

South Florida/Carribean Network

National Park Service
Inventory and Monitoring Division

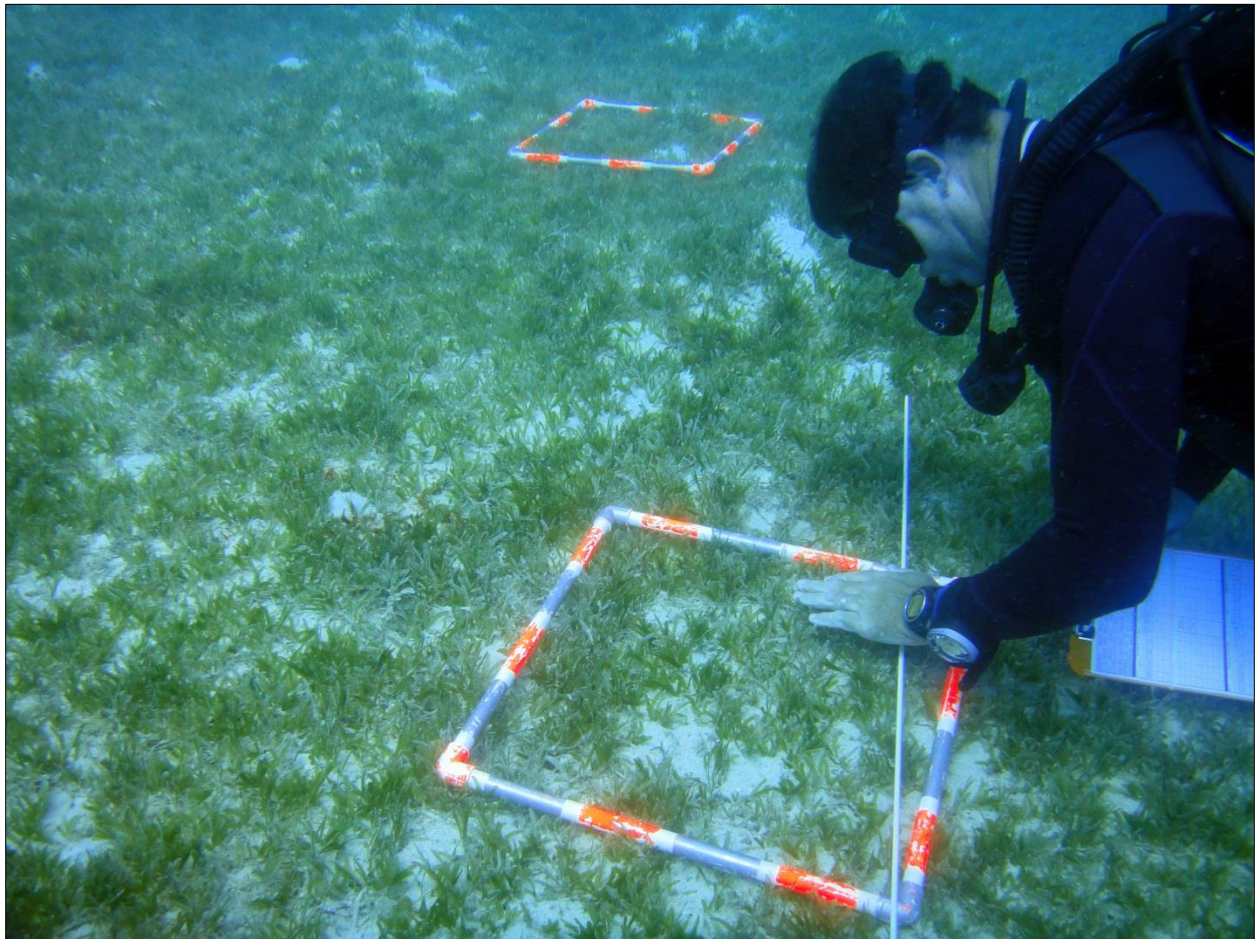


Seagrass Community Monitoring Protocol

Standard Operating Procedures

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ON THE COVER

NPS scientific diver performing a Braun-Blanquet survey at Virgin Islands National Park. Photo by NPS SFCN staff.

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Standard Operating Procedure 1

Sample Frame and Habitat Classification—Version 1.0

Purpose

The purpose of this SOP is to describe the sample frame and habitat classification used for allocating samples in this protocol. Stepwise procedures for creating a merged shapefile with appropriate habitat classification and depth information are described in SOP 3 *Creating a Seagrass Layer, Merging with Bathymetry Layer, and Assigning Strata*.

Revision Log

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Procedures

- The sample frame includes all mapped soft-bottom habitat within park boundaries, shallower than 30 meters (98.4 feet [ft]) and excluding areas that are not safely feasible to sample (i.e., high boat traffic areas and areas unreachable by boat are excluded) and areas with water quality concerns (i.e., Salt River Bay). The sample frame equals this defined target population. Areas that are considered to have become temporarily bare (e.g., blow outs from a storm) are still considered part of the sample frame.
- The benthic habitat maps used in the Florida Reef Fish Protocol (Brandt et al. 2009) and the Virgin Islands Reef Fish Protocol (Bryan et al. 2013) are used for this protocol. At the time of this writing, for the parks in the Virgin Islands (VIIS, BUIS, SARI), the NOAA benthic habitat maps are used (Kendall et al. 2001, Zitello et al. 2009). In Biscayne NP, the map product by Estep et al. (2017) is used.
- Initially, monitoring efforts are focused specifically on areas within park boundaries. In the future, depending on resources, management needs, and budget, sampling in areas outside park boundaries will be considered.
- Bathymetric and multibeam SONAR data will define areas within safe repetitive dive limits (< 30 meters [98.4 feet {ft}]).
- Only soft-bottom habitat classifications will be used in this protocol that define seagrass as the major biological cover found on either mud, sand and sand with scattered coral and rock. Seagrass habitat is defined as having 10% or more of the mapping unit dominated by any single species of seagrass or combination of species.

Literature Cited

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Standard Operating Procedure 2

Stratification—Version 1.0

Purpose

The purpose of this SOP is to describe the stratification used in this protocol. Stepwise procedures for creating strata with appropriate depth information are described in SOP 3 *Creating a Seagrass Layer, Merging with Bathymetry Layer, and Assigning Strata*.

Revision Log

[illegible]

Procedures

The stratification for the SFCN seagrass protocol will be based initially on depth within soft-bottom habitat (unconsolidated habitat) classified as seagrass. This SOP uses the actual mapped polygons from the benthic habitat maps from each park along with bathymetry data to create the strata. Soft-bottom polygons with seagrass are merged into a single shapefile layer. This shapefile is then split further based on depth class. These procedures are detailed in SOP 3 *Creating a Seagrass Layer, Merging with Bathymetry Layer, and Assigning Strata*.

For all parks, seagrass habitats will be stratified as follows:

Depth:

- less than 5 meter (16.4 ft)
- 5–15 meter (16.4–49.2 ft)
- greater than 15 meter (49.2 ft)

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Creating a Seagrass Layer, Merging with Bathymetry Layer, and Assigning Strata—Version 1.0

Purpose

The purpose of this SOP is to characterize the stepwise process to create a seagrass layer and merge that layer with available bathymetry layers. The best available bathymetry layer is modified and reclassified to depict the three depth strata outlined in SOP 2 *Stratification*. Then it is converted from a raster file to a vector polygon shapefile before being merged with the seagrass layer via the intersect tool. The final geospatial product will show seagrass layer features with a corresponding depth stratum.

Revision Log

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Procedures

Create a layer that contains only the seagrass features from the offshore benthic habitat layer

This procedure will create a layer containing and displaying only seagrass habitat features from the offshore benthic habitat layer using the selection function in ArcMap.

1. In ArcMap, click the “Selection” menu and choose “Select by Attributes...”
2. In the Select by Attributes window that appears:
 - a. Double-click the appropriate field that displays the benthic habitat information in the attribute table (for example, Level 5 in the 2012 BISC offshore benthic habitat layer). The field should now appear in the text box at the bottom of the Select by Attributes window.
 - b. Double-click on the “=” button.
 - c. Click on the “Get Unique Values” button, and select the appropriate value that depicts seagrass for the field selected in Step 2a. The resulting Select by Attributes code in the text box at the bottom of the window should read something like: “Level5” = ‘SRV’.
 - d. Click the Apply button at the bottom of the Select by Attributes window. The selection query will now run for the offshore benthic habitat shapefile.
3. Right-click the benthic habitat layer and choose “Selection” and then “Create Layer From Selected Features”.
4. The temporary layer created in Step 3 appears in the Table of Contents pane. The layer’s name will contain the original name of the offshore benthic habitat domain shapefile followed by the word “selection.”
5. In the Table of Contents pane in ArcMap, right click on the selection layer created in Step 4 and choose Data>Export Data.
6. In the Export Data window:
 - a. For the “Use the same coordinate system” section, select “this layer’s source data”.
 - b. For the “Output feature class” section, navigate to where the new layer should be saved and name it appropriately (e.g. BISC_offshore_seagrass). Click OK.
7. The new offshore seagrass shapefile has now been created and will appear in the Table of Contents pane.

***Note:** If conducting a post-stratification analysis and the benthic habitat layer has multiple seagrass categories (e.g. Continuous SRV, Discontinuous SRV) under the habitat field, create separate seagrass shapefiles by repeating Steps 1-7 for each distinct category of seagrass that exist in the benthic habitat layer being used.*

Use the ArcMap dissolve tool to create a singular seagrass polygon shapefile without any multipart features

This procedure will create a layer that merges all the separate seagrass habitat features from the shapefile created in the previous section, resulting in a seagrass polygon shapefile with one singular feature/attribute.

1. In ArcMap, click on the Geoprocessing menu and select the Dissolve tool.
2. In the Dissolve tool window that opens:
 - a. For Input Features, select the offshore seagrass shapefile created in the previous section.
 - b. For Output Feature Class, navigate to where the new dissolved layer should be saved and name it appropriately (e.g. BISC_offshore_seagrass_dissolve).
 - c. For the Dissolve_Field(s) option, select the field depicting the highest or most detailed level of habitat classification. For example, the field for the seagrass shapefile (created from the offshore benthic habitat layer in the previous section) that contains this information is “Level5.”
 - d. For the rest of the input options, leave the defaults.
 - e. Click the OK button to create the dissolved offshore seagrass shapefile.
3. The new dissolved offshore seagrass shapefile will now appear in the Table of Contents pane.

***Note:** If multiple seagrass shapefiles were created as specified in the previous section, create a dissolved seagrass shapefile by repeating Steps 1-3 for each of these distinct seagrass shapefiles.*

Smoothing out the bathymetry layer

The focal statistics tool is utilized to smooth out the bathymetry layer. This is one of the first steps needed for the creation of a bathymetry/depth vector layer. The focal statistics tool calculates for each bathymetry cell the mean of the values in a specified neighborhood around the cell.

1. In ArcMap, add the bathymetry raster.
2. Click on the Geoprocessing tab and select ArcToolbox.
3. In the ArcToolBox, click on “Spatial Analyst Tools”, then “Neighborhood” and double-click the “Focal Statistics” tool.

4. In the Focal Statistics window:
 - a. Select the bathymetry layer as the Input raster.
 - b. For Output raster, click on the folder icon and navigate to where the bathymetry layer to be modified should be saved and name it appropriately (e.g. BISC_LIDAR_focal_statistics.tif).
 - c. For Neighborhood, leave the drop-down option as Rectangle.
 - d. For Neighborhood Settings, set the Height to “10,” the Width to “10,” and Units to “Cell.”
 - e. For Statistics type, leave the drop-down as MEAN.
 - f. Click “OK.”
5. The new focal statistics bathymetry layer will appear in the Table of Contents, under the Source view.

Reclassifying the focal statistics bathymetry layer

The reclassify tool is utilized to reclassify the smoothed (focal statistics) bathymetry layer. This is the second step needed for the creation of a usable bathymetry/depth vector layer. The reclassify tool will change the values for each bathymetry cell based on criteria specified by the user, in this case the three depth strata outlined in SOP 2 *Stratification*.

1. In ArcMap, click on the Geoprocessing tab and select ArcToolbox.
2. In the ArcToolBox, click on “Spatial Analyst Tools”, then “Reclass” and double-click the “Reclassify” tool.
3. In the Reclassify window:
 - a. Select the focal statistics bathymetry layer as the Input raster.
 - b. For Reclass field, the drop-down should automatically display the VALUE field.
 - c. For Reclassification, click on the Classify button. In the Classification window that opens change the Classes option drop-down to “3.” Then in the Break Values text box change the first/top value to “-15” and the second/middle value to “-5.” Click “OK.” The Classification window will close and the Reclassify window will reappear.
 - d. For Output Raster, click on the folder icon and navigate to where the output raster should be saved and name it appropriately (e.g. BISC_LIDAR_focal_statistics_reclass.tif).

- e. Click “OK.”
4. The new reclassified bathymetry layer will appear in the Table of Contents, under the Source view.

Convert the reclassified bathymetry layer to a vector layer

The raster to polygon tool is utilized to convert the reclassified bathymetry layer into a vector polygon. This is the last step needed for the creation of a bathymetry/depth vector layer displaying the three depth strata outlined in SOP 2 *Stratification*.

1. In ArcMap, click on the Geoprocessing tab and select ArcToolbox.
2. In the ArcToolBox, click on “Conversion Tools”, then “From Raster” and double-click the “Raster to Polygon” tool.
3. In the Raster to Polygon window:
 - a. Select the reclassified bathymetry layer as the Input raster.
 - b. For Field, the drop-down should automatically display the VALUE field.
 - c. For Output polygon features, click on the folder icon and navigate to where the converted bathymetry layer should be saved and name it appropriately (e.g. BISC_LIDAR_reclass_vector.shp).
 - d. Click “OK.”
4. The new classified bathymetry layer will appear as a vector polygon shapefile in the Table of Contents, under the Source view.
5. In the Table of Contents, right click the new classified bathymetry shapefile and select “Open Attribute Table.”
6. In the attribute table, click on the Table Options icon and select “Add Field.”
7. For the Add Field window:
 - a. Type in “Depth_Stra” for the Name text box.
 - b. For Type, select “Text.”
 - c. For Field Properties, make the Length “20.”

- d. Click the OK button.
8. Back in the attribute table, click on the Table Options icon and select “Select by Attributes...”
9. In the Select by Attributes window that appears:
 - a. Ensure that Method is set to “Create a new selection.”
 - b. Double-click the gridcode field found in the input box beneath “Method.” The field should now appear in the text box at the bottom of the Select by Attributes window.
 - c. Double-click on the “=” button.
 - d. Type in “1.” The resulting Select by Attributes code in the text box at the bottom of the window should read something like: “gridcode” = 1.
10. Click the Apply button at the bottom of the Select by Attributes window. The selection query will now run.
11. In the attribute table (with the selected records highlighted in blue), right click on the new Depth_Stra field and select “Field Calculator.”
12. For the Field Calculator window:
 - a. Select VB Script for the Parser option.
 - b. For the Type option, select String.
 - c. For the “Depth_Stra =” text box below, type in “> 15 meters”.
 - d. Click OK. The Field Calculator tool will run and the selected features will now have the Depth_Stra field populated.
13. Go back in the attribute table, click on the Table Options icon and select “Select by Attributes...”
14. In the Select by Attributes window that appears:
 - a. Ensure that Method is set to “Create a new selection.”

- b. Double-click the gridcode field found in the input box beneath “Method.” The field should now appear in the text box at the bottom of the Select by Attributes window.
 - c. Double-click on the “=” button.
 - d. Type in “2.” The resulting Select by Attributes code in the text box at the bottom of the window should read something like: “gridcode” = 2.
- 15. Click the Apply button at the bottom of the Select by Attributes window. The selection query will now run.
- 16. In the attribute table (with the selected records highlighted in blue), right click on the new Depth_Stra field and select “Field Calculator.”
- 17. For the Field Calculator window:
 - a. Select VB Script for the Parser option.
 - b. For the Type option, select String.
 - c. For the “Depth_Stra =” text box below, type in “5 - 15 meters”.
 - d. Click OK. The Field Calculator tool will run and the selected features will now have the Depth_Stra field populated.
- 18. Go back in the attribute table, click on the Table Options icon and select “Select by Attributes...”
- 19. In the Select by Attributes window that appears:
 - a. Ensure that Method is set to “Create a new selection.”
 - b. Double-click the gridcode field found in the input box beneath “Method.” The field should now appear in the text box at the bottom of the Select by Attributes window.
 - c. Double-click on the “=” button.
 - d. Type in “3.” The resulting Select by Attributes code in the text box at the bottom of the window should read something like: “gridcode” = 3.

20. Click the Apply button at the bottom of the Select by Attributes window. The selection query will now run.
21. In the attribute table (with the selected records highlighted in blue), right click on the new Depth_Stra field and select “Field Calculator.”
22. For the Field Calculator window:
 - a. Select VB Script for the Parser option.
 - b. For the Type option, select String.
 - c. For the “Depth_Stra =” text box below, type in “< 5 meters”.
 - d. Click OK. The Field Calculator tool will run and the selected features will now have the Depth_Stra field populated.

Dissolve the bathymetry vector polygon shapefile

The dissolve tool is utilized to aggregate the polygon’s features based on the depth strata field (Depth_Stra).

1. In ArcMap, click on the Geoprocessing tab and select Dissolve.
2. In the Dissolve window that appears:
 - a. Select the classified bathymetry shapefile as the Input Features.
 - b. For the Output Feature Class, click on the folder icon and navigate to where the dissolved shapefile should be saved and name it appropriately (e.g. BISC_LIDAR_reclass_vector_dissolve.shp).
 - c. For the Dissolve_Field(s) option, select the Depth_Stra field.
 - d. Click “OK.”
3. The new bathymetry strata shapefile will now appear in the Table of Contents pane.

Use the ArcMap intersect tool to merge the seagrass and bathymetry strata shapefiles

This procedure will create a layer that intersects the dissolved offshore seagrass shapefile with the bathymetry strata shapefile. The resulting shapefile will show seagrass features categorized by depth strata.

1. In ArcMap, click on the Geoprocessing menu and select the Intersect tool.
2. In the Intersect tool window that opens:
 - a. For Input features, add the dissolved offshore seagrass shapefile and the bathymetry strata shapefile.
 - b. For Output Feature Class, navigate to where the new intersect layer should be saved and name it appropriately (e.g. BISC_offshore_seagrass_LIDAR_intersect.shp).
 - c. For the rest of the input options, leave the defaults.
 - d. Click the OK button to create the new intersected shapefile.
3. The new merged strata shapefile will appear in the Table of Contents.
4. In the Table of Contents, right click the new merged strata shapefile and select “Open Attribute Table.”
5. In the attribute table, click on the Table Options icon and select “Add Field.”
6. For the Add Field window:
 - a. Type in “Area_ha” for the Name text box.
 - b. For Type, select “Double.”
 - c. Click the OK button.
7. In the attribute table, right click on the new Area_ha field and select “Calculate Geometry.” Note, this field column should be empty as it was just created.
8. For the Calculate Geometry window:
 - a. Make sure that Property is set to Area.
 - b. For Coordinate System select the option “Use coordinate system of the data source.”
 - c. Set the Units to “Hectares [ha].”
 - d. Click the OK button.
9. The Area_ha field in the attribute table will now have areas (in hectares) calculated for each feature/record in the final strata shapefile.

Note: It may be necessary to repeat these steps for any additional seagrass shapefiles. As mentioned in the previous sections, each additional seagrass shapefile used should result in a corresponding dissolved seagrass shapefile, which will then be intersected by the classified bathymetry shapefile to create a final strata shapefile.

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Procedure

- The sample regions in this protocol are defined as Virgin Islands National Park, Buck Island Reef National Monument, Salt River Bay National Historical Park and Ecological Preserve, and Offshore Biscayne National Park.
- This SOP will use a stratified random selection of points, with a new sample of sites drawn for each survey.
- Samples are initially proportionally allocated within each stratum. This may later be adjusted based upon the variance structure of total seagrass or focal seagrass species (to be determined in consultation with each park) in order to reduce variance and optimize the ability to detect change if it is occurring in metrics of interest.
- Total number of samples is described as the best distribution of effort as established by analysis, within the limits of budget and personnel constraints. Initial estimates and planning are for 100 sites each for Virgin Islands NP and Biscayne NP and 100 sites combined for Buck Island Reef NM and Salt River Bay NHP&EP.
- Sites are randomly selected by stratum with a sampling design tool within ArcGIS.
- Initial sample stratification is as follows (Table SOP 4-1):
 - Depth: less than 5 meters (16.4 ft), 5–15 meters (16.4–49.2 ft), and greater than 15 meters (49.2 ft).

Table SOP 4-1. Initial strata and sampling allocation for unconsolidated sediment.

Depth	Sampling Allocation
Depth > 15 meters (49.2 ft)	Initially proportional allocation
Depth 5 to 15 meters (16.4 to 49.2 ft)	Initially proportional allocation
Depth < 5 meters (16.4 ft)	Initially proportional allocation

Procedure for selecting random sample sites using the NOAA BioGeo sampling tool

- Open the NOAA Sampling Design Tool within ArcGIS. If necessary, the tool can be downloaded and installed from the NOAA website:
<https://coastalscience.noaa.gov/projects/detail?key=185>
- The user's guide is also available from the [ArcGIS website](#)
- Within the “Sampling Design Tool” window:
 - Under “Sampling type”, choose “Select Samples from Frame.”
 - Under “Sampling design”, Choose “Stratified Random.”

- Check the “Export selected features” box.
- **Note:** *This will export a shapefile of the random sample sites to the location chosen in step 3.g. below.*
 - In “Sample frame,” select the shapefile from which the random sample sites will be drawn.
 - Under “Strata field,” select the field in the attribute table containing the strata of interest.
 - Click “Run.”
- Within the “Select Stratified Inputs” window:
 - Under “Allocation Method,” click on the “Proportional” button.
 - In the “Sample units to allocate” box, enter the total number of samples desired.
- **Note:** *This will proportionally allocate samples within each stratum. The “Define the number of sample units to select in each stratum” window will show the number of samples allocated in each stratum.*
 - Do not check the “Keep minimum distance between points” box.
 - Click “Run.”
 - In the “Save a feature class” window, navigate to the location where the shapefile of the random sample sites will be exported.
 - Under “Name:,” allocate an appropriate name for the shapefile.
 - Under “Save as type:” select “Feature classes.”
 - Click “Save.”

Naming convention for randomly selected sample sites

- Sample sites will be initially assigned a three-digit name during the random site selection process
- A new name must be designated for each randomly selected site, such that each sample site may readily be recognized as unique and distinguishable from any other sample site. To each site number, the sampling year shall be added to the name in the following format:
 - YY### (i.e. 18131, designates that this is sample # 131 of year 2018)

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Standard Operating Procedure 5

Field Methods—Version 1.0

Purpose

This SOP describes the procedures for performing a Braun-Blanquet (BB) survey in seagrass habitat. The procedure described is consistent with Dunton et al. (2011); however, the BB cover scores are recorded according to the methods described in Fourqurean et al. (2001).

Revision Log

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Equipment List

Following is a list of equipment (in addition to standard dive equipment and boat gear) needed to conduct this protocol:

- Dive buoy and GPS with a line and reel assembly
- 4 50 × 50 centimeter (19.7 × 19.7 inches [in]) PVC quadrats with each 10 centimeters (3.9 in) marked with alternating paint (2 per diver)
- 2 underwater still cameras (1 for each diver)
- 2 rulers (1 for each diver); clipboards with metric rulers on the side are acceptable
- Clipboards
- Dive pencils
- Field data sheets
- 2 probing sticks over 1 meter (3.28 feet [ft]) long, marked at the 1 meter (3.28 ft) length.

Procedures

Preparation for sampling in addition to standard dive gear and boat preparation

1. Prior to sampling, print out data sheets and assemble all gear.
2. Ensure 10 centimeters (3.9 in) markings on PVC quadrats are still readable. Otherwise touch up paint as necessary.
3. Ensure dive buoy and reel assembly are working properly.
4. Ensure the still camera housing o-rings are properly greased per manufacturer's instructions and are watertight.
5. Ensure cameras are functioning properly, batteries are charged and memory cards are empty.
6. Confirm that all divers have undergone training and meet accuracy standards described in SOP 6 *Training*.

Navigating to each sample site

- Navigate to within 10 meters (3.9 in) of the pre-established random coordinate (latitude, longitude) using a Global Positioning System. The intent is that despite drift, the actual quadrat samples are within 50 meters (164 ft) of the pre-established random coordinate and are within the map polygon.

Placement of BB quadrats

- Record the site number using the YY### format described in SOP 4 *Sample Allocation*, diver name, and diver number (normally “1” or “2”) and date/time on the datasheet before diving.
- Site photos: Diver “1” is designated to take site characteristic photos and marks “Y” under “site picture.” Other divers mark “N” in that field.
- Deploy divers with a buoy, reel and attached GPS unit.
- Each diver haphazardly deploys two 0.25 square meter (2.7 square feet [ft²]) quadrats by throwing them at random directions away from the body. No effort is made to toss the quadrats a certain distance or direction (it is a haphazard placement) within the constraint that final quadrat locations must be within 50 meters (164 ft) of the pre-established random coordinate and must be within the seagrass map polygon.
- Each diver follows the two quadrats until they settle to the bottom.
- In the event water visibility is poor, the divers may deploy the quadrats after submerging, when the benthos is clearly visible. This will prevent a diver from losing sight of the quadrat and not being able to find it again.
- If a quadrat lands on hard-bottom the quadrat will be tossed again. If no soft bottom habitat is available at the site, the survey is aborted and an alternate site within the same stratum is selected to replace it.

General site survey

- Water depth: record the water depth at the site in feet
- Water temperature: record in °F
- Current: circle the appropriate option
 - None: do not have to fin kick to stay in place
 - Moderate: must frequently fin kick to stay in place
 - Strong: must constantly fin kick to stay in place
- Visibility: Record maximum horizontal visibility distance in meters.
- Photos—the designated diver takes the site pictures; each diver takes field sheet and quadrat pictures as described below (any underwater camera may be used for this purpose):
 - Most cameras have a standard picture or “underwater” setting that is appropriate for all pictures; however, it is important to make sure the automatic flash settings are turned off and that neither the panoramic or close-up settings are being used.

- Diver “1” takes one picture of the data sheet (Figure SOP 5-1) with the site number and date visible, and one picture in each of four directions to record visual information for the site.
- Each diver takes a picture of the field datasheet (Figure SOP 5-1) which includes the site number, date and the first quadrat number so the pictures can be associated with that quadrat.
- Each diver takes a picture from directly above the first quadrat being surveyed. All four sides of the quadrat should be included within the photos. Check the zoom setting to ensure the camera is completely “zoomed out.” Move back from the quadrat far enough to capture the entire quadrat as described.
- Repeat steps “c” and “d” for the second quadrat.
- Site description: seagrass distribution and seagrass species within 7.5 meter (24.6 ft) radius of reel and buoy
 - Record all seagrass species present on the site by circling species codes
 - Record distribution of seagrass on the site
 - Dense (Virgin Islands): greater than or equal to 50% seagrass cover.
 - Sparse (Virgins Islands): less than 50% seagrass cover.
 - Continuous (Florida): continuous beds of any shoot density habitat with 10% or more cover of seagrass.
 - Discontinuous (Florida): isolated, semi-round patches or elongated areas of seagrass in a matrix of unconsolidated sediment (other soft-bottom) or hard-bottom.
 - Any other information such as blowouts or propeller scars.
- Queen Conch present: only *Lobatus gigas* is recorded
 - Write the number of Queen Conch present within a 7.5 m radius area originating from the reel and buoy (deployed at the site).
 - Circle whether the majority of Queen Conch seen are “Adult” or “Juv” (for juveniles)
- Notes: take note of any relevant and significant site observations such as:
 - Boat propeller scarring
 - Anchor damage

- Significant unidentified physical damage to seagrass
- Significant amount of anthropogenic debris
- Epiphyte presence and type
- Any other information that the observer may deem relevant

Quadrat characteristics (only one measurement per quadrat)

- Quadrat number:
 - Enter the respective quadrat numbers
 - Diver “1” performs quadrat “1” and “2”
 - Diver “2” performs quadrat “3” and “4”
 - In the event three or more divers perform a survey at the same site, each extra diver enters the consecutive quadrat numbers (Diver “3” performs quadrat “5” and “6”, and so forth)
- Substrate type within the quadrat:
 - Sandy-Mud (SM) = primarily mud with some sand in it
 - Muddy-Sand (MS) = primarily sand with some mud in it
- **Note:** If you pick up a clump in your hand and squeeze and it holds together, it is SM; if it falls apart, it is MS.
- Mud (MU)
- Sand (SA)
- Rock (RO)
- Live Coral (LC)
- Halimeda Hash (HH) = sediment primarily composed of dead *Halimeda* sp. oatmeal-like leaf segments
- Coarse Shell (CS)
- Rubble (RB)
- Taxon: record the code for each taxon present within the quadrat
- Braun-Blanquet:

- A quadrat made of PVC plastic tube 0.5 meter (1.6 ft) on a side (0.25 square meter [2.7 ft²]) is used to delineate the area inside the quadrat for each survey. These quadrats are deployed earlier (“Placement of BB quadrats,” above), and sampled at this point.
- List all seagrass and macroalgae species and “total” seagrass occurring in the quadrat in the “Taxon” box.
- Record a score based on the cover of each species and “total” score for all seagrass in that quadrat in the respective “Cover” box. Cover, as defined for this purpose, is the fraction of the total quadrat area that is obscured by a particular species when viewed from directly above. Species cover can range between 0 and 5, the maximum BB score (Table SOP 5 - 1). At a site, however, the sum of all taxon BB values can be greater than 5, because of the relatively broad cover ranges for each BB value and the fact that seagrass canopies are three dimensional.
- Height of seagrass canopy: record one average measurement for each seagrass taxon ignoring the tallest 20% of the leaves:
 - Canopy height is defined as the average length of the longest blade on each of three or four seagrass shoots, as measured from the substrate to the tip of the leaf.
- Sediment depth within the quadrat:
 - Push the sediment stick into the ground as far as possible. If you encounter resistance, try to push through it. Record in centimeters, rounded to the nearest 5 centimeters (2 in).

Table SOP 5-1. Braun-Blanquet (BB) cover scores.

Score	Cover
0	Taxon absent from quadrat
0.1	Taxon represented by a solitary shoot
0.5	Taxon represented by a few (2–5) shoots
1	Taxon represented by many (>5) shoots, less than 5% cover
2	Taxon represented by many (>5) shoots, 5–25% cover
3	Taxon represented by many (>5) shoots, 25–50% cover
4	Taxon represented by many (>5) shoots, 50–75% cover
5	Taxon represented by many (>5) shoots, 75–100% cover

It is important to write legibly when recording data; the information will be subject to QA/QC by others who will need to correctly interpret the written data. These raw data are also held as historical records that should be equally legible to future researchers.

- Score the Braun-Blanquet (BB) cover values for each benthic species as described above.
- When recording a taxon and cover score for a “general” alga (BOTH, GOTH, ROTH, CGTO), write the species of the taxon in the “taxon” or “notes” column (ex: BOTH = 1 = *Dictyota*) (Table SOP 5-2).
- Totals are taken for seagrass, calcareous green algae, green algae, red algae, and brown algae. The totals are NOT additive, as a quadrat with a PENI of “1” and a HALI of “1” does not necessarily score a GTOT of “2.”

Table SOP 5-2. Species Codes.

Taxa Group	Scientific Name	Code
Seagrasses	<i>Thalassia testudinum</i>	TTES
	<i>Syringodium filiforme</i>	SFIL
	<i>Halodule wrightii</i>	HWRI
	<i>Halophila decipiens</i>	HDEC
	<i>Halophila engelmannii</i>	HENG
	<i>Halophila stipulacea</i>	HSTI
	<i>Ruppia maritima</i>	RMAR
	<i>Halophila johnsonii</i>	HJOH
	Seagrass total	STOT
Calcareous Green Algae	<i>Halimeda sp.</i>	HALI
	<i>Udotea sp.</i>	UDOT
	<i>Penicillus sp.</i>	PENI
	<i>Rhipocephalus sp.</i>	RHIP
	<i>Acetabularia sp.</i>	ACET
	<i>Neomeris sp.</i>	NEOM
	<i>Cymopolia sp.</i>	CYMO
	Calcareous green total	CGTO
Green Algae	<i>Caulerpa sp.</i>	CAUL
	<i>Batophora sp.</i>	BATO
	<i>Avrainvillea sp.</i>	AVRA
	<i>Dasycladus sp.</i>	DASY
	Green other	GOTH
	Green total	GTOT

Taxa Group	Scientific Name	Code
Red Algae	<i>Laurencia sp.</i>	LAUR
	Red other	ROTH
	Calcareous red other	CROT
	Red total	RTOT
Brown Algae	<i>Sargassum sp.</i>	SARG
	<i>Dictyota sp.</i>	DICT
	Brown other	BOTH
	Brown total	BTOT
Other Taxa	Sponges	SPO
	Corals	CORALU
	Gorgonians	GO
	Other	O

Post-field work

All equipment, data sheets and cameras must be rinsed at the end of each field day. Dried datasheets are stored in a data folder until they can be returned to the office and scanned. Each day all photos must be downloaded from camera memory cards. All photos are taken primarily for QA/QC purposes if a review of the quadrat or site characteristics are needed. All files are renamed and stored on the SFCN server under the respective park folder located at Z:\SFCN\Vital_Signs\Seagrass\images as follows:

1. Sampling mission folder naming convention: YYYYMM_PPPP (e.g., 201806_BISC)
2. Individual site subfolder naming convention: PPPP_YY### (e.g., BISC_18131)
3. Individual picture naming convention according to photo type (site characterization or quadrat); where “SC00” is the site characterization slate picture and site pictures are “SC01,” “SC02,” “SC03” and “SC04”; Quadrat slate pictures are “QTS1” through “QTS4,” and quadrat pictures are “QT01” through “QT04”:
 - a. YYYYMM_PPPP_YYSSS_SC0# (e.g., 201806_BISC_18131_SC00)
 - b. YYYYMM_PPPP_YYSSS_QTS# (e.g., 201806_BISC_18131_QTS1)
 - c. YYYYMM_PPPP_YYSSS_QT0# (e.g., 201806_BISC_18131_QT03)

Vascular plants: TTESudinum SFILiforme HWRIghtii HDECipiens HENGelmannii HSTIpulacea RMARitima HJOHnsonii = STOTal												
Calc. Green: HALImeda UDOTea PENIcillus RHIPocephalus ACETabularia NEOMeris CYMOpolia = CGTOtal												
Green: CAULerpa BATOPhora AVRAinvillea DASYcladus Green OTHer (GOTH) = GTOTal												
Red: LAUREncia Red OTHer (ROTH) CROther = RTOTal Brown: SARGassum DICTyota Brown OTHer (BOTH) = BTOTal												
Sponges (SPO) Corals (CORALU) Gorgonians (GO) Other (O)												
ABUNDANCE		0.1 = 1 shoot; 0.5 = 2-5 shoots; 1 = 0-5% cover; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = 75-100%										
SUBSTRATE TYPE		MUD Sandy-Mud Muddy-Sand SAnd Coarse Shell Halimeda-Hash RuBble Live Coral ROck										
Site #:		Date:		Diver:			Depth (ft):		Temp:		Habitat:	
											USVI: Dense Sparse	
Site picture? Y / N		Time:		Current: None Mod Strong			Vis (ft):				Florida: Cont. Discont. Bare	
Quad #	Sub/Depth	Taxon	Canopy	Cover	# of Q. Conch in 7.5m radius? (write 0 if none)	Quad #	Sub/Depth	Taxon	Canopy	Cover	Notes	
	/						/					
	/						/					
	/						/					
	/						/					
	/				Mostly.... (circle one)		/					
	/				Adult / Juv		/					
	/				Seagrass species @ site (circle)		/					
	/						/					
	/				TTES SFIL		/					
	/				HWRI HDEC		/					
	/				HENG HSTI		/					
	/				RMAR HJOH		/					
Site #:		Date:		Diver:			Depth (ft):		Temp:		Habitat:	
											USVI: Dense Sparse	
Site picture (Y / N)		Time:		Current: None Mod Strong			Vis (ft):				Florida: Cont. Discont. Bare	
Quad #	Sub/Depth	Taxon	Canopy	Cover	# of Q. Conch in 7.5m radius? (write 0 if none)	Quad #	Sub/Depth	Taxon	Canopy	Cover	Notes	
	/						/					
	/						/					
	/						/					
	/						/					
	/				Mostly.... (circle one)		/					
	/				Adult / Juv		/					
	/				Seagrass species @ site (circle)		/					
	/						/					
	/				TTES SFIL		/					
	/				HWRI HDEC		/					
	/				HENG HSTI		/					
	/				RMAR HJOH		/					

Figure SOP 5-1. Example of a field data sheet.

Literature Cited

- Dunton, K., W. Pulich, and T. Mutchler. 2011. A seagrass monitoring program for Texas coastal waters: multiscale integration of landscape features with plant and water quality indicators. Final Report, Contract No. 0627. Coastal Bend Bays & Estuaries Program, Corpus Christi, Texas.
- Fourqurean, J. W., A. Willsie, C. D. Rose, and L. M. Rutten. 2001. Spatial and temporal pattern in seagrass community composite on and productivity in south Florida. *Marine Biology* 138:341–354.

Standard Operating Procedure 6

Purpose

Revision Log

[illegible]

Introduction

Accurate seagrass community surveys require participants to be proficient in the following skill sets:

1. Site selection and quadrat layout.
2. Species identification (seagrasses as well as other species and taxa described below).
3. Braun-Blanquet ordinal classification scores to estimate percent cover.
4. Measurement of canopy height and sediment depth.
5. Substrate identification.
6. Seagrass distribution estimation.
7. Identification of juvenile and adult Queen Conch (from other conch species).

In-water training is the best way to demonstrate and learn these skill sets, though the participants should familiarize themselves with species identification, methods, and data to be recorded prior to entering the water. The in-water training is split into two sections. First, emphasis is put on species identification, Braun-Blanquet estimates, and visual estimation of canopy height and sediment type and depth. The second section focuses on site selection, quadrat layout, distribution of seagrass and the identification and enumeration of Queen Conch. Once both individual sections of trainings are satisfactorily completed, a full site survey should be conducted by the trainee and the trainer. This step will task load the trainee similar to an actual survey and should be completed in less than 15 minutes bottom time. New divers should be paired with an experienced surveyor when actual surveys are conducted.

Species identification

Participants making observations should be competent in the identification of seagrass species and macroalgae to genera. This includes familiarization with eight species of seagrass and 14 genera of calcareous green, green, red and brown macroalgae and their four letter codes. *Marine Plants of the Caribbean, A Field Guide from Florida to Brazil* written by Littler et al. (1989) and *Caribbean Reef Plants, An Identification Guide to the Reef Plants of the Caribbean, Bahamas and Florida and Gulf of Mexico* by Littler and Littler (2000) are both excellent sources for field identification. Table SOP 5-2 has a list of scientific names and corresponding codes used for data entry. Participants also need to be able to differentiate the Queen Conch from other similar *Strombus* species including the Milk Conch *Strombus costatus*, Hawkwing Conch *Strombus raninus*, and *Strombus alatus* Florida Fighting Conch. Adult Queen Conch are distinct from juveniles due to a thick (5–12 millimeters [0.2–0.5 inches [in]]) flared lip that develops as they become reproductively mature (Appledorn 1997). The most recent edition of *Reef Creature Identification: Florida Caribbean Bahamas* by Humann et al. (2013) is a good resource for conch species identification for participants.

In-water training: species identification, Braun-Blanquet, canopy height and sediment

In-water training should be separated into two parts. First, emphasis is placed on species identification, Braun-Blanquet estimates, and visual estimation of canopy height and sediment type and depth. This is most effective if the in-water training occurs in an area where there is a high diversity of seagrass and macroalgae. Navigation to a site or random placement of quadrats is not emphasized in this exercise.

1. An experienced observer (trainer) brings the new diver(s) to a location where a diverse community of seagrass is expected to be encountered. A suitable test area should also be relatively shallow, with visibility exceeding 10 meters (32.8 ft), and with minimal current.
2. The trainer places two 0.25 square meter (m^2 ; 2.7 square feet [ft^2]) quadrats on the bottom. Both the trainer and the new surveyor score the species present in the quadrat and estimate the canopy height, substrate type and substrate depth for each taxon. The Braun-Blanquet score and codes are recorded as described in the “Performing a Braun-Blanquet survey at a predetermined sampling site” section in SOP 5 *Field Methods*.
3. Once completed the trainer may pick up the quadrats and repeat the exercise if a suitably diverse habitat is located nearby.
4. For the rest of the dive, the trainee is given the opportunity to locate and identify additional seagrass and macroalgae taxa.
5. Following the dive, the trainer and trainees compare the seagrass community data that were collected.
6. These steps are conducted on at least two sites with a combined total of at least eight quadrats. Sites may be adjacent to each other but preferably contain a variety of seagrass communities and densities. Data recorded by the trainee must be 95% accurate (when compared to the trainer’s data) for all seagrass and macroalgae taxa identified, including both the quadrat data and the site data. Identification of substrate type recorded must be 95% accurate. The Braun-Blanquet score for all seagrass and macroalgae taxa must be within 1 ordinal category for BB scores 0–1 and equal for BB scores 2–5 for each taxon. Seagrass canopy height must be $\pm 10\%$ for each seagrass species recorded. Sediment depth values must be ± 5 centimeters (2 in) up to a maximum measured depth of 1 meter (3.28 ft). A trainee that exhibits consistent and considerable error greater than these standards will need additional training.

In-water training: site selection/characterization, quadrat layout, Queen Conch

The second portion of in-water training focuses on site selection/characterization, quadrat layout, and the identification and enumeration of Queen Conch. Here, the trainees are assessed as to whether they can select a site and layout quadrats in an unbiased manner following SOP 5 *Field Methods*. These steps are described in the “Navigating to each sample site” and “Placement of BB quadrats” sections. Trainees also record all site characteristics listed in the “General site survey” section including the distribution of seagrass as described in 5.ii and the number of Queen Conch observed at the site.

1. Before entering the water, the trainer verbally discusses the decision rules and methods in order to select a site and place quadrats in an unbiased manner. The trainer also answers any questions the trainees may have prior to entering the water.
2. Under guidance of the trainer, the trainee deploys a buoy attached to a line and reel at the site and deploys quadrats as described in SOP 5 *Field Methods*. The trainer assesses whether the trainee deployed the buoy and quadrats in an unbiased manner. The trainee also records the diver name, site number and date and time on the datasheet.
3. Once the trainee has set up the site properly and divers are on the bottom, they characterize the site according to the steps in “General site survey” section in SOP 5 *Field Methods*. Information recorded includes: water depth, current, visibility, distribution of seagrass, Queen Conch present and notes on the site. Photographs of the site as described in step 4 are also taken by the trainee. The trainer records site data as well and compares data with the trainee after surfacing.
4. If possible, the trainer tries to locate and point out other *Strombus* species present to stress the different identifying features of each species.
5. Following the dive, the trainer and trainees compare the general site survey information that was collected.
6. These steps are conducted on at least two sites. Data recorded by the trainee must be 95% accurate (when compared to the trainer’s data) for all seagrass species and macroalgae taxa identified at the site. Water depth (ft) recorded must be ± 1 meter (3.28 ft). Estimation of current speed must be 100% accurate. The maximum horizontal visibility estimate must be ± 5 meters (16.4 ft). The total Queen Conch count must be $\pm 10\%$ accurate. Identification of queen conch and juvenile or adult classification must be 95% accurate and all identifications must be to the species level. A trainee that exhibits consistent and considerable error greater than these standards will need additional training.

It is unlikely all seagrass and macroalgae taxa will be seen during the training. The trainee should however be comfortable with the identification of most species and codes and know how to identify less-frequently encountered types. Once training is completed, a new diver can use a camera to document species they are unsure of and confirm identification with an experienced surveyor after a dive.

Surveys conducted by new divers, post-training

A new diver's first seagrass community surveys will occur with an experienced seagrass surveyor. The experienced surveyor will provide guidance and answer any questions. The new diver will also be calibrating their Braun-Blanquet estimates by comparing their taxon scores to those of the experienced surveyor. Queen Conch counts will also be checked and compared after the dive. In general, less experienced seagrass surveyors should continue to be paired with more experienced surveyors throughout the surveys. It is recommended that during actual surveys, the experienced diver should select the site and direct the placement of quadrats (SOP 5 *Field Methods*) until the new diver understands the decision rules for selecting a site and deploying quadrats. Regardless of experience, after a survey both divers should discuss how the survey was laid out, and compare and discuss observations and data collected during the survey.

Annual Surveys

Prior to the start of a new survey season, an in-water training session(s) will be held. Estimates of variability in metrics across observers will be made. Additionally, during park-wide surveys, 5% of sites will be selected for collection of quality control data. These sites will be completely resampled by a second diver. The position of quadrats will remain in place after the initial data are collected so a second diver can complete a duplicate QA/QC count. If possible, all participants in a survey will have their subsample data duplicated at least once by a second observer. Data quality standards must be met by all surveyors, regardless of level of experience.

Data entry and proofing training

All participants will be instructed on data entry methods and must be familiar with SOP 7 *Entering, Verifying and Performing a 100% QA/QC Check of Seagrass Data in the NPStoret Seagrass Database*. Once data entry is complete, participants will be briefed on how to perform basic QA/QC checks of the data. The data manager will assist in this process.

Literature Cited

Humann, P., N. DeLoach, and L. Wilk. 2013. Reef Creature Identification: Florida, Caribbean, Bahamas, 3rd Edition. New World Publications, Jacksonville, Florida.

Littler, D. S. and M. M. Littler. 2000. Caribbean Reef Plants. An Identification Guide to the Reef Plants of the Caribbean, Bahamas and Florida and Gulf of Mexico. Offshore Graphics Inc., Washington, D.C.

Littler, D. S., M. M. Littler, K. E. Bucher, and J. N. Norris. 1989. Marine Plants of the Caribbean. A Field Guide from Florida to Brazil. Smithsonian Institution Press, Washington, D.C.

Standard Operating Procedure 7

Purpose

Revision Log

[illegible]

Procedures

Open NPStoret database and navigate to data entry page

1. Open the NPStoret database.
2. Select “SFCN” in the “Available Organizations” window.
3. Select your name in the “Available Log In IDs” window (the SFCN data manager add your name to the list if it is not available).
4. Click on the “Results” tab.
5. Select “SFCN_Seagrass” in the “Available Projects” window.
6. Select “All the Organization’s Stations” in the “Available Station Input Groups.”
7. Select “All the Organization’s Characteristics” in the “Available Characteristic Input Groups.”
8. Click the “OK” button.
9. The “NPStoret Result Entry Template” window will open up.

Visits, Activities, and Results for Project: Seagrass (SFCN_SEAGRASS)

NPSTORET Result Entry Template

Quick Filter for Station:

Quick Filter for Visit Start Date:

Choose Input Group: All Organization Character

Jump to Activity:

Station ID:

Station Name: VIIS_DIL_002

Start Date: Start Time: Zone:

End Date: End Time: Zone:

Visit Comment:

Hydrologic Event:

Visit: of 57

Activity ID:

Activity Type: QC: ☐

Depth: Units: Custody ID:

Relative Depth: Person(s):

Sampling Component: Sampling Component Order:

Activity Comment:

Activity: of 1

Double-click a record to pop up an alternate data editing form

Local Name	Detection Condition	Result Value	Units	Value Status	Value Type	Statistic Type	Remark Code	Measure Que	Com
Substrate	Detected and Quantified	Rubble		Final	Actual				
Sediment Depth	Detected and Quantified	10	cm	Final	Actual				
HSTI_Canopy	Detected and Quantified	25	cm	Final	Actual				
*	Detected and Quantified			Final	Actual				

Figure 7-1. NPStoret Result Entry Template window.

Check if data for the specific site has already been entered

1. The data management team will create new station numbers for every survey in the YY### format described in SOP 4 *Sample Allocation*.
2. Select the station number in the “Quick Filter for Station” window.
3. Select the date the station was visited in the “Quick Filter for Visit Start Date.”
4. If the date does not appear in the drop down window, the visit has not been created yet.
5. If a visit for a specific site was already created, and site-level data already exist for that site, skip to the “**Enter Data**” section.
6. If the visit has not yet been created, continue to next section.

Choose the station for which data will be entered

1. Click the “Add New Visit” button.
2. Select the station in the “Station ID” window.
3. Add the start date for the mission in the “Start Date” window. Click the “Yes” button in the following window. This will populate the “Activity ID” window.
4. Add the start time for the first record of the mission in the “Start Time” window.
5. Select “AST,” “EDT,” or “EST” as appropriate in the “Zone” window.
6. Select “Field Msr/Obs-Habitat Assessment” in the “Activity Type” window.

Enter station data (each diver)

1. Fill out the site depth in the “Depth” window in feet.
2. Select “ft” in the “Units” window.
3. Type the Braun-Blanquet (BB) diver’s name in the “Person(s)” window.
4. Current: select the appropriate current category from the drop-down menu.
5. Visibility: enter visibility value in ft.
6. Select “ft” in the “Units” window.
7. Enter any pertinent site notes in the “Visit Comment” window.

Enter quadrat data

1. In the “Activity Comment” enter the BB quadrat number.
2. Enter the appropriate data in the “Result Value” column for each parameter.

- a. Substrate: select the appropriate substrate type from the drop-down menu.
 - b. Sediment Depth: enter the value in centimeters.
 - c. Taxa: select the BB score for each taxon present in the quadrat.
 - i. For seagrass species: also enter canopy height in centimeters.
 - d. Add any pertinent comments for “a” through “e” in the “Comments” column.
3. When done entering data for the first quadrat, or when entering data for a previously created visit that already contains data, click on the “Add New Activity” button.
 - a. When entering data from a previously created visit, the new activity number should be “3” and the following activity number will be “4.”
 - b. When a visit has already been created, there is no need to change the “Start Date” or the “Start Time” values. However, the “Start Date” should be identical for both divers, while the “Start Time” may be slightly different. If there are gross discrepancies in these two fields between the two divers, both divers must confer and determine the accurate values.
 - c. Make sure to add any pertinent comments to the “Visit Comment” window.
4. To continue with a new quadrat at the same site:
 - a. Select “Field Msr/Obs-Habitat Assessment” in the “Activity Type” window.
 - b. Re-enter the site depth in the “Depth” window in feet.
 - c. Select “ft” in the “Units” window.
 - d. Type the BB diver’s name in the “Person(s)” window.
 - e. In the “Activity Comment” enter the BB quadrat number.
 - f. Repeat steps 2a–2f.
5. The original observer should perform a data entry review and correct any discrepancies as they go along.

Enter Queen Conch data

- For all Queen Conch data, enter the appropriate data in the “Results Value” column for each parameter.
 - Queen Conch Count: enter the number of Queen Conch observed within a 7.5 meter (24.6 ft) radius.

- Queen Conch_Life Stage: select one of the following options from the Permitted Values window – ADULT or JUVENILE

100% QA/QC verification of entered data

The primary observer (diver) will conduct a 100% QA/QC verification of the entered data. QA/QC of the data should occur after data from the entire survey has been completed.

1. Open the NPStoret database.
2. Select “SFCN” in the “Available Organizations” window.
3. Select your name in the “Available Log In IDs” window.
4. Click on the “Results” tab.
5. Select “SFCN_Seagrass” in the “Available Projects” window.
6. Select “All the Organization’s Stations” in the “Available Station Input Groups.”
7. Select “All the Organization’s Characteristics” in the “Available Characteristic Input Groups.”
8. Click the “OK” button.
9. The “NPStoret Result Entry Template” window will open up.
 - a. Utilize the Quick Filters for “Station” and “Visit Start Date” at the top of the screen for navigation.
 - b. Compare each Visit, Activity, and Characteristic to the original field data sheet and fix discrepancies when they are discovered. Refer questions to the original observer for clarification.
10. Upon completing a 100% review of all the datasheets, the Project Leader will inform the Marine Ecologist who will do a spot check of the entered data and also check for anomalies in an ecological context. The Marine Ecologist will update the status of all verified records from “Preliminary” to “Verified.” This can be accomplished in bulk, but must be applied to each day of a seagrass survey.
 - a. Click the “Remove Filter” button at the bottom of the “NPSTORET Result Entry Template.”
 - b. In the “Quick Filter for Visit Start Date” select the first date that was verified.
 - c. Click the “Change Status” button and choose the “On all Station Visits for Project as filtered.”
 - d. In the ‘Set to:’ section choose “Verified.”

- e. Click “OK” to apply the change.
 - f. Repeat steps b–e for any additional days that were verified.
11. After data verification is performed as described and all discrepancies addressed, the data are referred to the South Florida/Caribbean Network’s marine ecologist for validation and then final certification.

National Park Service
Inventory and Monitoring Division



*Review, Certification and Export to Microsoft Excel,
EQuIS and STORET—Version 1.0*

This SOP describes the procedures for reviewing seagrass data, correcting errors and excluding questionable data. When this step is complete the data is certified by the SFCN data manager. The data is then sent to NPS Water Resources Division for inclusion in EQUIS and STORET.

[illegible]

Procedure

Data review and certification

1. The South Florida/Caribbean Network's marine ecologist and project leader will work with the data manager to check the data set for problems. This includes running the NPSTORET "QA Data Entry for Organization" utility and reviewing exports for missing or inconsistent data. Additionally, there are several characteristics listed below that can be used to check the ecological validity of the data set.
 - a. Are seagrass species found at inappropriate depths? Observations below the following depth limits are not necessarily incorrect, particularly in clear waters such as occur in the Caribbean basin. It is important that observers make notations of unusual sightings. Observers may take extra pictures if necessary, although quadrat pictures should capture any seagrass species observed below the following depths:
 - i. *Halodule wrightii*: 3 meters (9.8 feet [ft])
 - ii. *Halophila decipiens*: 40 meters (131 ft)
 - iii. *Halophila engelmannii*: 90 meters (295 ft)
 - iv. *Halophila stipulacea*: 50 meters (164 ft)
 - v. *Ruppia maritima*: 1 meter (3.3 ft)
 - vi. *Syringodium filiforme*: 16.5 meters (54.1 ft)
 - vii. *Thalassia testudinum*: 30 meters (98.4 ft)
 - b. Cover class
 - i. All seagrasses can be commonly found in all cover classes, with the exception of *Halophila decipiens*. Observers should make note of any Braun-Blanquet (BB) scores above 2 for this species; photos of BB quadrats should suffice to confirm BB score accuracy for QA/QC if necessary.
 - c. Canopy height
 - i. *Halodule wrightii*: 10–15 centimeters (3.9–5.9 inches [in])
 - ii. *Halophila decipiens*: 1.5–2 centimeters (0.6–0.8 in)
 - iii. *Halophila engelmannii*: 1–3 centimeters (0.4–1.2 in)
 - iv. *Halophila stipulacea*: 3–6 centimeters (1.2–2.4 in)
 - v. *Syringodium filiforme*: up to 50 centimeters (19.7 in)

vi. *Thalassia testudinum*: up to 36 centimeters (14.2 in)

2. Network marine ecologist and project leader will work with the data manager and assistant data manager to correct errors when possible. If necessary, the observer will be consulted to verify accuracy of any questionable data.
3. The marine ecologist will also check over the data and create preliminary graphs looking for unusual data in an ecological context, e.g., sudden large changes in dominant seagrass species may generate a review of photos to verify accurate species identification.
4. Inaccurate or questionable data will be corrected or flagged as “Rejected.” All decisions to correct or reject data will be properly documented in the database.
5. After the review is complete the data manager will change the “Value Status” of acceptable data to “Final.” According to IMD guidance, these data are considered “Certified” if a quality assurance plan (QAP) exists, or “Accepted” if a QAP is still being created.
 - a. Click the “Remove Filter” button at the bottom of the “NPSTORET Result Entry Template.”
 - b. In the “Quick Filter for Visit Start Date” select the first date to be certified.
 - c. Click the “Change Status” button and choose the “On all Station Visits for Project as filtered.”
 - d. In the “Set to:” section choose “Final.”
 - e. Click “Ok” to apply the change.
 - f. Repeat steps b–e for any additional days that need to be certified.

Submerged Aquatic Vegetation (SAV) Data Export to Microsoft Excel file

1. Open the NPStoret database.
2. Select “SFCN” in the “Available Organizations” window.
3. Select your name in the “Available Log In IDs” window.
4. Click on the “Reports and Stats” tab to open the “4. Export” page in the “NPSTORET Reports and Statistics” window.
 - a. In “Data Type” select “Results.”
 - b. In “New Row for Each” select “Activity.”
 - c. In “File Type” select “Excel.”
 - d. In “Fields” select “Subset.”

- i. In the “Select Fields for Export” select the following boxes: “NPSTORET Org ID/Code,” “Organization Name,” “Project ID,” “Project Name,” “Station ID,” “Station Name,” “Station Latitude,” “Station Longitude,” “Visit Comment,” “Visit Start Date,” “Visit Start Time,” “Activity/Sample ID,” “Activity Type,” “Depth to Activity,” “Depth Units,” “Activity Personnel,” “Activity Comment,” “Visit Late Update Date,” and “Activity Last Update Date” (Figure SOP 7-1).
- ii. In the lower, “Characteristic and Result Fields” section choose only “Subject Taxon,” “Units,” and “Result Value/Text” (Figure SOP 8-1).

Export Field Selection

Select Fields for Export

Project, Station Visit, and Activity Fields

☒ NPSTORET Org ID/Code	☒ Visit Comment	☒ Activity Type	Advanced Programming Fields: ☐ Visit Primary Key ☒ Visit Last Update Date ☐ Visit Source Org ID ☐ Activity Primary Key ☒ Activity Last Update Date
☒ Organization Name	☒ Visit Start Date	☒ Depth to Activity	
☒ Project ID	☒ Visit Start Time	☒ Depth Units	
☒ Project Name	☐ Visit End Date	☐ Relative Depth	
☒ Station ID	☐ Visit End Time	☐ Custody ID	
☒ Station Name	☐ Hydrologic Event Code	☒ Activity Personnel	
☒ Station Latitude	☒ Activity/Sample ID	☐ Sampling Component	
☒ Station Longitude	☒ Activity Replicate #	☐ Sampling Comp. Order	
☐ QC Sample	☒ Activity Comment		

Characteristic and Result Fields

☐ Local Characteristic Name	☒ Result Value/Text	☐ Analysis Date	Advanced Programming Fields: ☐ Result Primary Key ☐ Result Last Update Date ☐ Result Source Org ID ☐ Correction ☐ Individual # ☐ Group Summary Size ☐ Group Summary UOM
☐ STORET Characteristic Name	☐ Detection Condition	☐ Analysis Time	
☐ Sample Fraction	☐ Value Status	☐ Confidence Level	
☐ Medium	☐ Value Type	☐ Precision	
☐ Field/Lab	☐ Statistic Type	☐ Lower Confidence Limit	
☒ Subject Taxon	☐ Detection Limit	☐ Upper Confidence Limit	
☐ Subject Species #	☐ Lower Quant Limit	☐ Bias	
☐ Bio Part	☐ Upper Quant Limit	☐ Bias Corrected	
☐ Analytical Proc ID	☐ Det/Quant Limit Desc	☐ Replicate Analysis #	
☐ Sample Coll Proc ID	☐ Remark Code	☐ Dilution	
☒ Units	☐ Measure Qualifier	☐ Dilution Factor	
	☐ Result Comment	☐ Recovery	

Standard Set:

OK Cancel

Figure SOP 8-1. Screenshot of Select Fields for Export.

- e. In “File Name” navigate to where the file is to be exported and type in an appropriate filename.
 - f. In “Organizations” select “Subset.”
 - i. In the “Selected Organizations” window that pops up choose “SFCN: South Florida / Caribbean Network” and click the single up-arrow button to make this the selection. Click Ok.
 - g. In “Projects” select “All.”
 - h. In “Stations” select “All Stations.”
 - i. In “Date Ranges: select “Subset” and put in the desired dates.
 - j. In “Status” select “All,” “Preliminary,” “Verified,” or “Final” as appropriate.
 - k. Change other field defaults only as necessary for specific data export needs.
5. Click on the “Export Data” button to export the desired data set.

SAV data export to EQUIS and STORET

1. Open the NPStoret database.
2. Select “SFCN” in the “Available Organizations” window.
3. Select your name in the “Available Log In IDs” window.
4. Click on the “Utilities” button.
5. Click on the “Compact Back End” button to remove temporary tables and to reduce the file size.
6. Click on “Zip/Backup Organization Data.”
 - a. Click Browse to specify a file location and name for the file.
 - b. In the “Select Organization” window choose “SFCN.”
 - c. Check the two additional boxes to include linked files and complete, unfiltered data.
7. Click “OK” to create the zip file.
8. Attach the zip file created in Step 7 to an email and send it to Dean Tucker with the NPS Water Resources Division (Dean_Tucker@nps.gov).

Standard Operating Procedure 9

Source Protocol

South Florida/Caribbean Network. 2018. Long-Term Monitoring Protocol of Caribbean Spiny Lobster (*Panulirus argus*): Standard Operating Procedures. South Florida/Caribbean Network, Miami, Florida.

Purpose

Revision Log

[illegible]

Introduction

Data analyses and reporting will be specific to management questions and resource goals that are being addressed; however, some suggested analyses should be applied to the data after each survey. This includes data for reports as well as information for the iterative approach to sample design. This SOP includes a description of these analyses.

Creating an Initial Analysis-Ready Data Set

Generating Seagrass Data

Data will be available for download after final QA/QC (see SOP 7). The standardized NPStoret export must be converted into an analysis-ready format. Table SOP 8-1 lists the fields for the analysis-ready data set from which subsequent calculations described in this SOP can be made. In addition to this data set, a list of all possible strata for each region and management zone must be created along with a list of surveyed sites.

Table SOP 9-1. Data fields for an analysis-ready data set.

Field	Description	Source
Site_name	discrete site name	NPStoret
Activity/Sample ID	Quadrat number	NPStoret
Sub-region	St. John/St. Thomas, St. Croix, Biscayne	Calculated from Station_name
NPS Reporting Zone	BUIS, SARI, BISC, VIIS, DRTO RNA, OutsideNPS	Calculated from Station_name
Visit Start Date	Sample Date	NPStoret
Year	Year	Calculated from Visit Start Date
Depth to Activity	average depth from divers (ft.)	NPStoret
Strat	stratification	Calculated from depth
species_cd	four letter species code	NPStoret – transposed from row to column
BB-score	Braun-Blanquet score from 0-5	NPStoret – transposed from row to column; 0's added for empty cells

Documenting Summary Statistics for Strata

Initial sampling will be proportional to stratum area, but over time sampling may shift to an optimal allocation. Optimal sampling effort for each survey requires an adjustment to the allocation of sites sampled among strata and management zone. A list including the number of sites selected within each stratum and management zone, the actual number of sites surveyed and the total area of each stratum is imperative for population estimates and must be included with each report (Table SOP 9-

2). Whether or not to update the final strata classifications of sites based upon actual site depth from the survey data sheet (diver team classification, not the map) will be determined once at least one full sampling event of data has been collected and the frequency of such errors can be evaluated.

Table SOP 9-2. Example of summary statistics for strata in Virgin Islands National Park.

Zone	Strata	Mapped Area (hectares)	# Sites Selected	# Sites Surveyed
VIIS	< 5 meters (16.4 feet [ft]) deep	–	–	–
VIIS	5–15 meters (16.4–49.2 ft) deep	–	–	–
VIIS	> 15 meters (49.2 ft) deep	–	–	–

Statistical Background

Although the seagrass monitoring design has the appearance of a two-stage design, in practice the final placement of the quadrats would be more clustered than would be expected by a complete random sample due to the requirement that divers remain within visible sight of each other. Thus, the following calculations use the one stage statistical approach from Bryan et al. (2013) and quadrats are treated as subsamples.

All subsequent calculations use the following calculation of N_h (the total number of possible samples in stratum h) where A_h is the mapped stratum area.

$$N_h = \frac{A_h}{0.25 \text{ m}^2 \cdot \# \text{ quadrats per sample point}}$$

Note: All formulas and definitions are also provided in Table SOP 9-10 following this SOP.

Summary Statistics

Medians, minimums, maximums, quartiles, and proportion of points using each Braun-Blanquet (BB) score category will be generated by stratum for cover, frequency, and other metrics.

Frequency of Occurrence

An inventory of seagrass and algal species observed and their frequency of occurrence is generated by stratum for each park.

Frequency of occurrence (proportion of sites present) for each species (P_i): $P_i = \frac{N_i}{n}$; such that $0 \leq P_i \leq 1$, where P_i = proportion of occurrence or frequency of species i ; N_i = the number of quadrats at a site in which species i was present; and n = the total number of quadrats sampled at a site.

The site frequencies of occurrence are averaged by stratum: $(\bar{P}_h)$.

$$\bar{P}_h = \frac{1}{n_h} \sum_j P_{hj}$$

n_h is the total number of sites visited in each stratum. j is the individual site.

To determine the proportion of occurrence across the entire sampling domain, the stratum average frequencies of occurrence are multiplied by a weighting factor (w_h) and summed to provide an overall estimate ($\bar{P}_{st}$). This weighting factor is calculated for each stratum as:

$$w_h = \frac{N_h}{\sum_h N_h}$$

N_h is the total possible number of primary units that can be sampled in stratum h .

$$\bar{P}_{st} = \sum_h w_h \bar{P}_h$$

A non-parametric bootstrap is performed on the sample data using the `boot()` function in R. A parametric bootstrap resamples from a known distribution function and is more appropriate for continuous data sets. The non-parametric bootstrap resamples from the data that was actually collected and is more appropriate for a discrete data set. Thus, a non-parametric bootstrap is used in this protocol to calculate adjusted confidence intervals for frequency of occurrence. From the bootstrapped data, adjusted 95% confidence intervals are generated for each stratum as well as for the entire sample domain using the `boot.ci()` function in R.

Native Species Richness

In addition to proportion occurrence for all species, a total count of native species and non-native species observed throughout all surveys as well as mean native species richness (defined here as average number of species observed per site) is calculated.

The mean native species richness ($\bar{Sp}_h$) for each stratum (h) within the specified region of interest is calculated, where n_h is the number of primary units sampled in stratum h and non-native species are excluded from Sp . Sp_{hj} is the number of native seagrass species detected when pooled across the four quadrats at a site.

$$\bar{Sp}_h = \frac{1}{n_h} \sum_h Sp_{hj}$$

A non-parametric bootstrap is performed on the sample data using the `boot()` function in R to calculate adjusted confidence intervals for native species richness. From the bootstrapped data, adjusted 95% confidence intervals are generated for each stratum as well as for the entire sample domain using the `boot.ci()` function in R.

To calculate the average native species richness per site across the entire sampling domain, the stratum averages and a weighting factor are used:

$$\overline{SP}_{st} = \sum_h w_h \overline{SP}_h$$

where w_h is the stratum weighting factor

$$w_h = \frac{N_h}{\sum_h N_h}$$

N_h is the total possible number of primary units that can be sampled in stratum h .

Seagrass Cover Class Index

Note: Calculation of averages of BB scores will only be used for summary tables or graphs. Statistical analyses for change will use analyses appropriate for ordinal data as described further below.

A seagrass cover class BB score index can be estimated for each stratum within the area of interest. Seagrass cover, D , is the average of the BB score per site for a species or species group. The mean cover ($\overline{D}_h$) for each stratum (h) within the entire domain or specified region of interest is calculated where n_h is the number of primary units (j) sampled in stratum h .

$$\overline{D}_h = \frac{1}{n_h} \sum_j D_{hj}$$

To calculate the Seagrass Cover Class Index for the domain, the stratum cover class index averages and a weighting factor are used:

$$\overline{D}_{st} = \sum_h (w_h \overline{D}_h)$$

where w_h is the stratum weighting factor

$$w_h = \frac{N_h}{\sum_h N_h}$$

N_h is the total possible number of primary units that can be sampled in stratum h .

A hierarchical non-parametric bootstrap is performed on the sample data using the boot() function in the R statistical analysis package (R Foundation for Statistical Computing, Vienna, Austria, <https://www.R-project.org>) to calculate adjusted confidence intervals for average cover BB score for each seagrass species, total seagrass cover, and each algal species category. Unlike the other metrics above which have a single value per site, cover class will involve a hierarchical bootstrap in which

the 4 quadrats are bootstrapped and then sites are bootstrapped. From the bootstrapped data, adjusted 95% confidence intervals are generated for each stratum as well as for the entire sample domain using the `boot.ci()` function in R.

Change Analysis

Change in the average cover class index and frequency of occurrence will be calculated within each stratum and across strata. For seagrass cover metrics based on BB scores, the South Florida/Caribbean Network will use statistical methods designed for ordinal data such as ordinal regression (Guisan and Harrell 2000; Irvine and Rodhouse 2010; Damgaard 2014) or Kruskal-Wallis test (multiple years) or Mann-Whitney U-test (between years). Recent development of ordinal beta models that link category probabilities to continuous variables such as percent cover (Irvine and Rodhouse 2010; Irvine et al. 2016) and use ordinal regression are appropriate for interpretation of trends in hierarchical cover classes, such as Braun-Blanquet (Guisan and Harrell 2000; Irvine and Rodhouse 2010; Damgaard 2014). Cumulative logit models and ordinal beta models are applicable for trend analysis on ordered categorical variables used to visually estimate cover classes using areal plots. Logistic regression models, particularly with unequal cover class intervals, can effectively summarize changes in ranked data and are considered mathematically more appropriate than least squares linear regression modeling using cover class midpoints (Yeo et al. 2009). A logit model may also be referred to as proportional odds models (POM):

$$\text{logit} [Pr(C_i \leq j | \mathbf{X})] = \theta_j - \mathbf{X}\boldsymbol{\beta}$$

where C_i is the assigned category for observation i with $j + 1$ observed categories, and $\boldsymbol{\theta}$ is the set of ordered cutpoints (threshold parameters) with $-\infty = \theta_0 < \theta_1 < \dots < \theta_J < \theta_{J+1} = \infty$ and $\{\boldsymbol{\beta}, \theta_1, \dots, \theta_J\}$ (Irvine et al. 2016). The model can account for a latent variable distribution function but assumes that a shift to the next higher category is uniform across all classes; which is not the case with Braun-Blanquet data (Irvine et al. 2016). Recent development of ordinal beta models show promise as a way to link category probabilities to continuous variables such as percent cover (Irvine and Rodhouse 2010; Irvine et al. 2016). R and JAG code for implementation of the ordinal beta hurdle model and POM is available on the NPS Integrated Resource Management Applications (IRMA) portal at: <https://irma.nps.gov/DataStore/Reference/Profile/2231866>. Analyses that involve all three depth strata with stratum as a factor or “block” variable will also be conducted for BB scores using ordinal regression.

The following approach can be used with frequency of occurrence and native species richness metrics to determine whether a significant difference between two time periods exists. The differences between two time periods are bootstrapped to create a 95% confidence interval of the differences. These time periods can be individual sample events or grouped sample events from consecutive years. In this approach, a sample is taken from the first time period (T_1) and a sample from the second time period (T_2) is subtracted from it. This value is stored and the process repeated 10,000 times (the bootstrap). From this distribution, the 2.5 and 97.5 percentiles are identified (two-tailed test for $\alpha = 0.05$). If the value 0 falls outside of these percentiles, then the two time periods

are significantly different. This process should be completed for sampling domain-wide estimates and for each stratum individually.

To test for trends in frequency of occurrence and native species richness that occur over three or more time periods, a generalized linear model (GLM) is used. Time, stratum, and time by stratum interactions are included. Time is included as a linear regression variable where possible, but if change appears to be non-linear, then time must be included as a categorical variable. For the metric in question, the GLM uses the distribution that is most appropriate for the data set. The GLM for native species richness (count data) may require a Poisson or other distribution. For frequency of occurrence data, a binomial distribution may be required, but for frequencies less than 5%, a logistic regression may be most appropriate.

Analyses will be conducted in R. Code will be developed subsequent to publication of this protocol, but procedures are available for conducting these analyses in R. The R and JAG code for implementation of the ordinal beta hurdle model and POM is available on the NPS IRMA portal at: <https://irma.nps.gov/DataStore/Reference/Profile/2231866> (Irvine and Rodhouse 2010; Irvine et al. 2016). R code associated with bootstrapping routines for similar analyses of spiny lobster is found in Appendix G of the Caribbean spiny lobster protocol (Richter et al. 2018).

Trend analysis methods will be further refined after several years of data collection from a single park unit.

Summary Reporting

At the end of each survey season, the National Park Service will prepare a report containing analyses described in the section above. This report will provide managers and interested parties a single document from which to evaluate spatial and temporal trends of population level metrics. Specifics of this report are described below.

Individual Seagrass and Algal Species or Genus

A basic summary report will be created for all species using the metrics described in Table SOP 9-4. Summaries will be created for 33 variables listed in Table SOP 9-5.

NPS Reporting Zones

Data reports include several metrics that are broken down by reporting zone. In some cases these are the same as management zone and in other cases a park may be a single reporting zone or outside parks may be a reporting zone. A description is included below:

St. Croix

BUIS = Buck Island Reef National Monument

SARI = Salt River Bay National Historical Park and Ecological Preserve

St. John

VIIS = Virgin Islands National Park

VICR = Virgin Islands Coral Reef National Monument

Florida

BISC = Biscayne National Park

In addition to reporting data combined across reporting zones, data are reported by stratum within a reporting zone. Once several sampling events have occurred, example tables and figures will be provided as in Figure SOP 9-1. However, the first year of reporting would benefit from simpler tables showing multiple species at once.

Table SOP 9-4. Individual species metrics reported by stratum for summary report. Canopy cover index and frequency of occurrence are also reported as combined weighted multi-strata metrics.

Metric	Descriptive statistic
Frequency	Mean 95% Confidence Interval
Canopy Cover Index	Mean 95% Confidence Interval
Canopy Height (centimeters [cm])	Mean Standard Deviation Standard Error Median Minimum Maximum
Sediment Depth (centimeters [cm])	Mean Standard Deviation Standard Error Median Minimum Maximum
Water Depth (feet [ft])	Mean Standard Deviation Standard Error Median Minimum Maximum

Table SOP 9-5. Focal species list for reporting.

Taxonomic Group	Name	Exotic	Potential Optimization Taxon	Taxon Code
Seagrasses	<i>Thalassia testudinum</i>	–	X	TTES
	<i>Syringodium filiforme</i>	–	X	SFIL
	<i>Halodule wrightii</i>	–	–	HWRI
	<i>Halophila decipiens</i>	–	–	HDEC
	<i>Halophila engelmannii</i>	–	–	HENG
	<i>Halophila stipulacea</i>	X	X	HSTI
	<i>Ruppia maritima</i>	–	–	RMAR
	Seagrass total	–	X	STOT
Calcareous Green Alga	<i>Halimeda</i> sp.	–	–	HALI
	<i>Udotea</i> sp.	–	–	UDOT
	<i>Penicillus</i> sp.	–	–	PENI
	<i>Rhipocephalus</i> sp.	–	–	RHIP
	<i>Acetabularia</i> sp.	–	–	ACET
	<i>Neomeris</i> sp.	–	–	NEOM
	<i>Cymopolia</i> sp.	–	–	CYMO
	Calcareous green total	–	–	CGTO
Green Alga	<i>Caulerpa</i> sp.	–	–	CAUL
	<i>Batophora</i> sp.	–	–	BATO
	<i>Avrainvillea</i> sp.	–	–	AVRA
	<i>Dasycladus</i> sp.	–	–	DASY
	Green other	–	–	GOTH
	Green total	–	–	GTOT
Red Alga	<i>Laurencia</i> sp.	–	–	LAUR
	Red other	–	–	ROTH
	Calcareous red other	–	–	CROT
	Red total	–	–	RTOT
Brown Alga	<i>Sargassum</i> sp.	–	–	SARG

Taxonomic Group	Name	Exotic	Potential Optimization Taxon	Taxon Code
	<i>Dictyota</i> sp.	–	–	DICT
	Brown other	–	–	BOTH
	Brown total	–	–	BTOT
Other Taxa	Sponges	–	–	SPO
	Corals	–	–	CORALU
	Gorgonians	–	–	GO

Thalassia testudinum

Average Braun Blanquet Score by stratum and combined across strata. CI = Confidence Interval

Strata	Variable	2018	2021	2023	2025
> 15 m	Avg	0.00	0.00	0.00	0.00
	95% CI	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)
5 - 15 m	Avg	0.27	0.30	0.27	0.28
	95% CI	(0.00, 0.58)	(0.00, 0.60)	(0.00, 0.56)	(0.00, 0.57)
< 5 m	Avg	0.92	1.10	1.30	2.00
	95% CI	(0.48, 1.36)	(0.70, 1.50)	(0.88, 1.72)	(1.59, 2.41)
Combined	Avg	0.31	0.35	0.37	0.40
	95% CI	(0.15, 0.47)	(0.18, 0.52)	(0.22, 0.52)	(0.25, 0.55)

Average Frequency of Occurrence (% quadrats/site) by stratum and combined across strata.

CI = Confidence Interval

Strata	Variable	2018	2021	2023	2025
> 15 m	Avg	0.00	0.00	0.00	0.00
	95% CI	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.00)
5 - 15 m	Avg	0.21	0.25	0.24	0.27
	95% CI	(0.08, 0.34)	(0.15, 0.35)	(0.14, 0.34)	(0.18, 0.36)
< 5 m	Avg	0.45	0.60	0.65	0.70
	95% CI	(0.24, 0.66)	(0.35, 0.85)	(0.39, 0.91)	(0.45, 0.95)
Combined	Avg	0.11	0.20	0.21	0.22
	95% CI	(0.06, 0.16)	(0.14, 0.26)	(0.15, 0.27)	(0.15, 0.29)

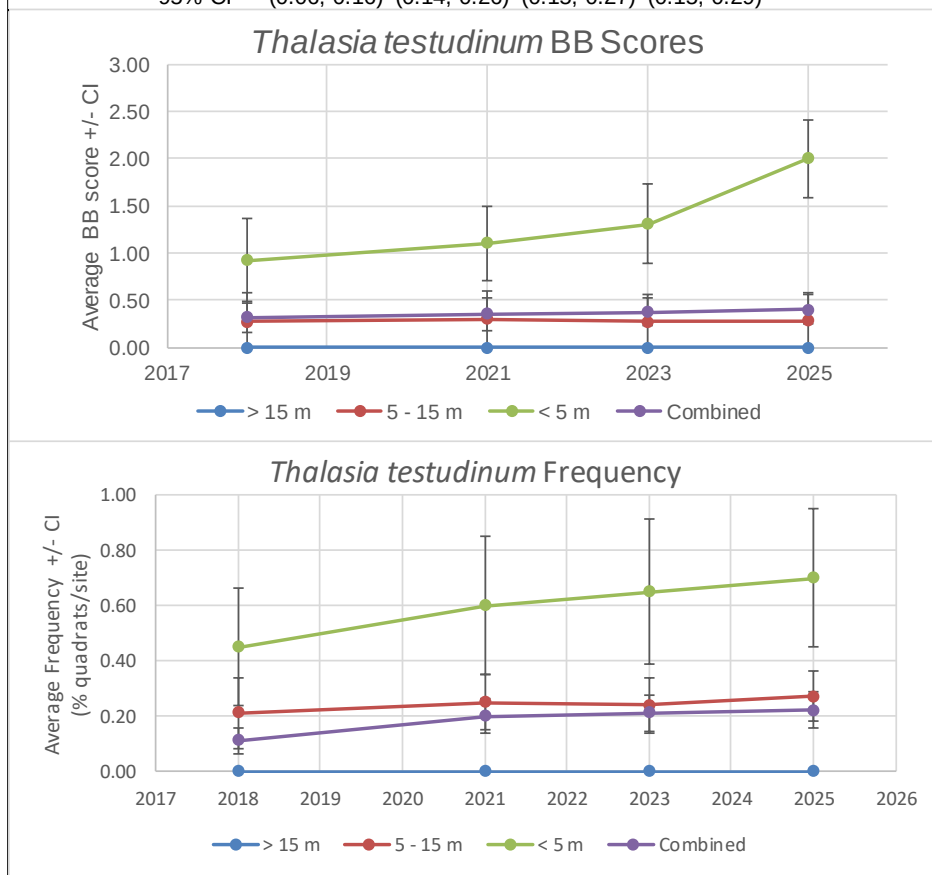


Figure SOP 9-1. Microsoft Excel spreadsheet illustrating a hypothetical individual species data summary for Virgin Islands NP.

Species Counts and Species Richness Summary

In addition to individual species reports a few community metrics will be reported. A running list of total number of species and new species observed by park will be reported in Table SOP 9-6. Mean native species richness of seagrass by strata and park over time will also be reported (Table SOP 9-7).

Table SOP 9-6. Summary of species counts for current sampling period.

Park	Total Species	Total New Species
BUIS	–	–
SARI	–	–

Table SOP 9-7. Seagrass species richness (average # detected per site) for Virgin Islands National Park (CI=Confidence Interval).

Stratum	Variable	2020	2023	2026
<15 meters (49.2 ft)	Avg	–	–	–
	95% CI	–	–	–
5–15 meters (16.4–49.2 ft)	Avg	–	–	–
	95% CI	–	–	–
>5 meters (16.4 ft)	Avg	–	–	–
	95% CI	–	–	–
Combined strata	Avg	–	–	–
	95% CI	–	–	–

Queen Conch

Within the national parks, Queen Conch occurrence based on field observations will also be included in reports as shown in Table SOP 9-8.

Table SOP 9-8. Queen Conch recorded (St. Croix).

Species	# Sites Present (BUIS)	% Occurrence (SARI)	# Sites Present (SARI)	% Occurrence (SARI)
Queen Conch	–	–	–	–

Design Performance Analysis

An examination of sampling size and allocation performance will be completed after each season. This analysis aids in determining sampling allocation for the subsequent year as described in SOP 4 *Sample Allocation*. Sampling design performance is ultimately the result of trade-offs between surveying cost (usually measured by the number of samples) and population estimate precision. A performance measure typically used is the coefficient of variation (CV) of density as shown in both the reef fish protocol for Virgin Islands SOP 2 *Stratification* and SOP 3 *Sample Allocation* (Bryan et al. 2013); and SOP A *Statistical Sampling Design in (A Cooperative Multi-Agency Reef Fish Monitoring Protocol for the Florida Keys Coral Reef Ecosystem* (Brandt et al. 2009). Additional data helps define the variance structure for each stratum which can change the allocation of sampling effort.

The sample allocation will start out as a proportional allocation (conservative) and then develop a more aggressive approach (adaptive) over time to reduce the variance of the estimates in the survey. Most likely densities of two or three key species important to management will be selected for optimization of the adaptive design (i.e., *Thalassia testudinum*, *Syringodium filiforme*, *Halophila stipulacea*).

Table SOP 9-9. Statistical symbol definitions.

Category	Symbol	Definition	Computational Formula
Mean	h	Stratum subscript	—
Cover	j	Sample unit subscript	—
Class and Allocation	D_j	Average density in sample unit j across i quadrats	—
	A_h	Stratum area	Total mapped area in stratum h
	n_h	Number of units sampled in stratum h	—
	N_h	Total possible number of sample units in stratum h	$N_h = \frac{A_h}{0.25 \text{ m}^2 \cdot \# \text{ quadrats per sample point}}$
	$\bar{D}_h$	Mean cover in stratum h	$\bar{D}_h = \frac{1}{n_h} \sum_j D_{hj}$
Frequency of Occurrence	P_j	Occurrence in sample unit j	—
	$\bar{P}_h$	Proportion occurrence by strata	$\bar{P}_h = \frac{1}{n_h} \sum_j P_{hj}$
Native Species Richness ¹	Sp_j	Species richness per site j	—
	$\bar{Sp}_h$	Mean strata species richness	$\bar{Sp}_h = \frac{1}{n_h} \sum_h sp_{hj}$

¹The number of species pooled across the quadrats at a site.

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National Park Service
Inventory and Monitoring Division



Revising the Protocol—Version 1.0

This standard operating procedure (SOP) describes how changes in the protocol and SOPs will occur and how they will be tracked.

[illegible]

Procedures

The *South Florida/Caribbean Network Seagrass Community Monitoring Protocol Narrative* (Davis et al. 2019), SOPs, and Quality Assurance Plan (QAP) can only be modified through the use of a versioning system with the following guidance. Changes will be designated as minor (e.g., software update or technology change) or major (e.g., modification of sample design, change in field methods, expansion of monitoring to new areas).

1. Minor editorial changes and formatting can proceed provided they do not affect the content or substance of the protocol and are communicated to all parties. Except for changes to the SOPs, which require in-house review by SFCN staff only, changes to the narrative or Quality Assurance Plan (QAP) require review from the regional program manager. If changes are indeed minor, there will not be an external review. Suggestions can be made at any time, but the South Florida/Caribbean Network may choose to compile them over the course of a year before releasing a new version.
2. Major changes, including those affecting content and substance of the protocol or SOPs, will require external review and approval by the regional program manager.
3. Protocol edits and versioning are tracked in the Revision History Log attached to the narrative and each individual SOP. Major changes result in updates by whole numbers (e.g., version 1.0 to 2.0) and minor changes by tenths (e.g., version 1.1 to 1.2). The new version number, date of revision, author of the revision, a description of the change, and rationale for the change must be included in the Revision History Log.
4. Any major changes to an individual SOP must be also tracked in the protocol's Revision History Log and the version number must be updated.
5. A digital version of the protocol narrative, SOPs, supporting documents, and scripts will be made available on the [SFCN website](#) and at <http://irma.nps.gov>.

Literature Cited

Davis, A.D., M. W. Feeley, M. Londoño, L. Richter, J. M. Patterson, A. J. Atkinson. 2019. South Florida/Caribbean Network seagrass community monitoring: Protocol narrative. Natural Resource Report NPS/SFCN/NRR—2019/1904. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2259756> (last accessed March 2019).