
National Coral Reef Monitoring Program (NCRMP) Benthic Community Assessment Survey Field Protocols for U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, and U.S. Virgin Islands 2024

Coral Reef Conservation Program (CRCP), National Oceanic and Atmospheric Administration (NOAA)

Suggested Citation

CRCP. 2024. National Coral Reef Monitoring Program (NCRMP) Benthic Community Assessment Survey Field Protocols for U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, and U.S. Virgin Islands. NOAA Coral Reef Conservation Program. 29 pp. doi: [10.25923/e3gf-vk84](https://doi.org/10.25923/e3gf-vk84)

Introduction

The National Coral Reef Monitoring Program (NCRMP)'s biological sampling provides a biennial ecological characterization of general reef condition for reef fishes, corals, and benthic habitat (i.e., fish species composition, density, and size; coral species composition, density, size, condition; and benthic community cover) at a broad spatial scale (CRCP 2021). In the U.S. Atlantic, NCRMP biological sampling includes coral reef and hardbottom habitats in Florida, Flower Garden Banks, Puerto Rico, and the U.S. Virgin Islands (USVI). NCRMP surveys at stratified random sites where the sampling domain for each geographic region is partitioned by habitat type and depth, sub-regional location (e.g., along-shelf position), and management zone. NCRMP provides data from a broader geographic context that complements a mosaic of regional and local (site-specific) coral reef monitoring.

NCRMP Benthic Community Assessment Summary

At each NCRMP Benthic survey site, a single Benthic Community Assessment survey is conducted. An NCRMP Benthic survey includes one Benthic Community Assessment Survey (CRCP 2024a) and one Coral Demographics survey (CRCP 2024b). NCRMP Benthic surveys may occur at all or a subset of NCRMP Fish surveys (CRCP 2024c). Benthic surveys may be conducted concurrently with co-located NCRMP Fish surveys or Benthic and Fish surveys may occur at separate field visits (Appendix I).

This protocol includes an overview of the field methodology, including pre-dive, site orientation, and the coral demographics survey, as well as an overview of data accessibility and use. The NCRMP Benthic Community Assessment surveys are designed to provide the following data:

1. Estimates of benthic cover for ecologically important species or functional groups/ types (e.g., macroalgae, turf algae, crustose coralline algae, corals, sponges, sand/sediment, etc.).
2. Estimates of topographic complexity (substratum rugosity) within the survey area (15 x 2m).
3. Abundance of commercially and ecologically-important macroinvertebrates (i.e., Caribbean spiny lobster, Queen conch, long-spined sea urchins [*Diadema antillarum*]) within the survey area (15 x 2m). Abundance of healthy, diseased, and dead *D. antillarum* within the survey area. Presence or absence of diseased, dying, or dead *D. antillarum* (newly added in 2022) at the site.
4. Presence or absence of Threatened coral species within the survey area (15 x 2m) and at the site.

NCRMP Benthic Community Assessment: Sequence of Events

NCRMP Benthic Community Assessment data collection occurs in multiple phases: (1) Pre-dive, (2) Site Information, (3) Benthic Community Assessment survey, and (4) Post-dive data entry. The Benthic Community Assessment survey includes: Line-Point Intercept (LPI) survey, measurement of reef complexity, presence or absence of Threatened coral species (within the survey area and at the site), abundance of select macro-invertebrates (Figure 1).

NCRMP Benthic Community Assessment Survey Flowchart

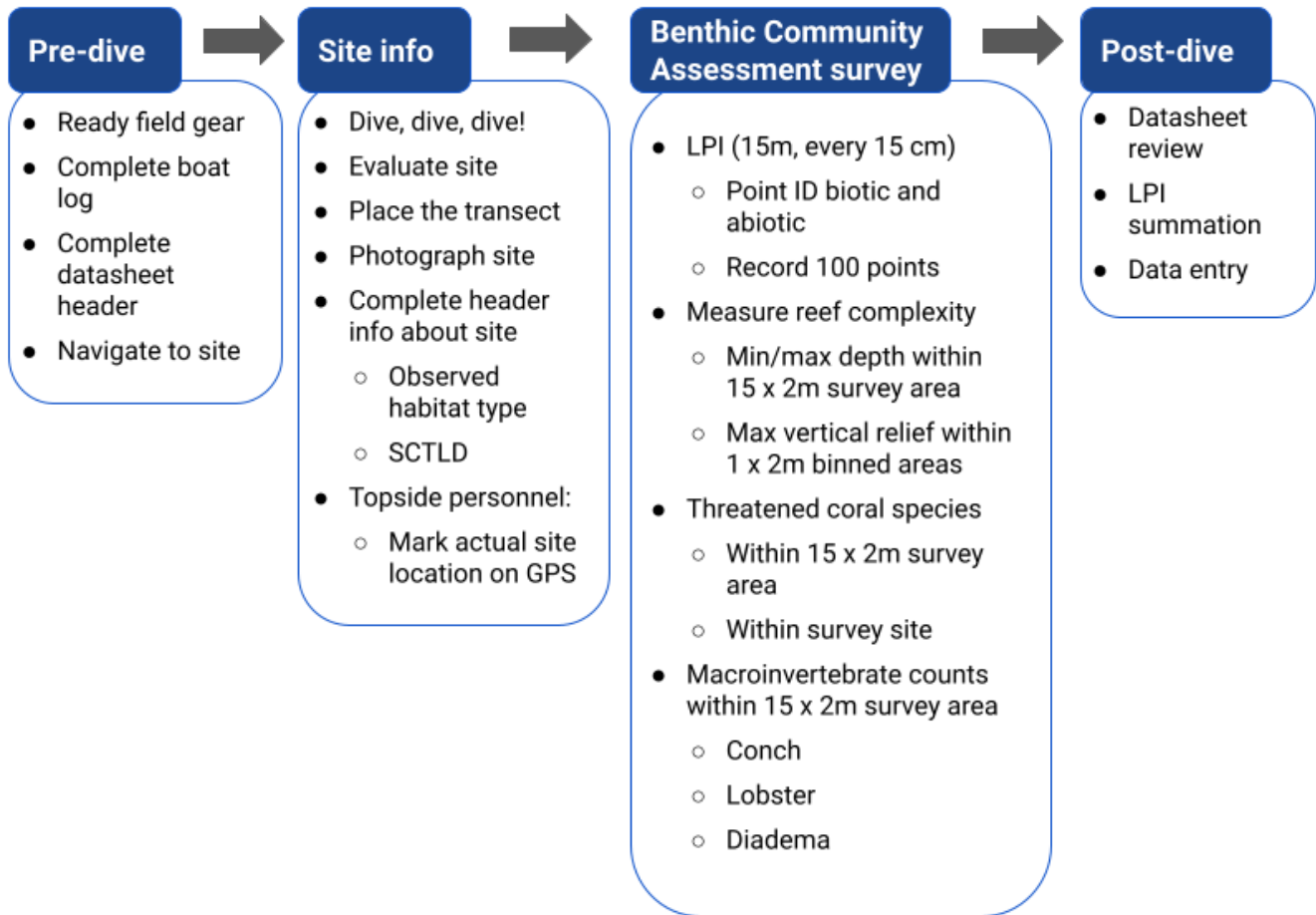


Figure 1. Benthic Community Assessment sequence of effort.

Pre-dive

The pre-dive phase consists of organizing field equipment to take underwater and filling out station information on two datasheets prior to entering the water: the boat log and the Benthic Community Assessment datasheet (Figures 2 and 3).

Organize Field Equipment

The following field gear will be organized to take on the dive.

1. Benthic Community Assessment survey datasheet
2. Demographics datasheet
 - a. One survey per datasheet
3. Benthic team transect tape, weights
4. Clipboard, pencil, spare pencil
5. Small rigid measuring instrument, marked in cm (e.g., “Flexiruler”) to assist Coral Demographics survey diver, and to aid in locating exact point under LPI transect tape
6. Measuring instrument marked in cm increments used for measuring coral colony dimensions and/or for measuring 1m out from the transect tape (e.g., 0.5 or 1-m PVC, marked in units or with measuring tape securely attached), and for assisting in Coral Demographics data collection
7. Benthic team camera (with charged battery, and space on memory card) and housing

Complete Boat Log

Prior to the dive, key fields to record on the boat log for station information include the following (Figure 2; Appendix II):

1. Site – The 4-digit site number
2. Station – (1) All regions are now 1-stage
3. Team (Team member assignment) – Letter code identifying the type of survey data being collected by the diver within their dive team
 - a. Fish (A/B) – A two-diver fish team consists of a Diver A and Diver B.
 - b. Benthic (J/X) – The diver collecting Benthic Community Assessment data is assigned the code ‘J’; the diver collecting Coral Demographics data is assigned ‘X’.

**** Codes are assigned to diver positions within the team and type of data collected; therefore, diver team codes could change by station as divers rotate ****

Date	DOD	Site	Station	Team	Diver	O2%	PSI IN	TIME IN
4/12/16	1	1200	1	A	Clark			
	1	1200	1	B	Blondeau			
	1	1200	1	J	Edwards			
	1	1200	1	X	Viehman			
4/12/16	2	1026	1	A	Nemeth			
	2	1026	1	B	Clark			
	2	1026	1	J	Viehman			
	2	1026	1	X	Blondeau			

Figure 2. Example of boat log with station information filled out. DOD = Dive of the day.

Example: Figure 2 provides an example of a boat log and the specific station information to record at the dive site. The first dive of the day consisted of four divers, one fish group and one benthic group. The benthic divers are Edwards and Viehman, identified by the J/X codes used. For the first dive, Edwards is identified as team member J (Benthic Assessment diver) and Viehman is X (Coral Demographics diver). Notice for the second dive of the day, Viehman is assigned diver J for the benthic team and Blondeau is diver X.

Datasheet Logistics and Station Information

The following information should be filled out legibly on the NCRMP Benthic Assessment datasheet (Figure 3; Appendix III).

- Names of all divers,
- Field ID –a unique alpha-numeric number, **FIELD ID = (SITE#) + (STATION#) + (TEAM letter)**
- Date,
- Time of survey,
- Mission data manager,
- Number of survey meters completed.

NCRMP Benthic Community Assessment Datasheet			
Diver: <u>K. Edwards</u>	Boatlog/Manger: <u>J. Blondeau</u>	Date: <u>6 JUNE 2023</u>	LPI Meters Complete: _____ m
Buddy: <u>S. Viehman</u>	Field ID: <u>4335 1J</u>	Sample Time: <u>1125</u>	
Habitat: <i>Bedrock</i> <i>Pavement</i> <i>Aggregate Reef</i> <i>Patch Reef</i> <i>Scat. Coral/Rock in Sand</i>			
Coral Disease with Tissue Loss: <i>None</i> <i>Not Sampled</i> <i>Fast (>1cm)</i> <i>Slow (<1cm)</i>		Coral restoration: <input type="checkbox"/> At site <input type="checkbox"/> in 15x2m <input type="checkbox"/> Unknown <input type="checkbox"/> None	

Figure 3. NCRMP Benthic Community Assessment Caribbean datasheet header with logistic and station information. In this example, Diver Edwards recorded the Field ID 12001J. According to the boat/dive log (Figure 2), Edwards is diver J for site 1200.

General Site Information

General site information includes navigation to the site, recording the station information on the boat log and datasheet, and when to terminate a dive. The pre-dive tasks have already been completed.

Navigate to the Site

Once in the field, the vessel captain navigates to the pre-selected NCRMP site using a handheld GPS unit. On-site, divers are deployed and maintain visual contact with each other throughout the entire census.

**** Divers should always be aware of their dive buddy and should make frequent visual contact through the entire dive, including during surveys****

1. Each vessel will have up to three **(3)** GPS units:
 - a. One **(GPS 1)** for vessel navigation to sites, and
 - b. Each boat will have one **(GPS 2)** dive flag/float with a GPS unit attached. This setup is unique for each boat and will be used by the diver teams to mark the site for surface support, to mark a starting point for the dive teams and to verify site location with computer generated sites. Record each team's unique GPS # and dive flag numbers on the daily boat log (Figure 2; Appendix II).
 - c. If using a GPS unit other than handheld to navigate to the sites, a handheld GPS **(GPS 3)** is used to collect topside waypoints (see #3 below).
2. Dive teams enter the water at provided GPS coordinates, descend to the bottom, affix the surface float line to the bottom, set up survey areas, and begin data collection.
 - d. If the benthic team is diving with the fish team, ALL dive teams enter the water as close to the same time as possible.
3. As the dive team(s) deploy from the vessel, the boat captain will use the handheld GPS to mark a waypoint of the surface float/flag and record the coordinates on the boat log (Appendix II).

****Vessel operators will safely mark waypoint, after divers have descended****

4. After completion of all surveys or at the end of the dive, all divers convene at the affixed float line and begin their ascent to the surface together.

Establishing the Survey – Evaluating the Site

1. Locate hardbottom: As the team descends and assesses the site, the lead team ascertains the presence of hardbottom.
 - a. Hardbottom presence/absence
 - i. Present – If hardbottom is present, continue habitat type assessment.
 - ii. Absent – If hardbottom is not **visible** at the site (no hardbottom at all, e.g.,

continuous sand or seagrass combined with limited visibility),

- iii. The dive will be terminated and an alternate site selected,
 1. Do not swim around searching for hardbottom – this is not reconnaissance.
2. Locate the survey site: If the team(s) deploy directly over the expected hardbottom habitat, they establish cylinders where they touch down on the bottom.
 - a. If the expected hardbottom habitat is not directly beneath them during descent, divers will swim to the expected habitat if it is within visual range.
 - i. If divers enter the water over sand, they will swim to nearby reef habitat for sampling.
 - ii. If divers enter the water over hardbottom different from that which was expected, but observe the expected habitat type within visible range from where deployed, they will swim to expected habitat for sampling.
 - b. If divers enter the water over hardbottom different from that expected and **do not** observe expected habitat type nearby, they will establish cylinders where deployed and indicate the alternate habitat on the datasheet and boat log.
3. Establish the survey site: When a benthic team (Benthic Community Assessment and Coral Demographics divers) deploys with the Fish team (pair of RVC fish divers), they establish the survey adjacent to the cylinders if possible, using the same anchor point for the belt transect (Appendix I). Additional information on establishing the survey site follows in Section III: Coral Demographics Surveys.
 - a. If hardbottom is patchy, the benthic team may swim to nearby hardbottom feature to start transect, remaining in visual context with the Fish divers and the surface float (Appendix I).
 - b. Establish the Benthic Survey transect.
 - c. **Secure transect tape.** The Benthic team secures the transect tape and the surface float line or reel.
 - d. **Lay out the transect.** The Benthic Community Assessment diver reels out the transect to a length greater than 15m, secures the tape so that it is taut, and weights as needed (Figure 1).
 - i. If the site is pavement or scattered coral in sand, soft weights may be used to weigh down the transect tape at the beginning and end to keep the transect in place.
 - ii. The diver will avoid wrapping the tape around substrate or biotic objects within the survey area, for this would distort sampling distances and locations for the benthic divers. Weights will not be placed on live coral.
 - iii. The end of the tape should be tied or clipped so that the transect tape is as taut as possible.
 - iv. If current is present at depth, transect tape may be aligned to face the current. If currents are too strong, the survey should be terminated.
4. Photograph the site: At least five photographs are taken per site. The Coral Demographics diver coordinates with the Benthic Community Assessment diver on who will take the site photographs (and subsequently upload, organize, and re-label the images).
 - a. Take one photograph of the station and logistic information at the top of the datasheet prior to taking any photographs of the site. The station name, date, time and heading information should be clear and legible in the photograph.

- b. Take four site photographs at the four cardinal compass headings (i.e. 0°: 0°, 90°, 180° and 270°).
 - c. Additional photographs may be taken of anything unusual (e.g., rare fish, bleached or rare corals), for species identification purposes, unique site features, putative SCTLTD and divers working.
5. Termination of dive due to conditions: Certain environmental conditions are not safe for operations and surveys should be automatically terminated and alternates chosen when any of the following conditions are met:
- a. Conditions are unsafe,
 - b. Visibility is less than 5m,
 - c. Bottom currents are strong enough that the divers cannot safely maintain a stationary position, or
 - d. Depth of the survey site is greater than 99ft.

Terminate a dive when any of the following conditions are met

- Conditions are unsafe,
- Visibility is low (<5m),
- Currents are strong, or
- Depth >99ft.

**** ALWAYS indicate on boat logs why and when the dive was terminated ****

NCRMP Benthic Community Assessment Survey

- **Datasheet.** A new datasheet is to be used for each Benthic Community Assessment survey, one survey per sheet (i.e., do not record data for survey Y on the back of survey X's datasheet). *This is important for data management.*
- **Survey area.** The NCRMP Benthic Community Assessment survey is 15m long. The line point intercept survey has 100 points along the 15m survey. The survey area for select invertebrates, ESA-listed corals, and reef complexity is 15 x 2m (Figure 4). At the end of the survey, fill out the completed meters on the datasheet (Figure 5).

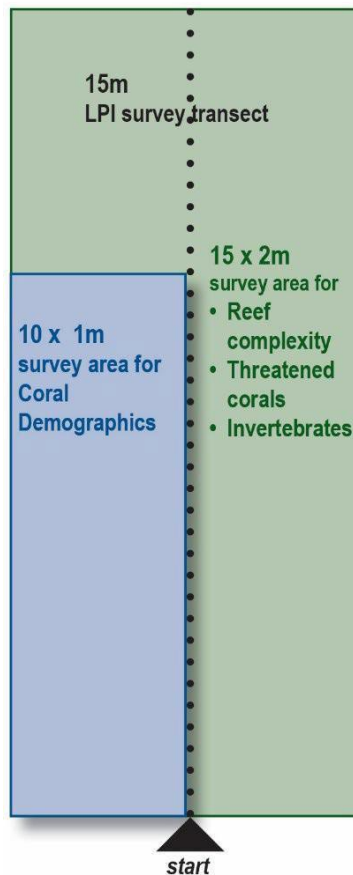


Figure 4. Diagram of NCRMP Coral Demographics survey area, Benthic Community Assessment survey area, and Benthic Community Assessment survey area for reef complexity, Threatened corals, and invertebrates. The size of each respective survey area is represented.

NCRMP Benthic Community Assessment Datasheet				
Diver: _____	Boatlog/Manger: _____	Date: _____	LPI Meters Complete: _____ m	
Buddy: _____	Field ID: _____	Sample Time: _____		
Habitat: <i>Bedrock</i> <i>Pavement</i> <i>Aggregate Reef</i> <i>Patch Reef</i> <i>Scat. Coral/Rock in Sand</i>				
Coral Disease with Tissue Loss: <i>None</i> <i>Not Sampled</i> <i>Fast (>1cm)</i> <i>Slow (<1cm)</i>			Coral restoration: <input type="checkbox"/> At site <input type="checkbox"/> in 15x2m <input type="checkbox"/> Unknown <input type="checkbox"/> None	

Figure 5. The NCRMP Benthic Assessment LPI survey length is 15m. The surveyor completes the datasheet at the end of the dive with the meters completed. If the survey is complete, this should be 15(m).

General Site Assessment

The Benthic Community Assessment diver collects the following header information at the site level. These may be scoped out during the dive and completed after the transect survey is finished.

1. Observed habitat type – Post-dive, the diver enters the habitat type(s) observed during the dive. This may be different from the mapped habitat (Figures 6 a-c).
 - a. Circle selection from the habitat categories (circle one on the Habitat datasheet).
 - b. Immediately after the dive, the diver should discuss with their buddy and other team members and try to come to a consensus. If consensus is not achieved, divers should note that in the Field/Boat Log.

c. NOTE: habitat types are different across regions (Appendix IV).

a.

NCRMP Benthic Community Assessment Datasheet					
Diver: _____	Boatlog/Manger: _____	Date: _____	LPI Meters Complete: _____ m		
Buddy: _____	Field ID: _____	Sample Time: _____			
Habitat: <u>Bedrock</u> Pavement Aggregate Reef Patch Reef Scat. Coral/Rock in Sand					
Coral Disease with Tissue Loss: None Not Sampled Fast (>1cm) Slow (<1cm) Coral restoration: <input type="checkbox"/> At site <input type="checkbox"/> in 15x2m <input type="checkbox"/> Unknown <input type="checkbox"/> None					

b.

NCRMP Benthic Community Assessment Datasheet					
Diver: _____	Boatlog/Manger: _____	Date: _____	LPI Meters Complete: _____ m		
Buddy: _____	Field ID: _____	Sample Time: _____			
Habitat: <u>High Relief</u> Low Relief					
Coral Disease with Tissue Loss: None Not Sampled Fast (>1cm) Slow (<1cm) Coral restoration: <input type="checkbox"/> At site <input type="checkbox"/> in 15x2m <input type="checkbox"/> Unknown <input type="checkbox"/> None					

c.

NCRMP Coral Demographics Datasheet					
Diver: _____	Boat/Manager: _____	Start Time: _____	Page _____ of _____		
Buddy: _____	Field ID: _____	Date: _____	Sheet filled by (circle diver): Demo LPI		
Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm)					
Habitat: <u>Contiguous S&G</u> Contiguous Other Isolated Rubble Matrix (Sand) Meters completed: _____ m					
Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown % HB of survey: _____					

Figure 6. Hardbottom categories of observed habitat type and meters completed section on the Benthic Community Assessment datasheet for (a) Caribbean, (b) Gulf of Mexico, and (c) Florida locations. *Note: Habitat categories differ by location.*

2. Coral Disease with Tissue Loss – Stony Coral Tissue Loss Disease is prevalent in many locations in Florida and the Caribbean. This header field provides a high-level observation of the site-level presence of recent mortality and associated coral tissue loss related to disease at the site level and is an indicator for SCTLD (Figure 7).

Each diver is to note 1 of the 4 options with an ‘X’ in the appropriate box:

- **None** – no disease with tissue loss is observed at the site.
- **Not Sampled** – diver did not include this measurement.
- **Fast (>1cm)** - tissue loss due to disease is observed on at least 1 coral colony at the site and the maximum width of recent mortality (uncolonized dead skeleton) is >1cm in width/diameter, therefore rate of disease spread is considered fast (acute). This rate can be indicative of Stony Coral Tissue Loss Disease.
- **Slow (<1cm)** - tissue loss due to disease is observed on at least 1 coral colony at the site and the maximum width of recent mortality is <1cm in width/diameter, therefore rate of disease spread is considered slow (sub-acute).

NCRMP Benthic Community Assessment Datasheet					
Diver: _____	Boatlog/Manger: _____	Date: _____	LPI Meters Complete: _____ m		
Buddy: _____	Field ID: _____	Sample Time: _____			
Habitat: Contiguous S & G Contiguous Other Isolated Rubble Matrix/Sand					
<u>Coral Disease with Tissue Loss: None Not Sampled Fast (>1cm) Slow (<1cm)</u> Coral restoration: <input type="checkbox"/> At site <input type="checkbox"/> in 15x2m <input type="checkbox"/> Unknown <input type="checkbox"/> None					

Figure 7. Categories of Stony Coral Disease with Tissue Loss on the NCRMP Benthic Community Assessment datasheet. This is for observations at the site level.

3. Restoration site - This identifies the presence of coral restoration (i.e., outplanting; Figure 8). Restoration outplanting may be indicated by epoxy or cement at the base of corals along with tagged corals and by potentially by species (e.g., Acroporids).
- **At site:** restoration is present within the holistic NCRMP survey site. The survey site is defined as anywhere in the visible range of the dive site. This is not reconnaissance to seek out coral restoration, but to note presence of these corals observed outside the transect.
 - **In 15x2m:** restoration is present within the BCA survey area.
 - **Unknown:** restoration is suspected within the site or BCA area, but there is uncertainty.
 - **None:** no evidence of restoration at either the site or within the BCA survey area.

NCRMP Benthic Community Assessment Datasheet					
Diver: _____	Boatlog/Manger: _____	Date: _____	LPI Meters Complete: _____ m		
Buddy: _____	Field ID: _____	Sample Time: _____			
Habitat: <i>Bedrock</i> <i>Pavement</i> <i>Aggregate Reef</i> <i>Patch Reef</i> <i>Scat. Coral/Rock in Sand</i>					
Coral Disease with Tissue Loss: <i>None</i> <i>Not Sampled</i> <i>Fast (>1cm)</i> <i>Slow (<1cm)</i>					
Coral restoration: <input type="checkbox"/> At site <input type="checkbox"/> in 15x2m <input type="checkbox"/> Unknown <input type="checkbox"/> None					

Figure 8. Evidence of coral restoration. This can be at the site level and/or within the NCRMP Benthic Assessment 15 x 2m survey area. It may also be marked as unknown or none within the header information on the NCRMP Benthic Community Assessment datasheet.

Benthic Community Assessment Survey Methodology

The Benthic Community Assessment methodology includes a line point intercept survey for cover (%), a belt transect for macroinvertebrate counts, topographic complexity, and Threatened coral species. The Benthic Community Assessment methodology is summarized in Figure 1.

1. Line Point Intercept (LPI)

LPI data are collected on the following information:

- Point identification** – At 15cm intervals along the transect tape, identify and categorize the substratum type according to available datasheet options (Appendix III). Identify the biotic organism (if any) for that abiotic substrate type (Hardbottom, Rubble or Sand) at each 15cm interval.

Identify points for evaluation objectively. Line a straight edge (e.g., pencil) with the transect point and vertically orientate it downward toward the substratum. Avoid bias, subjectivity and “artificial selection” of favored substrates (e.g., corals).

Record the first abiotic/biotic bottom type encountered in the point recording section of the datasheet (Figure 9).

Canopy cover of hard organisms such as branching corals is a valid point (e.g., *Acropora* spp.).

- Point intercepts with the canopy cover of soft branching organisms, (e.g., a calcareous algae, gorgonians, or sponges) and branching *Millepora* species **are not valid points**; however, point intercepts with the **holdfasts of such organisms are valid points and must be recorded**. In other words, canopy cover by “soft” branching organisms is only scored when the point intercepts a holdfast/attachment point.

Example: A gorgonian encrusted with *Millepora* species

- (1) **IF** the point intercepts the attachment point or holdfast of a gorgonian that is not encrusted by *Millepora*, the point is scored as *gorgonian*. **NOTE:** the vertical, flexible “fan” area of the sea fan is not a valid point, regardless of *Millepora* presence on the “fan”.
- (2) The point is scored as *Millepora* **ONLY IF** it intercepts the attachment point or holdfast of *Millepora* species or any other organism (such as a calcareous algae, gorgonian, or sponge) encrusted by *Millepora*.

Example: algae (e.g., *Sargassum* spp., *Dictyota* spp.).

- (1) A patch of *Dictyota* macroalgae growing on and covering crustose coralline algae (CCA) should be scored as *Dictyota* **ONLY IF** the point intersects with the *Dictyota* holdfast; otherwise the point should be scored as CCA.
- (2) A point is scored as *Sargassum* **ONLY IF** the point intersects with the holdfast or attachment point of the *Sargassum*. If the point intersects with the branching (non-holdfast) portion of the *Sargassum*, it should NOT be scored as *Sargassum*.

Record biotic and abiotic code every 15cm			Habitat code: H - Hardbottom			S - Soft		R - Rubble	
Meter	Cover	Hab	Meter	Cover	Hab	Meter	Cover	Hab	
0.15			5.70			11.25			
0.30			5.85			11.40			
0.45			6m			11.55			
0.60			6.15			11.70			
0.75			6.30			11.85			
0.90			6.45			12m			
1.05m			6.60			12.15			
1.20			6.75			12.30			
1.35			6.90			12.45			
1.50			7.05			12.60			
1.65			7.20			12.75			
1.80			7.35			12.90			
1.95			7.50			13.05m			
2.1m			7.65			13.20			
2.25			7.80			13.35			
2.40			7.95			13.50			
2.55			8.1m			13.65			
2.70			8.25			13.80			
2.85			8.40			13.95			
3.0m			8.55			14.1m			

Figure 9. Point identification and point recording location on datasheet.

- b. **Abiotic substratum** categories include hard (i.e., hardbottom or reef), soft (i.e., sand or mud), and rubble (Figure 9; Appendix V).
- c. **Biotic categories** include coral to species, bare, algal turf, etc., as described in Appendix V. Appendix VI provides example photos of these categories.
 - i. If a point falls on bare sand, the diver notes “Bare” in the cover column and “S” in the habitat column (Figure 9). Be mindful of hardbottom with a sand veneer and remember to check for hardbottom beneath the sand using your finger or pencil.
 - ii. If a point falls on turf algae growing on hardbottom with no sand trapped in the turf filaments, data is recorded as “H” in the habitat column next to the “TURF-no sediment” recorded in the cover column.
 - iii. Biotic category options (with the exception of coral species) are provided on the

datasheet (Appendix III) to assist in point identification.

- iv. **Meters completed** – Note the meter of completion of LPI survey on the datasheet determined by the data entered in the 15cm-interval boxes (Figure 5).

2. Topographic Complexity Survey

a. **Rugosity: Minimum/maximum depth.**

This information provides the depth range of the sample unit, as well as the potential variability of the substratum in certain habitats such as spur and groove.

- Measurements are made within the entirety of the 15 x 2m transect along **BOTH** transect sides (Figure 4), starting at meter 15, and 1m out on each transect side.
- Using a digital depth gauge, record the maximum and minimum depth of the substratum encountered within the 15m x 2m belt transect (recorded in feet) in the Rugosity section of the datasheet (Figure 9).

b. **Meters complete relief (m)**

This is a whole integer indicating the total number of relief measurements completed by the diver and recorded in the Rugosity section of the datasheet (Figure 10). The target number is 15.

Rugosity 15x2m		
Min depth (ft)		
Max depth (ft)		
Meters complete relief: _____m		
Relief 15x2m (1x2 m cells)		
meter	meter	meter
0-1	5-6	10-11
1-2	6-7	11-12
2-3	7-8	12-13
3-4	8-9	13-14
4-5	9-10	14-15

Figure 10. Topographic complexity section on Benthic Community Assessment datasheet

Reef complexity

Fifteen absolute measurements (whole cm) are collected to characterize the surface topography of the sample unit (i.e., 15 x 2m transect).

- The entire transect is subdivided into 15 1 x 2m smaller subplots (n=15 per sample unit), with each subplot scored for the highest hard-bottom relief feature.
- Within each 1 x 2m sub-plot the highest maximum hard relief feature (not including “soft complexity” features such as branching gorgonians, sponges, and fire corals) is measured and reported (cm) within the corresponding meter mark.
- If no search occurs, denote this with a large “X” through the entire rugosity column. If some portion of this survey does not occur, denote this with a large “X” through the portion that does not occur.

3. Threatened coral species

The presence or absence 1) within the 15 x 2m belt transect and 2) anywhere at the sample site, of all seven (7) Atlantic/Caribbean coral species listed as Threatened according to the U.S. Endangered Species Act will be recorded (Figure 11).

Threatened coral species		
Presence(1) or Absence(0)		
	<i>in 15 x 2m</i>	<i>At site</i>
<i>A. cervicornis</i>		
<i>A. palmata</i>		
<i>D. cylindrus</i>		
<i>O. annularis</i>		
<i>O. faveolata</i>		
<i>O. franksi</i>		
<i>M. ferox</i>		

Figure 11. Threatened ESA coral section on Benthic Community Assessment datasheet. The presence or absence of ESA-listed coral species is noted if they are within the Benthic Community Assessment 15 x 2m survey area or at the NCRMP site.

- This transect area lies within the 15 x 2m transect (Figure 4). This is also the same transect area that is surveyed for the macroinvertebrate counts.
- The survey site is defined as anywhere in the visible range of the dive site. This is not reconnaissance to seek out ESA species, but to note presence of these corals observed outside the transect.
- Presence or absence is recorded for each of these Atlantic/Caribbean ESA-listed or threatened scleractinian coral species: *Acropora palmata*, *A. cervicornis*, *Dendrogyra cylindrus*, *Orbicella annularis*, *O. faveolata*, *O. franksi*, and *Mycetophyllia ferox*.
 - i. **PRESENCE** of species – denoted by a “1” (one).
 - ii. **ABSENCE** of species – denoted by a “0” (zero).
- Photograph any colonies you are unable to identify to species and verify topside. If no search occurs, denote this with a large “X” through the entire ESA corals column. If some portion of this survey does not occur, denote this with a large “X” through the portion that does not occur. ***If this portion of the survey is not sampled, it is critical to indicate so on the datasheet. Not sampled is entirely different from a survey where species were absent (not encountered) within the 15 x 2m survey area.***

4. Notes: Additional notes may be added into the bottom of the datasheet (Appendix III).

- a. Indicate any field observation that may be important, such as presence of an ecological mortality event (e.g., disease).

5. Macroinvertebrate counts

- e. All Caribbean spiny lobster (*Panulirus argus*), queen conch (*Lobatus gigas*), and long-spined sea urchins (*Diadema antillarum*) are counted within the 15m x 2m belt transect (Figure 4).
- f. In 2022, the presence or absence and counts of diseased, dying, or dead *Diadema* has been added to the Macroinvertebrate survey in response to mass *Diadema* mortality observed in

the Caribbean.

- The invertebrate count survey area is within the 15 x 2m belt transect (Figure 4; Appendix I: Figure A). This is also the same transect area surveyed for ESA-listed coral species presence- absence.
- Healthy, diseased, and dead *Diadema* are counted specifically within the 15 x 2m macroinvertebrate counts survey area (Figure 12).

Macroinvertebrate counts (15x2m)	
<i>P. argus</i>	
<i>L. gigas</i>	
<i>D. antillarum</i>	

Figure 12. Macroinvertebrate counts section on the NCRMP Benthic Community Assessment datasheet.

- If no search occurs, denote this with a large “X” through the entire Count column. ***If this portion of the survey is not sampled, it is critical to indicate so on the datasheet. Not sampled is entirely different from a survey where species were absent (not encountered) within the 15 x 2m survey area.***

Assisting with the Coral Demographics Surveys

The Benthic Community Assessment diver will **always** bring a Coral Demographics datasheet, ruler, and a PVC meter stick to facilitate assisting the Demographics diver in data collection.

1. When the Benthic Community Assessment diver assists the Coral Demographics diver in the Coral Demographics survey, the Benthic Community Assessment diver will confirm with the Coral Demographics diver that that the demographic transect ends at 10m, will start the Demographics survey at the tenth meter, and will work toward the Demographics diver.
2. The Benthic Community Assessment and Coral Demographics divers will coordinate to avoid duplicating counts and will meet at a full meter. The meter range surveyed by each diver will be written on each respective datasheet.
3. Benthic Community Assessment divers will have completed training on the Coral Demographics Survey protocols and will have scientific training in and current working knowledge of Caribbean scleractinian coral species identification.

Post-dive: Data

Datasheet review

When divers return to the vessel after the underwater survey, the dive team exchanges datasheets for review by checking for completeness and legibility. A diver should not review his/her own datasheet.

1. *Benthic Assessment datasheet* – Review verifies the following:
 - a. Completeness and legibility of all data fields; including identification of second Demographics surveyor (if applicable).
 - b. Completeness and legibility of total meters completed.
 - c. Completeness and legibility of percent hardbottom of survey component.
 - d. Annotation in “Notes” section reporting the presence of multiple datasheets utilized for data collection (if applicable).

Post-dive data entry

1. The Benthic Community Assessment diver is responsible for all of the Benthic Community Assessment survey data entry for the site, even if the Benthic Assessment diver assists in Coral Demographics data collection.
2. In preparation for entry into the NCRMP data portal, the Benthic Community Assessment diver tallies the LPI section of Benthic Community Assessment datasheet by biotic categories by abiotic substrate. Tally totals are to equal the number of rows of recorded data (Figure 13). *This section is also to be used to assist in identifying biotic categories for point recording.*

Categoric Data Entry Counts							
Coralc (cp)	H	S	R		H	S	R
				Bare			
				Turf no sediment			
				Turf w/ sediment			
				Diatyota			
				Halimeda			
				Lobophora			
				Maoro - calc			
				Maoro - fleshy			
				CCA			
				Pecconnella			
				Ramiorusta			
				Gorg - encrust			
				Gorg - upright			
				Sponge - other			
				Sponge - Clionna			
				Cyano/Diatom			
				Millepora			
				Palythoa			
				Seagrass			
				Other			

Figure 13. Binned LPI section of Benthic Community Assessment datasheet to tally biotic categories by abiotic substrate for entry into database. Tally totals are to equal the number of rows of recorded data. *This section is also to be used to assist in identifying biotic categories for point recording.*

NCRMP Benthic Community Assessment Data Accessibility and Use

NCRMP Coral Demographics Data is publicly accessible in multiple locations.

Coral Reef Conservation Program website: <https://www.coris.noaa.gov/monitoring/biological.html>

Benthic (Benthic Community Assessment and Coral Demographic) analyses scripts are open source and available at NCRMP Benthic R package (Groves and Viehman 2019):

https://github.com/shgroves/NCRMP_benthics

NCRMP data should be cited in all publications. In addition, the following acknowledgement should be included: "NOAA's National Coral Reef Monitoring Program (NCRMP) data was funded by NOAA's Coral Reef Conservation Program, project #743."

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CRCP. 2021. National Coral Reef Monitoring Plan. NOAA Coral Conservation Program. Silver Spring, MD. 39 pp. doi: 10.25923/fqkq-w497

CRCP. 2024a. National Coral Reef Monitoring Program (NCRMP) Benthic Community Assessment Survey Field Protocols for U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, and U.S. Virgin Islands. NOAA Coral Reef Conservation Program. 29 pp. doi: 10.25923/e3gf-vk84

CRCP. 2024b. National Coral Reef Monitoring Program (NCRMP) Coral Demographics Survey Field Protocols for U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, and U.S. Virgin Islands– 2022. NOAA Coral Reef Conservation Program. 27 pp. doi: 10.25923/hgpr-jm80

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Acknowledgements

NCRMP Biological surveys in the U.S. Atlantic are a collaborative effort between NOAA's Coral Reef Conservation Program, NOAA's National Centers for Coastal Ocean Science (NCCOS), and NOAA Fisheries' Southeast Fisheries Science Center (SEFSC). NCRMP is grateful for the continued collaboration of many partners in each region. NOAA's NCRMP is funded by NOAA's Coral Reef Conservation Program, project #743.

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Appendices

Appendix I. Illustrations of survey placement and survey areas

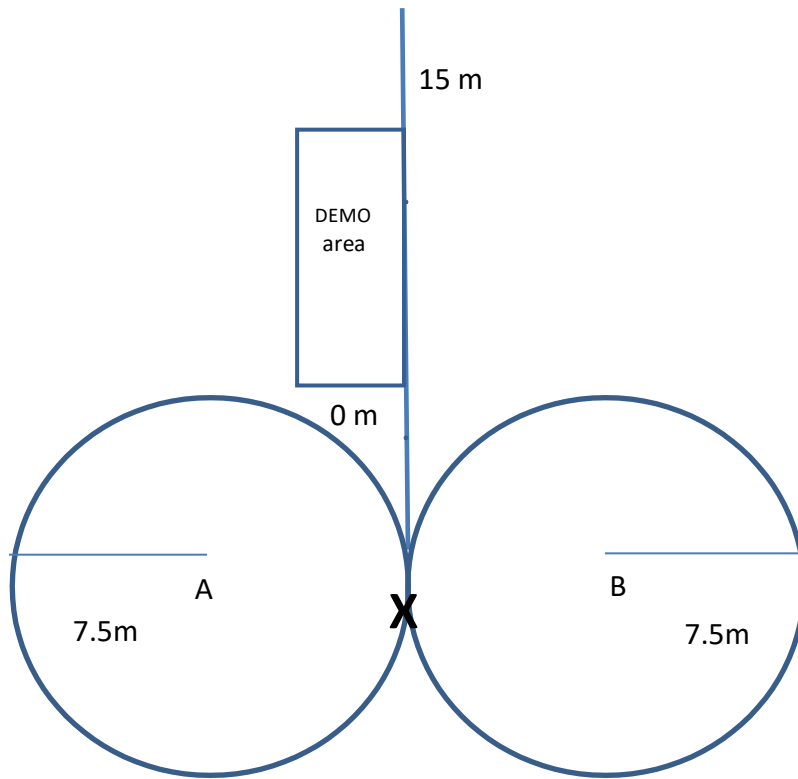


Figure A. Suggested placement of survey areas if continuous hardbottom. A and B represent two fish divers

Appendix III. Benthic Community Assessment Datasheets

Example 1: Puerto Rico and U.S. Virgin Islands datasheet

NCRMP Benthic Community Assessment Datasheet											
Diver: _____		Boatlog/Manger: _____		Date: _____							
Buddy: _____		Field ID: _____		Sample Time: _____				LPI Meters Complete: _____ m			
Habitat: <i>Bedrock</i> <i>Pavement</i> <i>Aggregate Reef</i> <i>Patch Reef</i> <i>Scattered Coral/Rock in Sand</i>											
Coral Disease with Tissue Loss: None Not Sampled Fast (>1cm) Slow (<1cm) Coral restoration: <input type="checkbox"/> At site <input type="checkbox"/> in 15x2m <input type="checkbox"/> Unknown <input type="checkbox"/> None											
Line Point Intercept: Record biotic and abiotic code every 15cm Habitat code: H - Hardbottom S - Soft R - Rubble											
									Rugosity (15x2m)		
Meter	Cover	Hab	Meter	Cover	Hab	Meter	Cover	Hab	Min depth (ft)		
0.15			5.70			11.25			Max depth (ft)		
0.30			5.85			11.40			Meters complete relief: m		
0.45			6m			11.55			Relief (15x2m, 1x2 m cells)		
0.60			6.15			11.70			meter	meter	meter
0.75			6.30			11.85			0-1	5-6	10-11
0.90			6.45			12m			1-2	6-7	11-12
1.05m			6.60			12.15			2-3	7-8	12-13
1.20			6.75			12.30			3-4	8-9	13-14
1.35			6.90			12.45			4-5	9-10	14-15
1.50			7.05			12.60					
1.65			7.20			12.75					
1.80			7.35			12.90			Macroinvertebrate counts (15x2m)		
1.95			7.50			13.05m					
2.1m			7.65			13.20			<i>P. argus</i>		
2.25			7.80			13.35			<i>L. gigas</i>		
2.40			7.95			13.50			<i>D. antillarum</i>		
2.55			8.1m			13.65			Threatened coral species Presence(1) or Absence(0)		
2.70			8.25			13.80					
2.85			8.40			13.95			in 15 x 2m At site		
3.0m			8.55			14.1m			<i>A. cervicornis</i>		
3.15			8.70			14.25			<i>A. palmata</i>		
3.30			8.85			14.40			<i>D. cylindrus</i>		
3.45			9m			14.55			<i>O. annularis</i>		
3.60			9.15			14.70			<i>O. faveolata</i>		
3.75			9.30			14.85			<i>O. franksi</i>		
3.90			9.45			15m			<i>M. ferox</i>		
4.05m			9.60			Categories Data Entry Counts					
4.20			9.75			Corals (sp) H S R			H	S	R
4.35			9.90						Bare		
4.50			10.05m						Turf no sediment		
4.65			10.20						Turf w/ sediment		
4.80			10.35						Dictyota		
4.95			10.50						Halimeda		
5.1m			10.65						Lobophora		
5.25			10.80						Macro - calc		
5.40			10.95						Macro - fleshy		
5.55			11.1m						CCA		
Notes									Peyssonella		
Circle survey grouping Combined Separate									Ramicrusta		
									Gorg - encrust		
									Gorg - upright		
									Sponge - other		
									Sponge - Clionna		
									Cyano/Diatom		
									Millepora		
									Palythoa		
									Seagrass		
									Other		

Example 2: Flower Garden Banks datasheet

NCRMP Benthic Community Assessment Datasheet

Diver: _____ Boatlog/Manger: _____ Date: _____
 Buddy: _____ Field ID: _____ Sample Time: _____ LPI Meters Complete: _____ m
 Habitat: *High Relief* *Low Relief*
 Coral Disease with Tissue Loss: None Not Sampled Fast (>1cm) Slow (<1cm) Coral restoration: At site in 15x2m Unknown None

Line Point Intercept: Record biotic and abiotic code every 15cm			Habitat code: H - Hardbottom S - Soft R - Rubble			Rugosity (15x2m)						
Meter	Cover	Hab	Meter	Cover	Hab	Meter	Cover	Hab				
0.15			5.70			11.25						
0.30			5.85			11.40						
0.45			6m			11.55						
0.60			6.15			11.70						
0.75			6.30			11.85						
0.90			6.45			12m						
1.05m			6.60			12.15						
1.20			6.75			12.30						
1.35			6.90			12.45						
1.50			7.05			12.60						
1.65			7.20			12.75						
1.80			7.35			12.90						
1.95			7.50			13.05m						
2.1m			7.65			13.20						
2.25			7.80			13.35						
2.40			7.95			13.50						
2.55			8.1m			13.65						
2.70			8.25			13.80						
2.85			8.40			13.95						
3.0m			8.55			14.1m						
3.15			8.70			14.25						
3.30			8.85			14.40						
3.45			9m			14.55						
3.60			9.15			14.70						
3.75			9.30			14.85						
3.90			9.45			15m						
4.05m			9.60									
4.20			9.75									
4.35			9.90									
4.50			10.05m									
4.65			10.20									
4.80			10.35									
4.95			10.50									
5.1m			10.65									
5.25			10.80									
5.40			10.95									
5.55			11.1m									
Notes						Categories Data Entry Counts						
						Corals (sp)	H	S	R	H	S	R
										Bare		
										Turf no sediment		
										Turf w/ sediment		
										Dictyota		
										Halimeda		
										Lobophora		
										Macro - calc		
										Macro - fleshy		
										CCA		
										Peyssonella		
										Ramicrusta		
										Gorg - encrust		
										Gorg - upright		
										Sponge - other		
										Sponge - Clionna		
										Cyano/Diatom		
										Millepora		
										Palythoa		
										Seagrass		
										Other		

Circle survey grouping
 Combined Separate

Example 3: Florida datasheet

NCRMP Benthic Community Assessment Data sheet

Diver: _____ Boatlog/Manger: _____ Date: _____
 Buddy: _____ Field ID: _____ Sample Time: _____ LPI Meters Complete: _____ m
 Habitat: *Contiguous S & G* *Contiguous Other* *Isolated* *Rubble* *Matrix/Sand*
 Coral Disease with Tissue Loss: None Not Sampled Fast (>1cm) Slow (<1cm) Coral restoration: At site in 15x2m Unknown None

Line Point Intercept: Record biotic and abiotic code every 15cm						Habitat code: H - Hardbottom S - Soft R - Rubble			Rugosity (15x2m)				
Meter	Cover	Hab	Meter	Cover	Hab	Meter	Cover	Hab	Min depth (ft)				
0.15			5.70			11.25			Max depth (ft)				
0.30			5.85			11.40			Meters complete relief: m				
0.45			6m			11.55			Relief (15x2m, 1x2 m cells)				
0.60			6.15			11.70			meter	meter	meter		
0.75			6.30			11.85			0-1	5-6	10-11		
0.90			6.45			12m			1-2	6-7	11-12		
1.05m			6.60			12.15			2-3	7-8	12-13		
1.20			6.75			12.30			3-4	8-9	13-14		
1.35			6.90			12.45			4-5	9-10	14-15		
1.50			7.05			12.60			Macroinvertebrate counts (15x2m)				
1.65			7.20			12.75			<i>P. argus</i>				
1.80			7.35			12.90			<i>L. gigas</i>				
1.95			7.50			13.05m			<i>D. antillarum</i>				
2.1m			7.65			13.20			Threatened coral species Presence(1) or Absence(0)				
2.25			7.80			13.35			in 15 x 2m At site				
2.40			7.95			13.50			<i>A. cervicomis</i>				
2.55			8.1m			13.65			<i>A. palmata</i>				
2.70			8.25			13.80			<i>D. cylindrus</i>				
2.85			8.40			13.95			<i>O. annularis</i>				
3.0m			8.55			14.1m			<i>O. faveolata</i>				
3.15			8.70			14.25			<i>O. franksi</i>				
3.30			8.85			14.40			<i>M. ferox</i>				
3.45			9m			14.55			Categories Data Entry Counts				
3.60			9.15			14.70			Corals (sp)	H	S	R	
3.75			9.30			14.85							
3.90			9.45			15m			Bare				
4.05m			9.60						Turf no sediment				
4.20			9.75						Turf w/ sediment				
4.35			9.90						Dictyota				
4.50			10.05m						Halimeda				
4.65			10.20						Lobophora				
4.80			10.35						Macro - calc				
4.95			10.50						Macro - fleshy				
5.1m			10.65						CCA				
5.25			10.80						Notes				
5.40			10.95						Circle survey grouping Combined Separate				
5.55		11.1m								Peyssonnelia			
										Ramicrusta			
										Gorg - encrust			
										Gorg - upright			
										Sponge - other			
										Sponge - Clionna			
										Cyano/Diatom			
										Millepora			
										Palythoa			
									Seagrass				
									Other				

Appendix IV. NCRMP habitat type classifications

Puerto Rico and U.S. Virgin Islands¹

Aggregate reef: Continuous, high-relief coral formation of variable shapes. Examples of aggregate reefs include fore reef, fringing reef, shelf edge reef, spur and groove reef).

Bedrock: Exposed bedrock contiguous with the shoreline. May be colonized or uncolonized (often covered by a thin sand veneer with sparse coverage of biota).

Patch reef: Coral formations that are isolated from other coral reef formations by sand, seagrass or other habitats. Can be an individual patch reef or aggregate patch reefs.

Pavement: Flat, low-relief, solid carbonate rock. May be colonized or uncolonized (often covered by a thin sand veneer with sparse coverage of biota).

Scattered coral/rock in sand: Primarily sand or seagrass bottom with scattered rocks or small, isolated coral heads that are too small to be delineated individually (i.e., smaller than individual patch reef).

Flower Garden Banks

High relief: The coral reef zone that typically consists of rugose boulder or reef building coral species.

Low relief: The coral reef zone that refers to the deeper (generally between 30-52 m), less rugose and non-reef building species.

Florida Reef Tract²

Contiguous Spur & Groove: A continuing reef structure with well-defined spur (hardbottom) and groove (sand channel) formations. Can be low or high relief spur and groove.

Contiguous Other: Contiguous low relief hardbottom.

Isolated: Larger reef formations that are isolated by sand, seagrass or other habitats; e.g., patch reefs, rocky outcrops, pinnacles.

Rubble: Scattered rocks and small isolated coral heads in sand or seagrass.

**Matrix and Sand are considered legacy categories and will no longer be used.*

¹Adapted from:

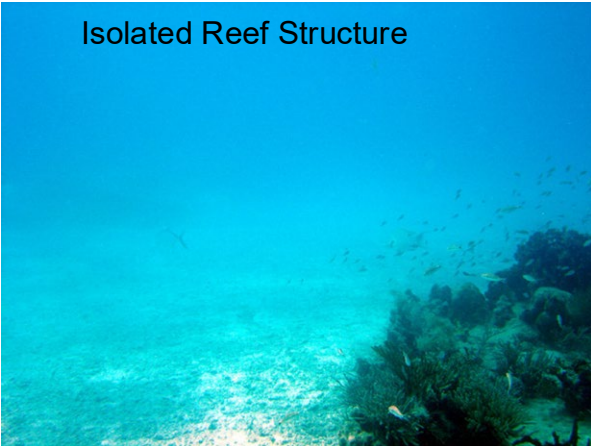
Kendall, M.S., C.R. Kruer, K.R. Buja, J.D. Christensen, M. Finkbeiner, R.A. Warner, and M.E. Monaco. 2001. Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands. NOAA Technical Memorandum NOS NCCOS CCMA 152. Silver Spring, MD. 46 pp.

²Adapted from:

Brandt, M. E., N. Zurcher, A. Acosta, J. S. Ault, J. A. Bohnsack, M. W. Feeley, D. E. Harper, J. H. Hunt, T. Kellison, D. B. McClellan, M. E. Patterson, and S. G. Smith. 2009. A cooperative multi-agency reef fish monitoring protocol for the Florida Keys coral reef ecosystem. Natural Resource Report NPS/SFCN/NRR—2009/150. National Park Service, Fort Collins, Colorado

Appendix IV. NCRMP habitat type classifications

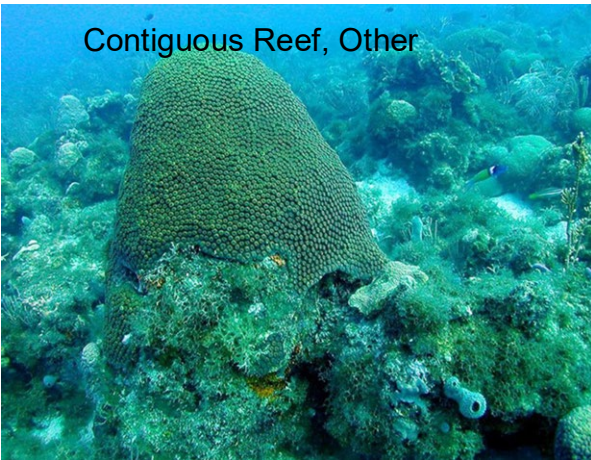
Isolated Reef Structure



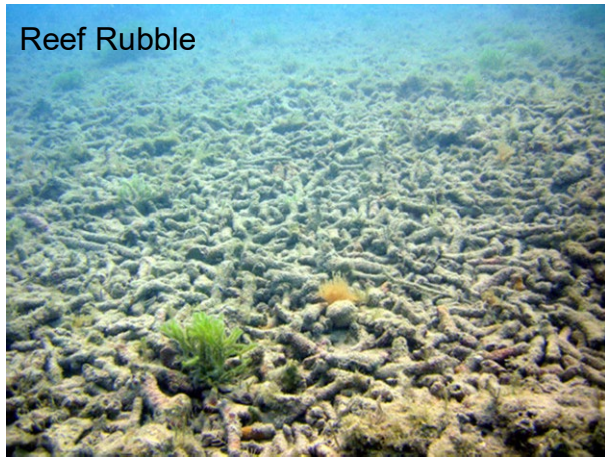
Contiguous Reef, Spur & Groove



Contiguous Reef, Other



Reef Rubble



Appendix V. NCRMP Benthic Community Assessment LPI survey: categories and definitions

1. Corals – scleractinian corals to species
2. Bare Substratum (hardbottom, rubble, or sand)
 - a. Hardbottom = uncolonized, with or without dusting/ veneer of sand <2.5cm (1 inch) deep
 - b. Soft = bare sand, depth of ≥ 2.5 cm (1 inch)
 - c. Rubble = uncolonized; >2.5cm grain size (see Wentworth Scale), larger than sand, moveable, up to cobbles and boulders (25+ cm) that are moveable.
3. Turf Algae – visible algal tufts or filaments on the substratum
 - a. No sediment – only algal filaments with no trapped sediment
 - b. With sediment – algal filaments with trapped sediment that has a cushiony texture
4. Macroalgae
 - a. *Dictyota*
 - b. *Halimeda*
 - c. *Lobophora*
 - d. Other fleshy, non-calcareous forms such as *Laurencia*, *Padina*, and *Sargassum*
 - e. Other calcareous forms – e.g., *Penicillus* and *Udotea*, branching red algae such as *Galaxaura*, *Amphiroa*, and *Jania*
5. CCA – crustose coralline algae, exclusive of *Peyssonellia* and *Ramicrusta* species
6. *Peyssonellia* - red alga
7. *Ramicrusta* spp – encrusting red algae
8. Gorgonians
 - a. Upright - basal attachment only. Do not record branch canopy cover.
 - b. Encrusting – includes *Briareum asbestinum* and *Erythropodium caribaeorum*
9. Sponges
 - a. *Cliona* spp. - In the Atlantic, the following species could be encountered: *aprica*, *caribbea*, *delitrix*, and *langae*
 - b. Other – including and combining upright and encrusting morphotypes. Similar to branching gorgonians, branch sponge canopy cover is not recorded.
10. Cyanobacteria/Diatoms
11. *Millepora* – milleporid hydrocorals
12. *Palythoa* – colonial zoanthids, including both *P. caribeorum* and *P. mammilosa*
13. Seagrasses – all species combined
14. Other – include hydroids, anemones, corallimorpharians, zoanthids other than *Palythoa*, bryozoans, and tunicates

Appendix VI. Field Identification Definitions and Examples

1. Scleractinian Corals (to species)



2c. Bare Rubble



2a. Bare Hardbottom



3a. Turf Algae (no sediment)



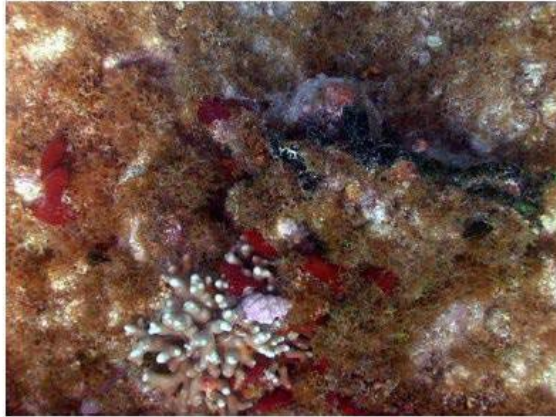
2b. Bare Soft (Uncolonized sand)



3b. Turf Algae with Sediment



4a. Macroalgae - *Dictyota*



4d. Macroalgae – Other Non-calcareous



4b. Macroalgae - *Halimeda*



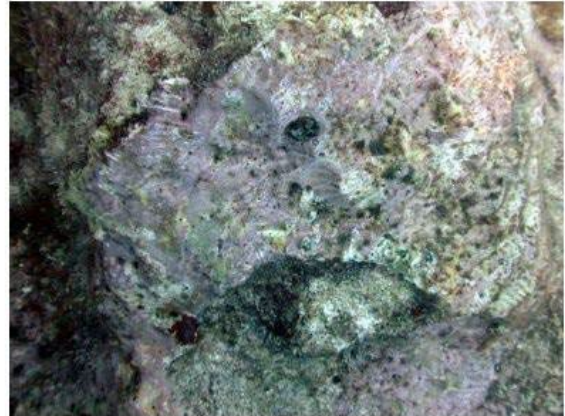
4e. Macroalgae – Other Calcareous



4c. Macroalgae - *Lobophora*



5. Crustose Coralline Algae (CCA)



6. *Peyssonmelia*



8b. Gorgonian - Encrusting



7. *Ramicrostia*



9a. Sponges – *Cliona* spp.



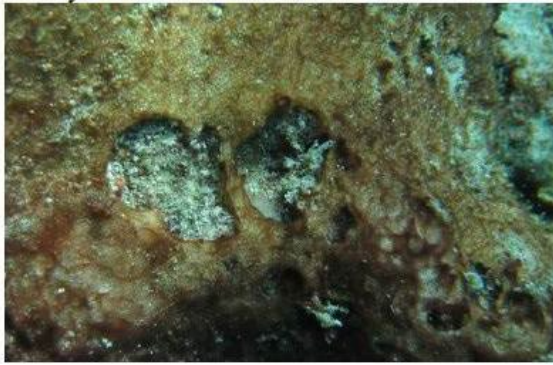
8a. Gorgonian - Upright



9b. Sponges - Other



10. Cyanobacteria/Diatoms



11. Milleporid Hydrocorals (*Millepora*)



12. Palythoa (colonial zoanthid)



13. Seagrass



14. Other (anemones)



14. Other (corallimorpharians)



14. Other (zoanthids)

