, etc. NCRMP survey respondents in USVI were asked to rate their frequency of participation in pro-environmental behaviors on a scale of "not at all" to "several times a month or more." Through discussion with coral reef managers, a goal of two-thirds participation at least several times a year was established (i.e., a goal of at least 2/3 of respondents participating in any form of pro-environmental behavior at least several times a year).

Support for Management Actions

The Support for Management indicator measures the level of support that respondents to the NCRMP jurisdictional resident survey indicate for coral reef management activities. The USVI survey asked one set of questions related to support for coral reef management rules and regulations, and a second set related to support for MPAs. After consultation with local partners, the threshold for both indicators was set at two-thirds of the respondents in support and in agreement, respectively.

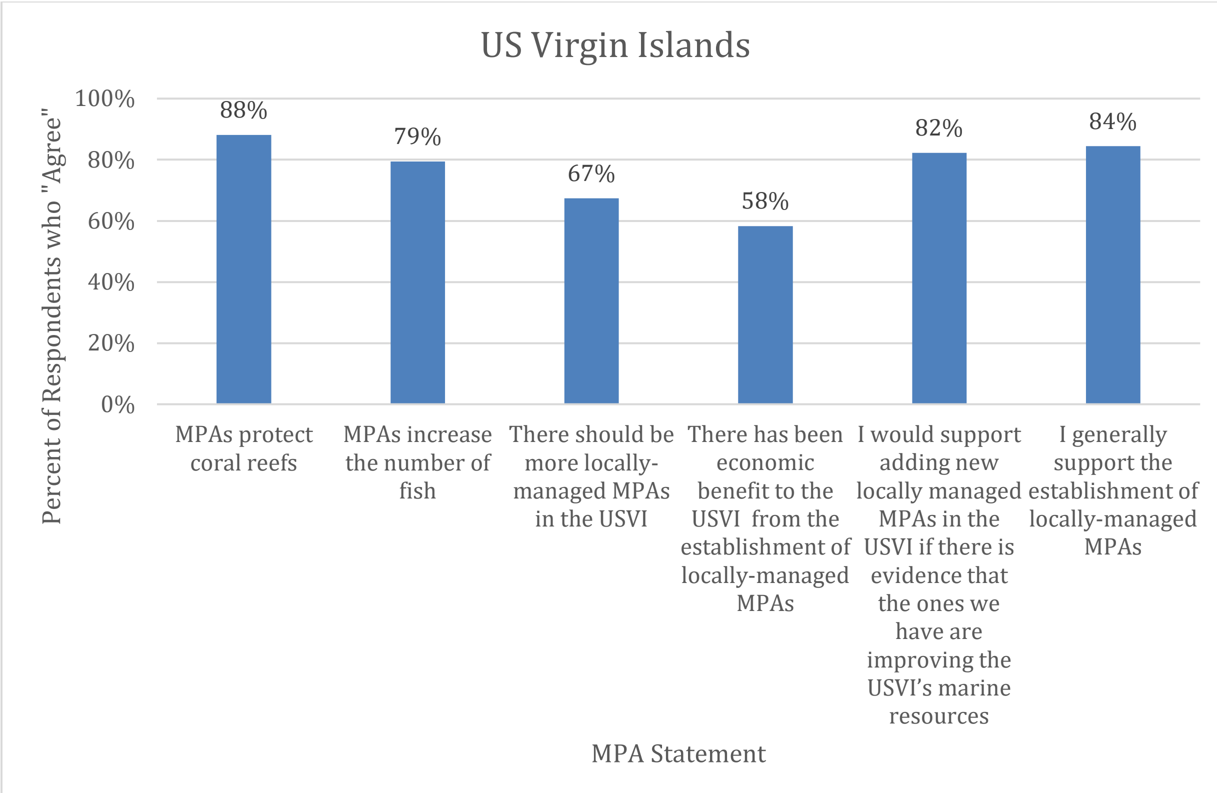
Support for coral reef management rules and regulations

Respondents were asked to rate their agreement with various management initiatives on a scale of "strongly disagree" to "strongly agree." The threshold goal of two-thirds of survey respondents in support with the proposed management initiatives was set after consultation with coral reef managers.



Agreement with marine protected area functions

The marine protected area question section contained ten statements, and respondents were asked to rate how much they “agree” with the statements on a scale of “strongly disagree” to “strongly agree.” Four of these statements had either negative directionality or were ambiguous in their interpretation since an increase in agreement could be perceived as positive or negative by different stakeholders. As a result, they were omitted from analysis, and the other six statements in this section were analyzed. Agreement with these remaining statements can be interpreted as positive indicators. A threshold of two-thirds agreement was established for the “positive” statements after consultation with coral reef managers in USVI.



IV.IV.III South Florida

All indicators are evaluated at the jurisdictional level, not at the reporting region level. Due to resource constraints, the NCRMP team was not able to collect representative samples of Southeast Florida reefs and the Florida Keys, although the team plans to increase representativeness for future survey iterations. Dry Tortugas is not inhabited, and therefore does not have human connections-representative metrics. The NCRMP team and local partners weighted survey data by age, Hispanic origin, and county of residence to correct for under-sampling of younger people, Hispanic people, and residents of Martin and Monroe Counties. Thus, the indicators for awareness, support for management actions, and participation in pro-environmental behaviors reflect the weighted jurisdictional level.

For more information about the South Florida NCRMP survey, visit https://www.coris.noaa.gov/activities/ncrmpFL/.

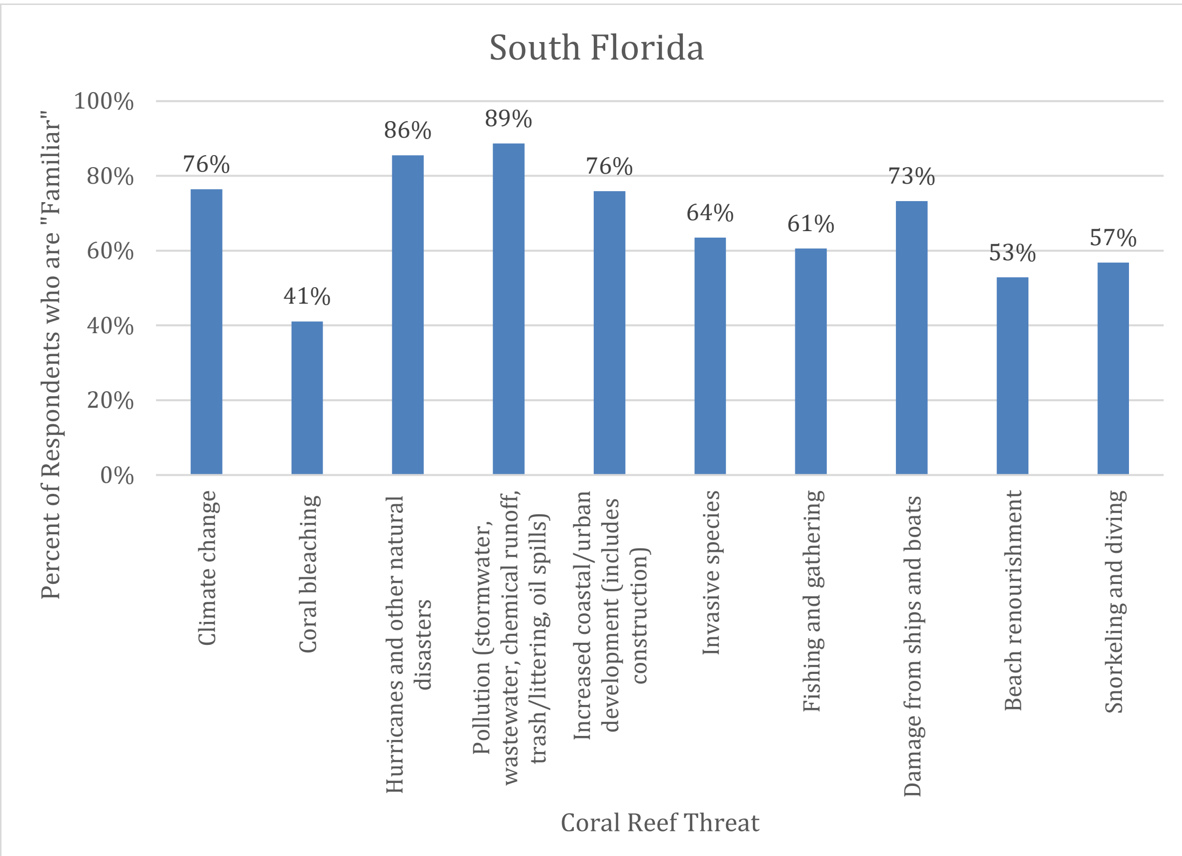
For an infographic depicting the results of the South Florida NCRMP survey, visit https://www.coris.noaa.gov/monitoring/socioeconomic_SF.html.

Awareness

The Awareness indicator is an indicator of residents' familiarity with threats to and the importance of reefs. Three awareness metrics, obtained from the NCRMP jurisdictional resident survey, were averaged into an overall Awareness indicator score. The three metrics for South Florida are: familiarity with threats to coral reefs; familiarity with coral reef management organizations; and the value or importance respondents place on coral reefs.

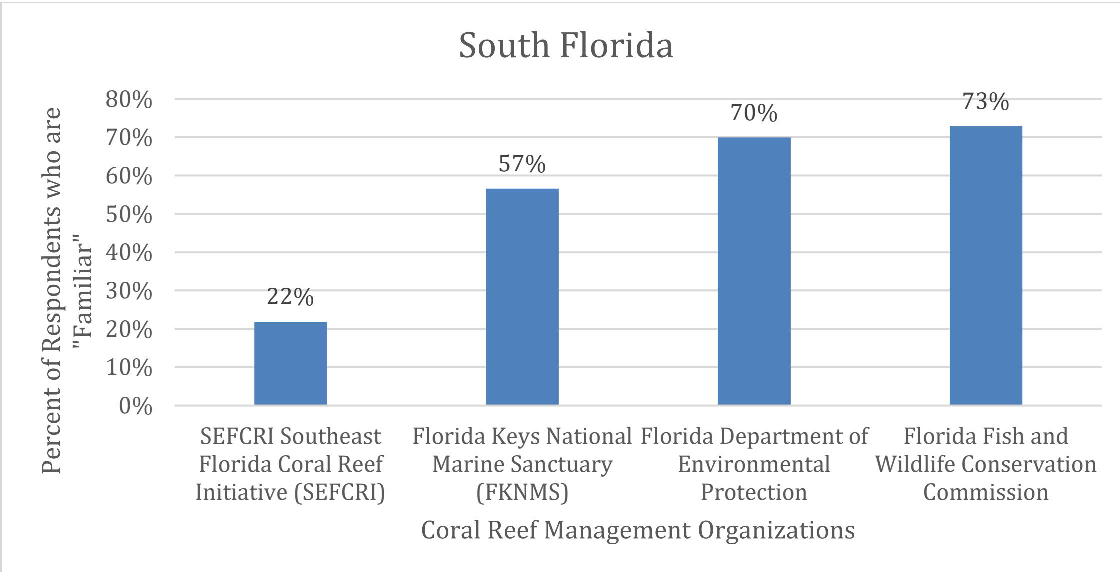
Familiarity with threats to coral reefs

Survey respondents in South Florida were asked to rate their familiarity with various threats posed to coral reefs on a scale of “very unfamiliar” to “very familiar.” Familiarity with threats indicates local awareness of the need for management action. The percentage of respondents that are at least “familiar” was calculated for each of the ten threats that were proposed in the South Florida survey. A threshold of seventy percent was established (i.e., a goal that at least 70% of respondents are at least “familiar” with the threat). Coral reef managers in South Florida confirmed that this goal was appropriate (i.e., professional judgement).



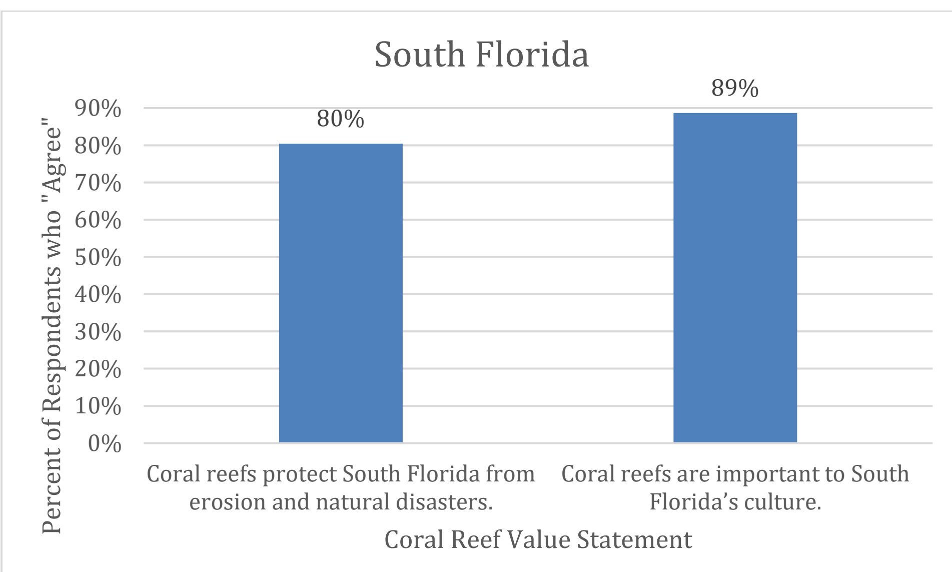
Familiarity with coral reef management organizations

Survey respondents in South Florida were asked to rate their familiarity with specified coral reef management organizations on a scale of “very unfamiliar” to “very familiar.” Familiarity with local coral reef management organizations indicates success of jurisdictional education and outreach campaigns. The percentage of respondents that are at least “familiar” with coral reef management organizations was calculated. A threshold of seventy percent was established (i.e., a goal that at least 70% of respondents are at least “familiar” with management organizations). Coral reef managers in South Florida confirmed that this goal was appropriate (i.e., professional judgement).



Value or Importance of coral reefs

The value or importance that respondents in South Florida place on coral reefs was examined. This section of the survey contained four questions in which statements were proposed and respondents were asked to rate how much they "agree" with the statements on a scale of "strongly disagree" to "strongly agree." Two of these statements were ambiguous in their interpretation since an increase in agreement could be perceived as positive or negative by different stakeholders. As a result, they were omitted from analysis, and the other two questions in this section were analyzed. Agreement with these remaining statements can be interpreted as positive indicators. A threshold of seventy percent in agreement with the protection and culture statements was established after consultation with coral reef managers in South Florida.

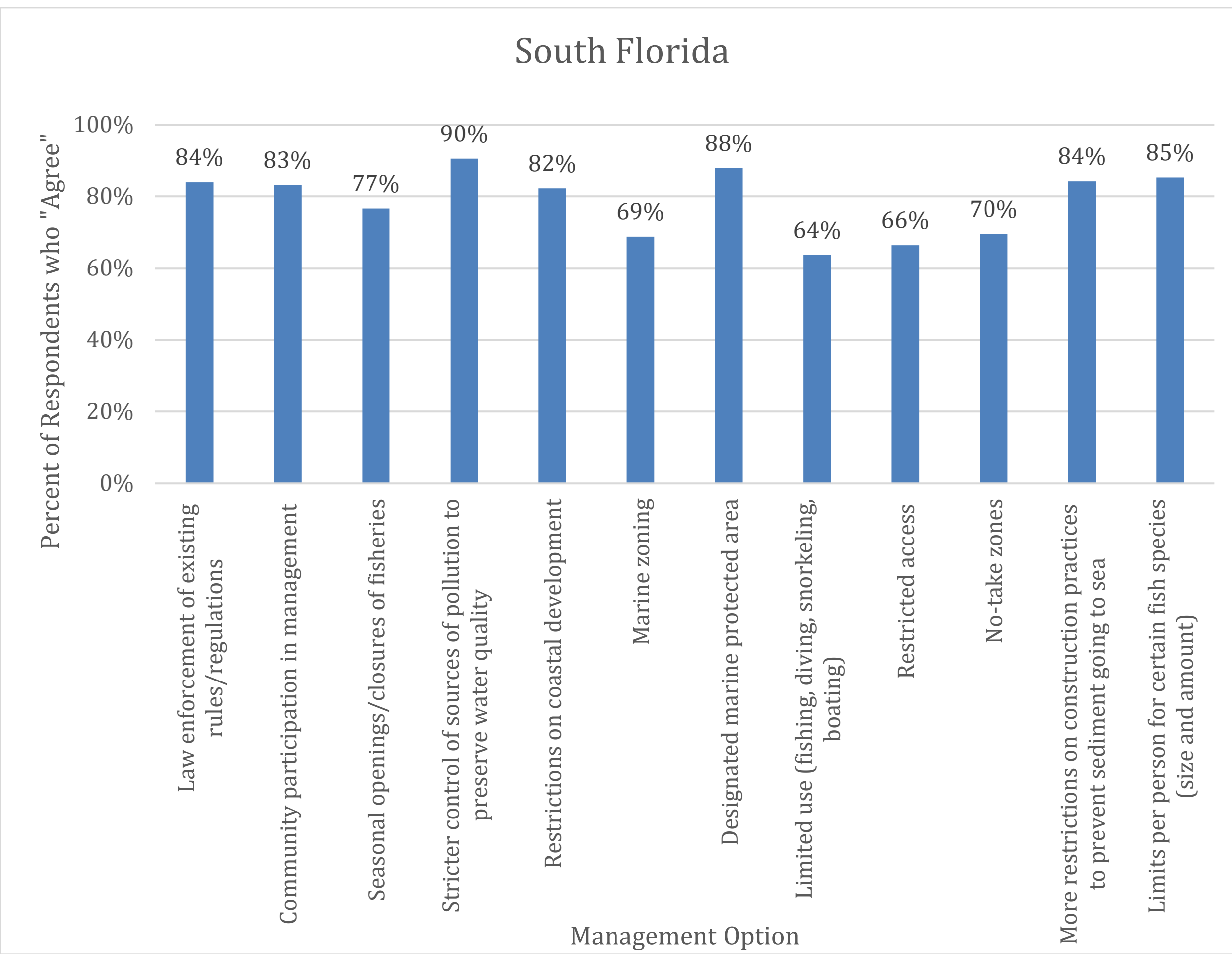


Pro-Environmental Behavior

The Pro-Environmental Behavior indicator measures residents' (active) participation in activities that help the environment, such as beach clean-ups, volunteering with an environmental group, recycling, etc. NCRMP survey respondents in South Florida were asked to rate their frequency of participation in pro-environmental behaviors on a scale of "not at all" to "several times a month or more." Through discussion with coral reef managers, a goal of seventy percent participation was established (i.e., a goal that at least 70% of respondents participate in any form of pro-environmental behavior and at any frequency).

Support for Management Actions

The Support for Management indicator measures the level of support that respondents to the NCRMP jurisdictional resident survey indicate for coral reef management activities. The South Florida survey asked for respondents' agreement with coral reef management rules and regulations. Respondents were asked to rate their level of agreement with various management options on a scale of "strongly disagree" to "strongly agree." After consultation with local partners, the threshold was set at seventy-five percent (i.e., 75% of respondents agree with the proposed management options).



V. OVERALL SCORING PROCESS

The above sections described the individual indicators and how they were compared against historical or reference data. Once the individual indicators within each category were scored, those scores were averaged within each category. For example, reef material growth, temperature stress, and ocean acidification each received a score, rounded to the whole number. Generally, those three scores were averaged for an overall climate score and rounded to the whole number.

The overall indicators scores for Florida's Coral Reef and U.S. Virgin Islands were area-weighted scores based on reporting region coral reef areas (see Section II for area calculations). For example, Florida's Coral Reef has three reporting regions – Southeast Florida, the Florida Keys, and Dry Tortugas. The three climate scores for these reporting regions were area-weighted and summed to the overall Florida individuals scores. For example, reef material growth was scored and rounded to the whole number for Southeast Florida, the Keys, and Dry Tortugas. That rounded score was area-weighted and summed to a Florida reef material growth score, rounded to the whole number. The three area-weighted indicator scores were averaged to an overall Florida *climate* score. The four category scores were averaged into an overall Florida *coral reef* health score.

The three category (corals & algae, fish, and climate) scores were averaged and rounded to the whole number for Flower Garden Banks, which did not have reporting regions within it. There is no Human Connection score for Flower Garden Banks. The four category (corals & algae, fish, climate, human connections) scores were averaged and rounded to the whole number for Puerto Rico, which did not have any reporting regions.

VI. SUMMARY

A coral reef status report addresses the need to summarize and communicate coral reef monitoring and assessment in U.S. jurisdictions to decision-makers, policy-makers, and the public. These assessments provide the status of U.S. coral reef areas in order to track change over time and evaluate ecosystem condition. This methods document explains the scoring process for the Flower Garden Banks, Florida's Coral Reef, Puerto Rico, and U.S. Virgin Islands coral reef status reports. The criteria which experts used to choose indicators were: 1) data availability, 2) sufficient understanding of reference conditions, and 3) importance to overall ecosystem health. These indicators and scoring process were refined over months of discussion between different groups, jurisdictions, and NOAA headquarters. This methods document should be used to understand the detailed process by which each indicator was assessed and scored.

VII. FREQUENTLY ASKED QUESTIONS

QUESTION: What is the NOAA Coral Reef Conservation Program?
ANSWER: NOAA's Coral Reef Conservation Program brings together expertise from across the agency (National Ocean Service, National Marine Fisheries Service, Office of Oceanic and Atmospheric Research, and National Environmental Satellite, Data, and Information Service) for a multidisciplinary approach to preserve, sustain, and restore the condition of coral reef ecosystems for current and future generations. The program was established in 2000 to help fulfill NOAA's responsibilities under the Coral Reef Conservation Act and Presidential Executive Order 13089 on Coral Reef Protection. It is headquartered in Silver Spring, Maryland and sits within NOAA's Office for Coastal Management. For more information, visit http://coralreef.noaa.gov/

QUESTION: **What is the National Coral Reef Monitoring Program?**
ANSWER: The National Coral Reef Monitoring Program was established by the Coral Reef Conservation Program as an integrated and focused monitoring effort with partners across the U.S. The resulting data provide a robust picture of the condition of U.S. coral reef ecosystems and the communities connected to them.

The goals of the National Coral Reef Monitoring Program are to:

- develop consistent and comparable methods and standard operating procedures (SOPs), which detail specific field, laboratory, and/or analytical procedures and best practices, for all indicators (with periodic updates to reflect new technologies or logistical considerations);
- develop and maintain strong partnerships with federal, state/territory, and academic partners;
- collect scientifically sound and geographically comprehensive biological, climate, and socioeconomic data in U.S. coral reef areas;
- deliver high-quality data, data products, and tools to the coral reef conservation community;
- provide context for interpreting results of localized monitoring; and,
- provide periodic assessments of the status and trends of the nation's coral reef ecosystems.

For more information, visit https://www.coris.noaa.gov/monitoring/

QUESTION: Are the status reports providing updated information to previously released status reports? If so, how do the results differ, if at all?
ANSWER: The status reports are new products from the National Coral Reef Monitoring Program that replace the previous State of the Reefs Reports.

QUESTION: How did CRCP create the physical status reports?
ANSWER: NOAA CRCP partnered with the University of Maryland Center for Environmental Sciences (UMCES) Integration and Application Network (IAN) to design the status reports. UMCES IAN specializes in synthesizing scientific monitoring data into communication products for the public and for policy makers without a science background.

QUESTION: **What data were used to create the status reports?**
ANSWER: The status reports include information on four indicator groups of coral reef ecosystem conditions:

- coral and algae, including cover, abundance, and mortality
- coral reef-dependent fish populations (including commercial fisheries)
- connections between coral reefs and climate and NOAA Coral Reef Watch data

- human connections to coral reefs using socioeconomic surveys

QUESTION: What do the scores mean?
ANSWER: The following rubric is used to assign overall scores to the jurisdictions:

Very Good (90-100%): All or almost all indicators meet reference values. Conditions in these locations are unimpacted, or minimally impacted. Human connections are very high.*
Good (80-89%): Most indicators meet reference values. Conditions in these locations are slightly impacted or have slightly declined. Human connections are high.*
Fair (70-79%): Some indicators meet reference values. Conditions in these locations are moderately impacted or have declined moderately. Human connections are moderate.
Impaired (60-69%): Few indicators meet reference values. Conditions in these locations are very impacted or have declined considerably. Human connections are lacking.
Critical (0-59%): Very few or no indicators meet reference values. Conditions in these locations are severely impacted or have declined substantially. Human connections are severely lacking.

*Human connections data are not collected in the Dry Tortugas region of Florida or the Flower Garden Banks because no humans live in those two regions.

QUESTION: **Why is there a specific methodology report for the Atlantic jurisdiction status reports?**
ANSWER: Each basin has a methodology report due to differences in methodologies for some indicator groups. For example, reef material growth differs between basins due to different coral species and having different growth rates. Human connections data also differ due to the parameters set for each jurisdiction by local stakeholders.

QUESTION: **Why are status reports only being released for Atlantic, Caribbean, and Gulf of Mexico states and territories?**
ANSWER: Status reports for the Pacific jurisdictions were released in December 2018. Because of data quality assurance and quality control (QA/QC), as well as resource availability, all nine Pacific and Atlantic jurisdictions' status reports were not able to be produced at the same time.

QUESTION: **Why was there such a large time gap between the release of the Atlantic, Caribbean, and Gulf of Mexico reports and Pacific reports?**
ANSWER: The status report process is a very collaborative and time-intensive process that begins with an in-person, multi-day stakeholder workshop, involves data analysis and content production, and ends with an 8-page printed document. The process typically takes one year from start to finish. The process includes data discovery, data QA/QC, data analyses, writing text, graphic design layout, and peer review. As such, five reports in the Pacific and four reports in the Atlantic represent a large body of work and require stakeholder input from each jurisdiction, which is why the Atlantic reports were released about a year after the Pacific reports. We plan to release a national roll-up summary report later this year (2020) to contextualize both sets of reports in one place.

QUESTION: **Why isn't there a standardized format among the status reports?**
ANSWER: The status report development process includes input from local stakeholders. The stakeholders decide what information (other than the data summary) should be featured and highlighted for the coastal communities in their jurisdiction. For example, Florida's report features a story about the response to Stony Coral Tissue Loss Disease, while the Puerto Rico report includes basic

"101" information on coral biology — information that stakeholders felt were a priority for their status report.

QUESTION: **Will the scores be used to inform work and projects? Will there be an effort to increase the scores for the next iteration?**
ANSWER: Scores are meant as a communication tool rather than to directly inform program activities. They are also not meant to assess management actions or restoration success. Scores represent the current condition of a particular U.S. coral reef area to the best of our knowledge in relation to its historical condition and are meant to inform a broader audience. The status report process helps to start a dialogue about the issues and threats facing coral reefs.

QUESTION: **Are scores comparable between jurisdictions?**
ANSWER: Scores are calculated based on the jurisdiction's specific historical conditions to the best of experts' knowledge, so scores are only representative of that region. To account for natural regional variability, the historical scoring baselines are unique to each jurisdiction. By developing jurisdiction-specific reference and assessment points, indicator scores are representative of that system only and are not a comparison between different regions.

QUESTION: How precise and accurate are scores?
ANSWER: Scores were analyzed in the most scientifically objective way possible for each jurisdiction given the data available from the NCRMP program and historical data available in each region to serve as a reference/baseline. Each jurisdiction was scored based on references that were determined by group consensus at local stakeholder workshops that kicked-off each status report process. Please see the methods document for a full explanation of the scoring process.

QUESTION: **What is the plan for future reports?**
ANSWER: Because this was CRCP's first time with these types of status reports, we will evaluate their release and determine if or when they will be repeated.

QUESTION: Were the scores surprising or what you would expect?
ANSWER: It is important to note that the scores represent data collected from 2014 to 2018. Many stressors impacted coral reefs during that time and have continued to affect reefs since, and data collected in 2019 was not yet ready to be incorporated into these reports at the time of publication.

- **Florida** (Impaired: 69%):
    - It's important to note that these results are compared to a baseline that may already represent significant changes from an even earlier state of the system. Ideally, a historical baseline would be data collected before the U.S. industrial revolution in the 1800s. However, we don't have much scientific monitoring data in U.S. coral reef regions collected before the 1970s or 1980s; therefore, the score of "Impaired" reflects an already shifting baseline.
    - A lower score might have been expected due to Stony Coral Tissue Loss Disease, which was first identified in Miami-Dade County, Florida in 2014. As of 2019, the disease was observed from the upper reaches of Florida's Coral Reef continuing past Key West, yet 2019 data is not reflected in this report. See Stony Coral Tissue Loss Disease figure in Florida status report.
    - When the individual indicators are examined, the only indicator that is "Good" is fish diversity. Within regions, fish diversity is "Good" or "Very Good" in the Florida Keys and the Dry Tortugas, which is the result of successful management, especially with

ornamental coral reef fishes. This is a success story that highlights the importance of management and regulation. Scores for corals & algae, climate, and human connections suggest that overall Florida is impaired for coral reef health and should not be expected to improve quickly due to Stony Coral Tissue Loss Disease and climate change.
    - There are opportunities to change the trajectory of coral reef conditions in Florida with initiatives like the Florida Keys National Marine Sanctuary Restoration Blueprint and *Mission: Iconic Reefs* that aim to improve coral conditions through active restoration and conservation. The positive scores for fish diversity support continued management and restoration work through these initiatives.
- **Flower Garden Banks** (Good: 89%): Flower Garden Banks is a huge success story, highlighting that healthy coral reef ecosystems do still exist in U.S. waters.
    - These results suggest that Flower Garden Banks has not degraded much relative to its historical baseline, in part because Flower Garden Banks is well-managed and far away from coastal human populations. It is also in deeper waters, which may limit extensive human usage as it is hard to access and protect the reefs from some climate change impacts.
    - These results highlight the importance of engaging in pro-environmental behaviors for communities in much closer proximity to coral reefs.
    - The status report should support the upcoming open comment period for changes to the proposed boundaries of Flower Garden Banks National Marine Sanctuary, as well as pelagic longline and spearfishing exemption requests.
- **Puerto Rico** (Fair: 70%): Puerto Rico's score is right on the cusp of being categorized as "Impaired."
    - Areas that were critical in Puerto Rico were reef fish diversity as well as survey respondents' self-reported participation in pro-environmental behaviors.
    - However, in Puerto Rico, survey respondents had very high support for management actions, and temperature stress was good in the data used for this report.
- **US Virgin Islands** (Fair: 72%): USVI's score may be due to a smaller human population as well as other factors.
    - Critical scores, meaning human connections are severely lacking, in USVI were in survey respondents' self-reported engagement in pro-environmental behaviors and in reef fish sustainability.
    - However, temperature stress was good in the data used for this report, as was coral mortality (indicating not much observed temperature stress and not much observed coral mortality).
    - Additionally, Stony Coral Tissue Loss Disease had not yet been observed in St. Thomas when the data to support this report were collected. Some data were also lost due to the 2017 hurricane season.

QUESTION: What do scores use as a baseline/reference point?
ANSWER: Corals & algae - Developing the reference/baseline values for biophysical indicators (benthic and fish) was consistently the most challenging part of each status report process. The workshop discussions centered on how to capture pre-human impact conditions when robust historical data did not exist or was not statistically comparable to the NCRMP datasets. The concept of shifting baselines was discussed extensively, as ideally references would all be pre-disturbance, i.e., major hurricanes, bleaching events, disease events, etc. However, in some jurisdictions, reference data prior to the 2000s did not exist, and so the challenge was comparing current data to reference data that was already impacted, hence the shifting baseline. **Climate -** Developing reference/baseline data for the climate data

was much easier because we have very good historical data records of pre-human impact conditions, i.e., we know what pre-industrial carbon dioxide values were. **Human connection -** Human connection data references were more subjective and were chosen using expert opinion because of their nature, i.e., local stakeholders helped develop what they thought would be a reasonable baseline for the percentage of their surveyed population that is aware of threats to coral reefs, etc.

QUESTION: Is it possible for an area to achieve a Very Good score?
ANSWER: Yes, all indicators can receive a Very Good score in comparison to historical baseline conditions within a jurisdiction. However, because of past and more recent impacts such as bleaching events, hurricanes, etc., it will be difficult for some indicators to receive a Very Good score for many years. One can see in the current reports that some indicators did receive "Very Good" scores, especially in offshore regions like Flower Garden Banks that are further away from human impacts.

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APPENDIX A

List of fish species used in richness calculations for all reporting jurisdictions.

COMMON_NAME	SCIENTIFIC_NAME
African pompano	*Alectis ciliaris*
almaco jack	*Seriola rivoliana*
Atlantic bearded brotula	*Brotula barbata*
Atlantic bonito	*Sarda*
Atlantic creolefish	*Paranthias furcifer*
Atlantic guitarfish	*Rhinobatos lentiginosus*
Atlantic spadefish	*Chaetodipterus faber*
Atlantic trumpetfish	*Aulostomus maculatus*
balloonfish	*Diodon holocanthus*
banded butterflyfish	*Chaetodon striatus*
banded jawfish	*Opistognathus macrognathus*
banded rudderfish	*Seriola zonata*
bandtail puffer	*Sphoeroides spengleri*
bandtail searobin	*Prionotus ophryas*
bandtooth conger	*Ariosoma balearicum*
bank butterflyfish	*Prognathodes aya*
bank sea bass	*Centropristis ocyurus*
bar jack	*Caranx ruber*
barred cardinalfish	*Apogon binotatus*
barred hamlet	*Hypoplectrus puella*
beaugregory	*Stegastes leucostictus*
belted cardinalfish	*Apogon townsendi*
belted sandfish	*Serranus subligarius*
Bermuda chub	*Kyphosus sectatrix*
bicolor damselfish	*Stegastes partitus*
bigeye	*Priacanthus arenatus*
black brotula	*Stygnobrotula latebricola*
black durgon	*Melichthys niger*
black grouper	*Mycteroperca bonaci*
black hamlet	*Hypoplectrus nigricans*
black jack	*Caranx lugubris*
black margate	*Anisotremus surinamensis*
black sea bass	*Centropristis striata*
blackbar soldierfish	*Myripristis jacobus*
blackear wrasse	*Halichoeres poeyi*
blackedge moray	*Gymnothorax nigromarginatus*
blackfin cardinalfish	*Astrapogon puncticulatus*
blackfin snapper	*Lutjanus buccanella*
blacktip shark	*Carcharhinus limbatus*

blackwing searobin	*Prionotus rubio*
blue angelfish	*Holacanthus bermudensis*
blue chromis	*Chromis cyanea*
blue dartfish	*Ptereleotris calliura*
blue hamlet	*Hypoplectrus gemma*
blue parrotfish	*Scarus coeruleus*
blue runner	*Caranx crysos*
blue tang	*Acanthurus coeruleus*
bluehead	*Thalassoma bifasciatum*
bluelip parrotfish	*Cryptotomus roseus*
bluespotted cornetfish	*Fistularia tabacaria*
bluestriped grunt	*Haemulon sciurus*
bluestriped lizardfish	*Synodus saurus*
boga	*Inermia vittata*
bonefish	*Albula vulpes*
bonnethead	*Sphyrna tiburo*
bonnetmouth	*Emmelichthyops atlanticus*
bridle cardinalfish	*Apogon aurolineatus*
bridled burrfish	*Chilomycterus antennatus*
brown chromis	*Chromis multilineata*
brown garden eel	*Heteroconger longissimus*
bucktooth parrotfish	*Sparisoma radians*
bull shark	*Carcharhinus leucas*
butter hamlet	*Hypoplectrus unicolor*
caesar grunt	*Haemulon carbonarium*
cave basslet	*Liopropoma mowbrayi*
cero	*Scomberomorus regalis*
chain moray	*Echidna catenata*
chalk bass	*Serranus tortugarum*
checkered puffer	*Sphoeroides testudineus*
cherubfish	*Centropyge argi*
chestnut moray	*Enchelycore carychroa*
clown wrasse	*Halichoeres maculipinna*
cobia	*Rachycentron canadum*
cocoa damselfish	*Stegastes variabilis*
common snook	*Centropomus undecimalis*
conchfish	*Astrapogon stellatus*
coney	*Cephalopholis fulva*
cottonwick	*Haemulon melanurum*
cownose ray	*Rhinoptera bonasus*
creole wrasse	*Clepticus parrae*
crevalle jack	*Caranx hippos*
cubbyu	*Pareques umbrosus*
cubera snapper	*Lutjanus cyanopterus*

deepwater squirrelfish	*Sargocentron bullisi*
doctorfish	*Acanthurus chirurgus*
dog snapper	*Lutjanus jocu*
dusky damselfish	*Stegastes adustus*
dusky shark	*Carcharhinus obscurus*
dusky squirrelfish	*Sargocentron vexillarium*
dwarf goatfish	*Upeneus parvus*
dwarf sand perch	*Diplectrum bivittatum*
dwarf wrasse	*Doratonotus megalepis*
emerald parrotfish	*Nicholsina usta*
fairy basslet	*Gramma loreto*
flagfin mojarra	*Eucinostomus melanopterus*
flameback angelfish	*Centropyge aurantonotus*
flamefish	*Apogon maculatus*
flying gurnard	*Dactylopterus volitans*
foureye butterflyfish	*Chaetodon capistratus*
freckled soapfish	*Rypticus bistrispinus*
French angelfish	*Pomacanthus paru*
French grunt	*Haemulon flavolineatum*
fringed filefish	*Monacanthus ciliatus*
gag	*Mycteroperca microlepis*
glasseye snapper	*Heteropriacanthus cruentatus*
glassy sweeper	*Pempheris schomburgkii*
golden hamlet	*Hypoplectrus gummigutta*
goldentail moray	*Gymnothorax miliaris*
goldface toby	*Canthigaster jamestyleri*
goldspotted eel	*Myrichthys ocellatus*
goliath grouper	*Epinephelus itajara*
gray angelfish	*Pomacanthus arcuatus*
gray snapper	*Lutjanus griseus*
gray triggerfish	*Balistes capriscus*
graysby	*Cephalopholis cruentata*
great barracuda	*Sphyraena barracuda*
great hammerhead	*Sphyrna mokarran*
greater amberjack	*Seriola dumerili*
greater soapfish	*Rypticus saponaceus*
green moray	*Gymnothorax funebris*
green razorfish	*Xyrichtys splendens*
greenblotch parrotfish	*Sparisoma atomarium*
guaguanche	*Sphyraena guachancho*
harlequin bass	*Serranus tigrinus*
high-hat	*Pareques acuminatus*
hogfish	*Lachnolaimus maximus*
honeycomb cowfish	*Acanthostracion polygonia*

honeycomb moray	*Gymnothorax saxicola*
horse-eye jack	*Caranx latus*
hovering dartfish	*Ptereleotris helenae*
hybrid hamlet	*Hypoplectrus hybrid*
indigo hamlet	*Hypoplectrus indigo*
inshore lizardfish	*Synodus foetens*
jackknife-fish	*Equetus lanceolatus*
jolthead porgy	*Calamus bajonado*
key worm eel	*Ahlia egmontis*
king mackerel	*Scomberomorus cavalla*
knobbed porgy	*Calamus nodosus*
ladyfish	*Elops saurus*
lancer dragonet	*Paradiplogrammus bairdi*
lane snapper	*Lutjanus synagris*
lantern bass	*Serranus baldwini*
leatherjack	*Oligoplites saurus*
lemon shark	*Negaprion brevirostris*
lesser electric ray	*Narcine bancroftii*
little tunny	*Euthynnus alletteratus*
littlehead porgy	*Calamus proridens*
longfin damselfish	*Stegastes diencaeus*
longjaw squirrelfish	*Neoniphon marianus*
longsnout butterflyfish	*Prognathodes aculeatus*
longspine squirrelfish	*Holocentrus rufus*
lookdown	*Selene vomer*
mahogany snapper	*Lutjanus mahogoni*
manytooth conger	*Conger triporiceps*
marbled grouper	*Dermatolepis inermis*
mardi gras wrasse	*Halichoeres burekae*
margate	*Haemulon album*
midnight parrotfish	*Scarus coelestinus*
mimic cardinalfish	*Apogon phenax*
mottled jawfish	*Opistognathus maxillosus*
mottled mojarra	*Eucinostomus lefroyi*
mutton hamlet	*Alphestes afer*
mutton snapper	*Lutjanus analis*
Nassau grouper	*Epinephelus striatus*
night sergeant	*Abudefduf taurus*
northern stargazer	*Astroscopus guttatus*
nurse shark	*Ginglymostoma cirratum*
ocean surgeon	*Acanthurus bahianus*
ocean triggerfish	*Canthidermis sufflamen*
ocellated frogfish	*Antennarius ocellatus*
orange filefish	*Aluterus schoepfii*

orangeback bass	*Serranus annularis*
orangespotted filefish	*Cantherhines pullus*
orbicular batfish	*Platax orbicularis*
oyster toadfish	*Opsanus tau*
painted wrasse	*Halichoeres caudalis*
palometa	*Trachinotus goodei*
pearly razorfish	*Xyrichtys novacula*
peppermint basslet	*Liopropoma rubre*
permit	*Trachinotus falcatus*
pigfish	*Orthopristis chrysoptera*
pinfish	*Lagodon rhomboides*
planehead filefish	*Stephanolepis hispidus*
pluma porgy	*Calamus pennatula*
porcupinefish	*Diodon hystrix*
porkfish	*Anisotremus virginicus*
princess parrotfish	*Scarus taeniopterus*
puddingwife	*Halichoeres radiatus*
purple reeffish	*Chromis scotti*
purplemouth moray	*Gymnothorax vicinus*
pygmy filefish	*Stephanolepis setifer*
pygmy sea bass	*Serraniculus pumilio*
queen angelfish	*Holacanthus ciliaris*
queen parrotfish	*Scarus vetula*
queen triggerfish	*Balistes vetula*
rainbow parrotfish	*Scarus guacamaia*
rainbow runner	*Elagatis bipinnulata*
rainbow wrasse	*Halichoeres pictus*
red grouper	*Epinephelus morio*
red hind	*Epinephelus guttatus*
red lionfish	*Pterois volitans*
red lizardfish	*Synodus synodus*
red porgy	*Pagrus pagrus*
red snapper	*Lutjanus campechanus*
redband parrotfish	*Sparisoma aurofrenatum*
redspotted hawkfish	*Amblycirrhitus pinos*
redtail parrotfish	*Sparisoma chrysopterum*
reef butterflyfish	*Chaetodon sedentarius*
reef croaker	*Odontoscion dentex*
reef scorpionfish	*Scorpaenodes caribbaeus*
reef shark	*Carcharhinus perezii*
reef squirrelfish	*Sargocentron coruscum*
reticulate moray	*Muraena retifera*
rock beauty	*Holacanthus tricolor*
rock hind	*Epinephelus adscensionis*

rosy razorfish	*Xyrichtys martinicensis*
sailors choice	*Haemulon parra*
sand diver	*Synodus intermedius*
sand drum	*Umbrina coroides*
sand perch	*Diplectrum formosum*
sand tilefish	*Malacanthus plumieri*
sandbar shark	*Carcharhinus plumbeus*
saucereye porgy	*Calamus calamus*
sawcheek cardinalfish	*Apogon quadrisquamatus*
scalloped hammerhead	*Sphyrna lewini*
scamp	*Mycteroperca phenax*
school bass	*Schultzea beta*
schoolmaster	*Lutjanus apodus*
scrawled cowfish	*Acanthostracion quadricornis*
scrawled filefish	*Aluterus scriptus*
sea bream	*Archosargus rhomboidalis*
sergeant major	*Abudefduf saxatilis*
sharpnose puffer	*Canthigaster rostrata*
sharptail eel	*Myrichthys breviceps*
sheepshead	*Archosargus probatocephalus*
sheepshead porgy	*Calamus penna*
shortnose batfish	*Ogcocephalus nasutus*
shy hamlet	*Hypoplectrus guttavarius*
silver jenny	*Eucinostomus gula*
silver porgy	*Diplodus argenteus*
slender filefish	*Monacanthus tuckeri*
slender mojarra	*Eucinostomus jonesii*
slippery dick	*Halichoeres bivittatus*
smallmouth grunt	*Haemulon chrysargyreum*
smooth trunkfish	*Lactophrys triqueter*
snake eel Myrichthys	*Myrichthys species*
Snowy grouper	*Epinephelus niveatus*
southern puffer	*Sphoeroides nephelus*
southern sennet	*Sphyraena picudilla*
southern stargazer	*Astroscopus y-graecum*
southern stingray	*Dasyatis americana*
Spanish grunt	*Haemulon macrostomum*
Spanish hogfish	*Bodianus rufus*
Spanish mackerel	*Scomberomorus maculatus*
speckled hind	*Epinephelus drummondhayi*
splitfin bass	*Parasphyraenops incisus*
sponge cardinalfish	*Phaeoptyx xenus*
spotfin butterflyfish	*Chaetodon ocellatus*
spotfin hogfish	*Bodianus pulchellus*

spotfin mojarra	*Eucinostomus argenteus*
spottail pinfish	*Diplodus holbrookii*
spotted burrfish	*Chilomycterus atinga*
spotted drum	*Equetus punctatus*
spotted eagle ray	*Aetobatus narinari*
spotted goatfish	*Pseudupeneus maculatus*
spotted moray	*Gymnothorax moringa*
spotted scorpionfish	*Scorpaena plumieri*
spotted snake eel	*Ophichthus ophis*
spotted trunkfish	*Lactophrys bicaudalis*
squirrelfish	*Holocentrus adscensionis*
stoplight parrotfish	*Sparisoma viride*
striped burrfish	*Chilomycterus schoepfii*
striped grunt	*Haemulon striatum*
striped parrotfish	*Scarus iseri*
sunshinefish	*Chromis insolata*
swordtail jawfish	*Lonchopisthus micrognathus*
tan hamlet	*Hypoplectrus tann*
tarpon	*Megalops atlanticus*
tattler	*Serranus phoebe*
threespot damselfish	*Stegastes planifrons*
tiger grouper	*Mycteroperca tigris*
tiger shark	*Galeocerdo cuvier*
tobaccofish	*Serranus tabacarius*
tomtate	*Haemulon aurolineatum*
townsend angelfish	*Holocanthus townsendi*
trunkfish	*Lactophrys trigonus*
twinspot bass	*Serranus flaviventris*
twospot cardinalfish	*Apogon pseudomaculatus*
unicorn filefish	*Aluterus monoceros*
vermilion snapper	*Rhomboplites aurorubens*
viper moray	*Enchelycore nigricans*
wahoo	*Acanthocybium solandri*
wenchman	*Pristipomoides aquilonaris*
western comb grouper	*Mycteroperca acutirostris*
white grunt	*Haemulon plumierii*
whitebone porgy	*Calamus leucosteus*
whitespotted filefish	*Cantherhines macrocerus*
whitespotted soapfish	*Rypticus maculatus*
whitestar cardinalfish	*Apogon lachneri*
wrasse basslet	*Liopropoma eukrines*
yellow goatfish	*Mulloidichthys martinicus*
yellow jack	*Carangoides bartholomaei*
yellow stingray	*Urobatis jamaicensis*

yellowbelly hamlet	*Hypoplectrus aberrans*
yellowcheek wrasse	*Halichoeres cyanocephalus*
yellowedge grouper	*Epinephelus flavolimbatus*
yellowfin grouper	*Mycteroperca venenosa*
yellowfin mojarra	*Gerres cinereus*
yellowhead jawfish	*Opistognathus aurifrons*
yellowhead wrasse	*Halichoeres garnoti*
yellowmouth grouper	*Mycteroperca interstitialis*
yellowtail damselfish	*Microspathodon chrysurus*
yellowtail hamlet	*Hypoplectrus chlorurus*
yellowtail parrotfish	*Sparisoma rubripinne*
yellowtail reeffish	*Chromis enchrysura*
yellowtail snapper	*Ocyurus chrysurus*

APPENDIX B

List of species used in ornamental density calculations for all Florida jurisdictions.

COMMON_NAME	SCIENTIFIC_NAME
sergeant major	*Abudefduf saxatilis*
roughhead blenny	*Acanthemblemaria aspera*
papillose blenny	*Acanthemblemaria chaplini*
secretary blenny	*Acanthemblemaria maria*
tube blenny Acanthemblemaria	*Acanthemblemaria species*
spinyhead blenny	*Acanthemblemaria spinosa*
honeycomb cowfish	*Acanthostracion polygonia*
scrawled cowfish	*Acanthostracion quadricornis*
ocean surgeon	*Acanthurus bahianus*
doctorfish	*Acanthurus chirurgus*
blue tang	*Acanthurus coeruleus*
surgeonfish species	*Acanthurus sp.*
key worm eel	*Ahlia egmontis*
mutton hamlet	*Alphestes afer*
unicorn filefish	*Aluterus monoceros*
orange filefish	*Aluterus schoepfii*
scrawled filefish	*Aluterus scriptus*
filefish species	*Aluterus sp.*
redspotted hawkfish	*Amblycirrhitus pinos*
porkfish	*Anisotremus virginicus*
ocellated frogfish	*Antennarius ocellatus*
bridle cardinalfish	*Apogon aurolineatus*
barred cardinalfish	*Apogon binotatus*
flamefish	*Apogon maculatus*
twospot cardinalfish	*Apogon pseudomaculatus*
sawcheek cardinalfish	*Apogon quadrisquamatus*
cardinalfish species	*Apogon species*
belted cardinalfish	*Apogon townsendi*
bandtooth conger	*Ariosoma balearicum*
cardinalfish species	*Astrapogon sp.*
conchfish	*Astrapogon stellatus*
Atlantic trumpetfish	*Aulostomus maculatus*
triggerfish species	*Balistes sp.*
queen triggerfish	*Balistes vetula*
frillfin goby	*Bathygobious soporator*
blenny species	*blenny species*
spotfin hogfish	*Bodianus pulchellus*
Spanish hogfish	*Bodianus rufus*
white-eye goby	*Bollmannia boqueronensis*

whitespotted filefish	*Cantherhines macrocerus*
orangespotted filefish	*Cantherhines pullus*
ocean triggerfish	*Canthidermis sufflamen*
sharpnose puffer	*Canthigaster rostrata*
cherubfish	*Centropyge argi*
yellowface pikeblenny	*Chaenopsis limbaughi*
bluethroat pikeblenny	*Chaenopsis ocellata*
pikeblenny species	*Chaenopsis species*
foureye butterflyfish	*Chaetodon capistratus*
spotfin butterflyfish	*Chaetodon ocellatus*
reef butterflyfish	*Chaetodon sedentarius*
banded butterflyfish	*Chaetodon striatus*
striped burrfish	*Chilomycterus schoepfii*
blue chromis	*Chromis cyanea*
yellowtail reeffish	*Chromis enchrysura*
sunshinefish	*Chromis insolata*
brown chromis	*Chromis multilineata*
purple reeffish	*Chromis scotti*
creole wrasse	*Clepticus parrae*
manytooth conger	*Conger triporiceps*
colon goby	*Coryphopterus dicrus*
pallid goby	*Coryphopterus eidolon*
bridled goby	*Coryphopterus glaucofraenum*
peppermint goby	*Coryphopterus lipernes*
masked goby	*Coryphopterus personatus*
spotted goby	*Coryphopterus punctipectophorus*
goby species	*Coryphopterus sp.*
patch-reef goby	*Coryphopterus tortugae*
sand-canyon goby	*Coryphopterus venezuelae*
bluelip parrotfish	*Cryptotomus roseus*
dash goby	*Ctenogobius saepepallens*
marked goby	*Ctenogobius stigmaticus*
damselfish species	*damselfish species*
balloonfish	*Diodon holocanthus*
porcupinefish	*Diodon hystrix*
dwarf wrasse	*Doratonotus megalepis*
chain moray	*Echidna catenata*
shortstripe goby	*Elacatinus chancei*
sharknose goby	*Elacatinus evelynae*
yellowline goby	*Elacatinus horsti*
spotlight goby	*Elacatinus louisae*
tiger goby	*Elacatinus macrodon*
greenbanded goby	*Elacatinus multifasciatus*
neon goby	*Elacatinus oceanops*

broadstripe goby	*Elacatinus prochilos*
yellownose goby	*Elacatinus randalli*
leopard goby	*Elacatinus saucrum*
yellowprow goby	*Elacatinus xanthiprora*
sailfin blenny	*Emblemaria pandionis*
tube blenny Emblemaria	*Emblemaria species*
blackhead blenny	*Emblemariopsis bahamensis*
glass blenny	*Emblemariopsis diapha*
tube blenny Emblemariopsis	*Emblemariopsis species*
chestnut moray	*Enchelycore carychroa*
viper moray	*Enchelycore nigricans*
pearl blenny	*Entomacrodus nigricans*
jackknife-fish	*Equetus lanceolatus*
spotted drum	*Equetus punctatus*
bluespotted cornetfish	*Fistularia tabacaria*
goldspot goby	*Gnatholepis thompsoni*
rockcut goby	*Gobiosoma grosvenori*
goby species	*goby species*
green moray	*Gymnothorax funebris*
goldentail moray	*Gymnothorax miliaris*
spotted moray	*Gymnothorax moringa*
blackedge moray	*Gymnothorax nigromarginatus*
honeycomb moray	*Gymnothorax saxicola*
moray eel Gymnothorax	*Gymnothorax species*
purplemouth moray	*Gymnothorax vicinus*
slippery dick	*Halichoeres bivittatus*
mardi gras wrasse	*Halichoeres burekae*
painted wrasse	*Halichoeres caudalis*
yellowcheek wrasse	*Halichoeres cyanocephalus*
yellowhead wrasse	*Halichoeres garnoti*
clown wrasse	*Halichoeres maculipinna*
rainbow wrasse	*Halichoeres pictus*
blackear wrasse	*Halichoeres poeyi*
puddingwife	*Halichoeres radiatus*
wrasse species	*Halichoeres species*
wrasse blenny	*Hemiemblemaria simula*
lined seahorse	*Hippocampus erectus*
longsnout seahorse	*Hippocampus reidi*
seahorse/pipefish species	*Hippocampus species*
blue angelfish	*Holacanthus bermudensis*
queen angelfish	*Holacanthus ciliaris*
rock beauty	*Holacanthus tricolor*
townsend angelfish	*Holocanthus townsendi*
barred blenny	*Hypleurochilus bermudensis*

blue hamlet	*Hypoplectrus gemma*
shy hamlet	*Hypoplectrus guttavarius*
indigo hamlet	*Hypoplectrus indigo*
black hamlet	*Hypoplectrus nigricans*
barred hamlet	*Hypoplectrus puella*
butter hamlet	*Hypoplectrus unicolor*
labrisomid blenny species	*Labrisomid sp.*
puffcheek blenny	*Labrisomus bucciferus*
quillfin blenny	*Labrisomus filamentosus*
palehead blenny	*Labrisomus gobio*
downy blenny	*Labrisomus kalisherae*
spotcheek blenny	*Labrisomus nigricinctus*
hairy blenny	*Labrisomus nuchipinnis*
spotted trunkfish	*Lactophrys bicaudalis*
trunkfish species	*Lactophrys species*
trunkfish	*Lactophrys trigonus*
smooth trunkfish	*Lactophrys triqueter*
wrasse basslet	*Liopropoma eukrines*
cave basslet	*Liopropoma mowbrayi*
peppermint basslet	*Liopropoma rubre*
swordtail jawfish	*Lonchopisthus micrognathus*
crested goby	*Lophogobius cyprinoides*
goldline blenny	*Malacoctenus aurolineatus*
diamond blenny	*Malacoctenus boehlkei*
dusky blenny	*Malacoctenus gilli*
rosy blenny	*Malacoctenus macropus*
blenny species	*Malacoctenus species*
saddled blenny	*Malacoctenus triangulatus*
barfin blenny	*Malacoctenus versicolor*
black durgon	*Melichthys niger*
Seminole goby	*Microgobius carri*
banner goby	*Microgobius microlepis*
dashback goby	*Microgobius signatus*
goby Microgobius	*Microgobius species*
yellowtail damselfish	*Microspathodon chrysurus*
filefish species	*Mocanthus species*
fringed filefish	*Monacanthus ciliatus*
slender filefish	*Monacanthus tuckeri*
reticulate moray	*Muraena retifera*
moray species	*Muraenidae species*
sharptail eel	*Myrichthys breviceps*
goldspotted eel	*Myrichthys ocellatus*
blackbar soldierfish	*Myripristis jacobus*
orangespotted goby	*Nes longus*

emerald parrotfish	*Nicholsina usta*
reef croaker	*Odontoscion dentex*
shortnose batfish	*Ogcocephalus nasutus*
batfish species	*Ogcocephalus sp.*
redlip blenny	*Ophioblennius macclurei*
yellowhead jawfish	*Opistognathus aurifrons*
banded jawfish	*Opistognathus macrognathus*
mottled jawfish	*Opistognathus maxillosus*
jawfish species	*Opistognathus sp.*
dusky jawfish	*Opistognathus whitehursti*
oyster toadfish	*Opsanus tau*
spotfin goby	*Oxyurichthys stigmalophius*
seaweed blenny	*Parablennius marmoreus*
marbled blenny	*Paraclinus marmoratus*
blackfin blenny	*Paraclinus nigripinnis*
Atlantic creolefish	*Paranthias furcifer*
high-hat	*Pareques acuminatus*
cubbyu	*Pareques umbrosus*
glassy sweeper	*Pempheris schomburgkii*
orbicular batfish	*Platax orbicularis*
gray angelfish	*Pomacanthus arcuatus*
French angelfish	*Pomacanthus paru*
rusty goby	*Priolepis hipoliti*
longsnout butterflyfish	*Prognathodes aculeatus*
razorfish species	*razorfish species*
tusked goby	*Risor ruber*
greater soapfish	*Rypticus saponaceus*
molly miller	*Scartella cristata*
midnight parrotfish	*Scarus coelestinus*
blue parrotfish	*Scarus coeruleus*
rainbow parrotfish	*Scarus guacamaia*
striped parrotfish	*Scarus iseri*
parrotfish species	*Scarus sp.*
princess parrotfish	*Scarus taeniopterus*
queen parrotfish	*Scarus vetula*
orangeback bass	*Serranus annularis*
lantern bass	*Serranus baldwini*
belted sandfish	*Serranus subligarius*
tobaccofish	*Serranus tabacarius*
harlequin bass	*Serranus tigrinus*
chalk bass	*Serranus tortugarum*
greenblotch parrotfish	*Sparisoma atomarium*
redband parrotfish	*Sparisoma aurofrenatum*
redtail parrotfish	*Sparisoma chrysopterum*

bucktooth parrotfish	*Sparisoma radians*
yellowtail parrotfish	*Sparisoma rubripinne*
parrotfish species	*Sparisoma sp.*
stoplight parrotfish	*Sparisoma viride*
dusky damselfish	*Stegastes adustus*
longfin damselfish	*Stegastes diencaeus*
beaugregory	*Stegastes leucostictus*
bicolor damselfish	*Stegastes partitus*
threespot damselfish	*Stegastes planifrons*
cocoa damselfish	*Stegastes variabilis*
planehead filefish	*Stephanolepis hispidus*
pygmy filefish	*Stephanolepis setifer*
black brotula	*Stygnobrotula latebricola*
dashback goby	*Syngnathus dawsoni*
bluehead	*Thalassoma bifasciatum*
yellow stingray	*Urobatis jamaicensis*
rosy razorfish	*Xyrichtys martinicensis*
pearly razorfish	*Xyrichtys novacula*
green razorfish	*Xyrichtys splendens*

APPENDIX C

List of species used in ornamental density calculations for all Florida jurisdictions.

Common Name	Scientific Name	M	K	L_{∞}	L_c	L_{λ}	L_m
Queen Triggerfish	*Balistes vetula*	0.21	0.14	441.30	290.00	400.00	21.50
Gray triggerfish	*Balistes capriscus*	0.21	0.14	589.70	304.80	523.86	21.00
Coney	*Cephalopholis fulva*	0.16	0.20	377.00	200.00	372.84	22.00
Red Hind	*Epinephelus guttatus*	0.17	0.11	571.00	210.00	514.94	21.50
Red grouper	*Epinephelus morio*	0.10	0.13	829.00	440.05	810.05	29.00
Nassau grouper	*Epinephelus striatus*	0.14	0.10	932.00	300.00	844.88	43.50
White Grunt	*Haemulon plumierii*	0.17	0.52	280.95	170.00	280.93	16.70
Bluestriped Grunt	*Haemulon sciurus*	0.13	0.32	314.00	190.00	313.89	20.50
Hogfish	*Lachnolaimus maximus*	0.13	0.11	848.99	304.80	784.27	18.00
Mutton snapper	*Lutjanus analis*	0.07	0.17	799.05	419.89	798.16	32.30
Schoolmaster snapper	*Lutjanus apodus*	0.07	0.12	482.00	254.00	479.77	20.00
Gray snapper	*Lutjanus griseus*	0.11	0.17	717.00	234.40	670.43	23.00
Dog Snapper	*Lutjanus jocu*	0.10	0.11	878.00	291.21	842.48	48.00
Lane snapper	*Lutjanus synagris*	0.18	0.17	449.00	187.36	432.93	24.00
Black grouper	*Mycteroperca bonaci*	0.09	0.14	1334.00	594.59	1289.41	83.00
Yellowmouth grouper	*Mycteroperca interstitialis*	0.10	0.14	755.00	474.20	746.93	42.00
Scamp	*Mycteroperca phenax*	0.10	0.09	772.00	377.19	740.09	33.00
Yellowtail snapper	*Ocyurus chrysurus*	0.13	0.13	489.35	230.00	474.20	23.20
Barracuda	*Sphyraena barracuda*	0.16	0.26	1236.40	0.00	1229.05	80.00

Life history parameter definitions.

Parameter	Definition	Units
M	Mortality Estimator	
K	Brody's growth coefficient	per year
L_{∞}	Asymptotic length	mm
L_c	Length at first capture	mm
L_{λ}	Length at maximum age	mm
L_m	Length at 50% maturity	mm