

Benthic Assessment Protocols for the Atlantic Region: U.S. Caribbean, Florida and the Gulf of Mexico: 2018

National Coral Reef Monitoring Program (NCRMP)

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

Introduction

The National Coral Reef Monitoring Program (NCRMP) provides a biennial ecological characterization at a broad spatial scale of general reef condition for reef fishes, corals and benthic habitat (*i.e.*, fish species composition/density/size, benthic cover, and coral density/size/condition). Data collection occurs at stratified random sites where the sampling domain for each region (*e.g.*, Florida, Puerto Rico, U.S. Virgin Islands, Flower Garden Banks National Marine Sanctuary [FGBNMS]) is partitioned by habitat type and depth, sub-regional location (*e.g.*, along-shelf position) and management zone. NCRMP will provide broader geographic context to supplement local monitoring efforts and studies of tropical reef ecosystems.

Line point-intercept (LPI) sampling, the main component of the Benthic Assessment protocols, provides benthic cover estimates for ecologically important cover types/groups (*e.g.*, macroalgae, turf algae, crustose coralline algae, corals, sponges, sand/sediment, etc.). This method is complementary to the NCRMP Coral Demographics sampling method that collects detailed information on scleractinian corals, including density, size and condition (percent mortality and bleaching) measurements (Refer to *Coral Demographic Survey Protocol for Florida: 2018*).

As a result of NCRMP standardization throughout the project's regions (*e.g.* Florida and Pacific regions), the protocols previously known as the 'LPI Survey Protocols' have been renamed to Benthic Assessment Protocols. Most notably, changes to the document format and sections have been re-formatted to identify the four main components of the Benthic Assessment protocols. Specific differences in methodologies between regions, where applicable, are noted within the protocols.

Goal of the Benthic Assessment Surveys

The goals of these surveys are to provide: (1) a quantification of percent cover of biotic and abiotic benthic components using the LPI method; (2) information on topographic complexity (substratum rugosity) of the survey locations where Benthic Assessment and Coral Demographic surveys are completed; (3) quantitative information on local commercially and ecologically-important macroinvertebrates (lobster, conch, urchin); and (4) presence- absence information for ESA-listed corals on hardbottom and coral reef habitats in Florida, U.S. Caribbean (U.S. Virgin Islands and Puerto Rico) and FGBNMS. Surveys are concurrent with and along the same transect with Coral Demographic surveys (Appendix I; Refer to *Coral Demographic Survey Protocol for Florida: 2018*).

General Task Description

There are two possible task allocation scenarios for Benthic Assessment data collection:

1. Benthic Assessment data collection only:
 - Benthic Assessment diver completes LPI, ESA coral, macroinvertebrate and topographic surveys.
2. Benthic Assessment data collection and Coral Demographic assistance:
 - Upon completion of the Benthic Assessment data collection, the Benthic Assessment diver coordinates with the Coral Demographic diver to assist with completing the demographic survey if bottom time and identification skills allow.

General Site Information

Navigating to site

Once in the field, the boat captain navigates to selected 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 dive buddy and make frequent visual contact with dive buddy throughout entire dive (this includes during surveys as well)****

1. Each boat will have up to three (3) GPS units:
 - a. One (1) for navigation to sites, and
 - b. Each boat will have one (1) dive flag/float with a GPS unit attached. This set up is unique for each boat and will be used by the fish and benthic 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 3; Appendix II).
 - c. If using a GPS unit other than handheld to navigate to the sites, a handheld GPS is used to collect topside waypoints (see #3 below)
2. Dive teams enter the water at selected GPS coordinates, descend to bottom, affix the surface float line to the bottom, set up survey areas and begin data collection.
 - a. If benthic team is diving with the fish team, **ALL dive teams should 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).
4. Once all surveys are complete, all divers convene at the affixed float line and begin their ascent to the surface together.

****Boat drivers will safely mark waypoint, after divers have descended****

Recording the station information

Station information is to be recorded in two primary locations prior to entering the water: (1) *Boat/Dive log* and (2) *datasheet* (Appendix II and III). The log and data sheet are to have the same information recorded on both.

Evaluating the site

1. As the team descends and assesses the site, the fish 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** during descent or at the site (*i.e.*, continuous softbottom, or limited visibility),
 1. Then the dive will be terminated and an alternate selected,
 2. **Do not swim around searching for hardbottom – this is not reconnaissance.**
2. Observed habitat type – If the team(s) deploy over hardbottom they are to establish the transect where deployed.
 - a. If necessary, during descent, divers will swim to appropriate habitat 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 habitat different from that expected **and** observe expected habitat type within visible range from where deployed, they will swim to expected habitat for sampling.
 - b. If divers enter the water over habitat different from that expected and **do not** observe expected habitat type nearby, they will establish transect where deployed and indicate the alternate habitat on the datasheet and boat log.
3. When a benthic team deploys with the RVC team, they are to set up adjacent to the cylinders if possible, using the same anchor point for the belt transect (Appendix I, Figure A).
 - a. If hardbottom is patchy, the benthic team can swim to nearby hardbottom feature to start transect, remaining in visual context with the RVC divers and the surface float (Appendix I).

4. **Terminating the dive** – Certain environmental conditions are not safe for operations and surveys should be automatically terminated and alternates chosen when:
 - a. **Visibility is less than 5 m**
 - b. **Bottom currents are strong enough that the divers cannot maintain a stationary position,**
 - c. **Depth of the selected site is greater than 99 ft.**

Reasons to terminate a dive:

- Visibility (> 5m)
- Strong currents
- Depth (> 99ft)

**** ALWAYS Indicate reasons for terminating dives on boat logs****

Benthic Assessment Transect and Station Information

Benthic Assessment surveys will be conducted at all fish survey sites.

Establishing transect

1. Benthic team will tie the transect tape to the surface float line or reel. The Benthic Assessment Diver will roll out the tape keeping it taut for a length greater than 15m using weights clipped to the transect tape (Figure 1).
2. The Benthic Assessment diver will avoid wrapping the tape around substrate or biotic object, as this will distort sampling distances and locations for the benthic divers.
3. The end of the tape should be tied or clipped so that the transect tape is as taut as possible. The tape may use weights clipped to the transect tape (Figure 1).



Figure 1. Example of weight attached to transect tape.

4. If current is present at depth, transect tape may be aligned to face the current. If currents are too strong, survey should be terminated.
5. If site is pavement or scattered coral in sand, soft weights may be used to weight the transect tape at the beginning and end to keep transect in place.

Data collection

1. The Benthic Assessment diver collects the following information (Appendix III):
 - a. *LPI data* – **100** points, at 15cm intervals, starting at the 15cm mark and ending at the 15m mark along the transect tape.
 - i. 100 points (one point every 15cm) will be collected along the 15m section of the transect. No habitat will be skipped over (i.e., data are collected in non-hardbottom habitats, such as sand).
 - ii. The estimated average time for completion is 15-20 min (5-7 points scored per minute).
 - b. *Topographic complexity data* – The Benthic Assessment diver will also collect topographic relief information.
 - i. Timing for topography measurements is generally 1-2 minutes.
 - c. *Macroinvertebrate counts* – Spiny lobster (*Panulirus argus*), queen conch (*Lobatus gigas*) and long-spined sea urchin (*Diadema antillarum*) are enumerated in the 15m x 2m area of the belt transect AFTER completing the LPI survey.
 - i. This survey area lies within the 15m x 2m transect area and is defined as the full length of the transect (i.e., 15m length) with a width of one meter on each side of the transect tape (Appendix I: Figure B). This is also the same transect area that is surveyed for the ESA-listed coral species presence-absence.
 - d. *Presence/absence of Endangered Species Act (ESA)-listed corals* – The presence/absence of seven (7) ESA-listed scleractinian coral species in the 15m x 2m transect area are recorded AFTER completing the LPI survey.
 - i. Macroinvertebrate count and ESA coral surveys can be conducted in the same transect pass. Timing is generally 3-4 minutes.
 - e. *Site Photographs* – Underwater photographs of the survey datasheet (1 photo), general survey area (4 cardinal directions), including the transect seascape, as well as interesting features and species identification questions are taken.
2. The Benthic Assessment diver may assist the Coral Demographic diver to finish the coral demographic survey within depth/time limits of dive.
 - a. Benthic Assessment diver should bring a Coral Demographic data sheet and PVC meter stick for measurements
 - b. If Benthic Assessment diver assists Coral Demographic diver, Benthic Assessment diver begins his/her demographic survey at the tenth meter of the survey and works until s/he meets Coral Demographic diver. Benthic Assessment and Coral Demographic divers will coordinate to avoid duplicating counts upon convergence.

Benthic Assessment Sequence of events

Benthic Assessment data collection occurs in (4) phases: (1) Pre-dive, (2) Line-Point Intercept, and (3) topographic and site, and (4) macroinvertebrate/ESA coral assessments (Figure 2).

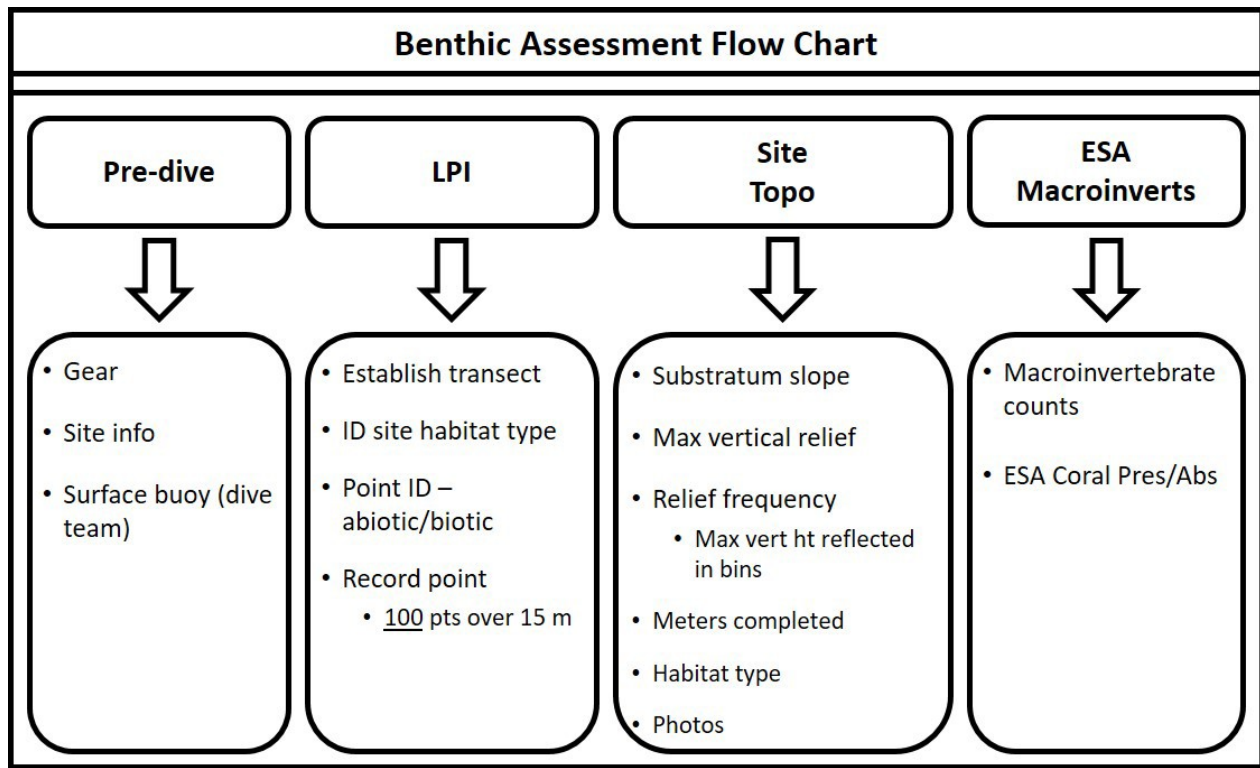


Figure 2. Benthic Assessment sequence of events.

Pre-dive

Station information is to be recorded in two primary locations prior to entering the water: *Boat/Dive log* and *datasheet* (Figure 3 and 4).

Boat Log

Key fields to record for station information include:

1. *Site* – The 4-digit station number.
2. *Station* – The location of each “team” of replicate fish divers at the station.
 - a. Caribbean and FGBNMS is 1-stage and always ‘1’
 - b. Florida is 2-stage where ‘1’ and ‘2’ would be assigned
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 Assessment data is assigned the code ‘J’; the diver collecting Demographic 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 potentially 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 3. Example of boat log with station information filled out. DOD = Dive of the day

Example: Figure 3 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 Demographic diver). Notice for the second dive of the day, Viehman is assigned diver J for the benthic team.

Datasheet

Divers should pre-populate station information, same as recorded on the boat log, on their datasheet prior to entering the water.

1. *Logistic and station information* – Names of all divers, Field ID, date, time of survey, mission data manager and meters completed (Figure 4; Appendix III). Fill in all categories legibly.
 - a. **Field ID** – The **Field ID** is a unique alpha-numeric number the diver is to record on the datasheet at each station.

$$\text{FIELD ID} = (\text{SITE \#}) + (\text{STATION \#}) + (\text{TEAM letter})$$

Example (Figure 4): Diver Edwards recorded the **Field ID** 12001J. According to the boat/dive log (Figure 3), Edwards is diver J for site 1200 (and 1 used for all Caribbean and Gulf of Mexico fish surveys).

- Dive start time is the time divers leave the boat.

Diver: <u>Edwards</u>	Boatlog/Manger: <u>Hile</u>	Date: <u>4/12/2016</u>	Sample Time: <u>1100</u>
Buddy: <u>Viehman</u>	Field ID: <u>12001J</u>		
Habitat: <u>Bedrock</u>	<u>Pavement</u>	<u>Agg. Reef</u>	<u>Patch Reef</u>
<u>Scat. Coral/Rock in Sand</u>	Meters Complete: <u>15</u>		m

Figure 4. NCRMP Benthic Assessment Caribbean datasheet header with logistic and station information (Caribbean location).

2. *Coral disease with Tissue Loss* - in light of increasing concern for coral disease in Florida and the Caribbean, a field was added to all dive sheets to track evidence of coral tissue loss related to disease at the site level using the following selections in your header information.

Coral Disease with Tissue Loss: ☐ None ☐ Not sampled ☐ Fast (>1 cm) ☐ Slow (<1 cm)

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 was not able to observe

Fast (>1cm) - tissue loss due to disease is observed on at least 1 coral colony at the site and the maximum width of tissue loss is >1cm in width/diameter, therefore rate of disease spread is fast (acute).

Slow (<1cm) - tissue loss due to disease is observed on at least 1 coral colony at the site and the maximum width of tissue loss is <1cm in width/diameter, therefore rate of disease spread is slow (sub-acute).

3. *Observed habitat type* – Identification of the habitat type observed at the diver scale (not mapped category, Figures 5-8). Circle selection.

Diver: <u>Edwards</u>	Boatlog/Manger: <u>Hile</u>	Date: <u>4/12/2016</u>	Sample Time: <u>1100</u>
Buddy: <u>Viehman</u>	Field ID: <u>12001J</u>		
Habitat: <u>Bedrock</u> <u>Pavement</u> <u>Agg. Reef</u> <u>Patch Reef</u> <u>Scat. Coral/Rock in Sand</u>			Meters Complete: <u>15</u> m

Figure 5. Hardbottom categories of observed habitat type and meters completed section on the Benthic Assessment datasheet for Caribbean locations.

Diver: <u>Edwards</u>	Boatlog/Manger: <u>Hile</u>	Date: <u>4/12/2016</u>	Sample Time: <u>1100</u>
Buddy: <u>Viehman</u>	Field ID: <u>12001J</u>		
Habitat: <u>Low Relief</u> <u>High Relief</u>			Meters Complete: <u>15</u> m

Figure 6. Hardbottom categories of observed habitat type and meters completed section on the Benthic Assessment datasheet for Gulf of Mexico location.

Diver: <u>Edwards</u>	Boatlog/Manger: <u>Hile</u>	Date: <u>4/12/2016</u>	Sample Time: <u>1100</u>
Buddy: <u>Viehman</u>	Field ID: <u>12001J</u>		
Habitat: <u>Contiguous S&G</u> <u>Contiguous Other</u> <u>Isolated</u> <u>Rubble</u> <u>(Matrix)</u> <u>(Sand)</u>			Meters Complete: <u>15</u> m

Figure 7. Hardbottom categories of observed habitat type and meters completed section on the datasheet for Florida location.

Field Equipment

- Benthic Assessment and Coral Demographic datasheets, clipboard, pencil, spare pencil

- Instrument to aid in locating exact point under transect tape (*e.g.*, PVC stick, ruler)
- Slide marker to keep point location along transect (optional, *e.g.*, clothes pin)
- Camera (battery, housing)
- 1m (or half meter) PVC stick or other rigid measuring device for rugosity, topography/relief and key species surveys to accurately determine a 1m linear distance out from the transect tape AND demographic data collection (if assistance required).

Line Point-Intercept Survey Protocols

LPI data are collected on the following information:

1. *Point identification* – At 15cm intervals along the transect tape, identify and categorize the substratum type according to available datasheet options (Figure 8; Appendix III). Identify the biotic organism (if any) for that substrate type (if any) at each 15cm interval.

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		
3.15			8.70			14.25		

Figure 8. Point identification and point recording location on datasheet.

- a. Abiotic substratum categories include hard (*i.e.*, hardbottom or reef), soft (*i.e.*, sand or mud), and rubble (Figure 8; Appendix IV).
 - b. Biotic categories include coral to species, bare, algal turf, etc., as described in Appendix IV. Appendix V provides example photos of these categories.
 - i. If a point falls on bare sand, the diver notes “Bare” in cover column and “S” in the habitat column (Figure 8).
 - 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.
 - c. **Meters completed** – Note the meter of completion on the datasheet determined by the data entered in the 15cm-interval boxes (Figure 4).
- Identify points for evaluation objectively. Line a straight edge (*e.g.*, pencil) up with the transect point and vertically orientate it downward toward the substratum. Avoid bias, subjectivity and “artificial selection” of favored substrates (*e.g.*, corals).
 - Biotic category options (with the exception of coral species) are provided on the datasheet (Appendix III) to assist in point identification.

3. *Recording the Point* – Record the first abiotic/biotic bottom type encountered.
- 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 not scored unless the point intercepts a holdfast/attachment point.

Example: A gorgonian encrusted with *Millepora* species

- 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”.
- 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.).

- 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.
- 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*.

Topographic Complexity Survey Protocols

Minimum/maximum depth and maximum vertical relief measurements are made within the entirety of the 15m x 2m transect along **BOTH** transect sides (Figures 9 and 10), starting at meter 15 and 1m out on each transect side.

- Data are recorded in “Rugosity” and “Relief” section of the datasheet (Figure 9; Appendix III).

Rugosity 15x2m	
Min depth (ft)	
Max depth (ft)	
Max vert ht (cm)	
Relief 15x2m (bin by 1x2 m; 15 total ticks)	
0 - 19 cm	
20 - 49 cm	
50 - 99 cm	
100 - 149 cm	
150 - 199 cm	
≥ 200 cm	

Figure 9. Topographic complexity section on Benthic Assessment datasheet.

Data are collected on the following:

1. *Substratum slope* – 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). 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.
2. *Maximum vertical relief* – Using a digital depth gauge or a 0.5 or 1m measuring device, record the maximum vertical relief present in the 15m x 2m belt transect area (recorded in centimeters).
 - a. This is accomplished by measuring the height of the most structurally complex feature in the sample unit, whether a coral head, barrel sponge, side of a coralline spur, or other topographic feature.

Note that gorgonians, branching sponges, and branching *Millepora alcicornis* colonies are NOT included in this measurement.

3. *Surface area topography (relief frequency)* – Fifteen measurements are collected to characterize the surface topography of the sample unit (i.e., 15m x 2m transect)
 - a. The entire transect is subdivided into 15 1m x 2m smaller subplots (n=15 per sample unit), with each subplot scored for the highest hard-bottom relief feature (Figure 10).
 - b. Each 1m x 2m sub-plot is scored for vertical relief using one of the following six categories: <20cm, 20–<50cm, 50–<100cm, 100–<150cm, 150–<200cm and 200cm (Figure 9).

If the diver encounters a feature >200 cm bin, there should be a value in the “Max Vert Ht (cm)” section to reflect this measurement
 - c. Looking within each individual sub-plot, measure the highest relief feature (not including “soft complexity” features such as branching gorgonians, sponges, and fire corals) and place a mark in the appropriate relief category on the datasheet.

Example data along a 15m x 2m belt transect, subdivided into 1m x 2m subplots (for ease of sampling; 15 marks recorded on the underwater datasheet)

Category	Frequency (# of 1x2m units)
<20 cm	2
20–<50 cm	3
50–<100 cm	5
100–<150 cm	3
150–<200 cm	2
200 cm+	0
15	

In this example (Figure 10), an estimated 20% of the sample unit had <20cm of relief, 24% had 20–50cm of relief, and so on.

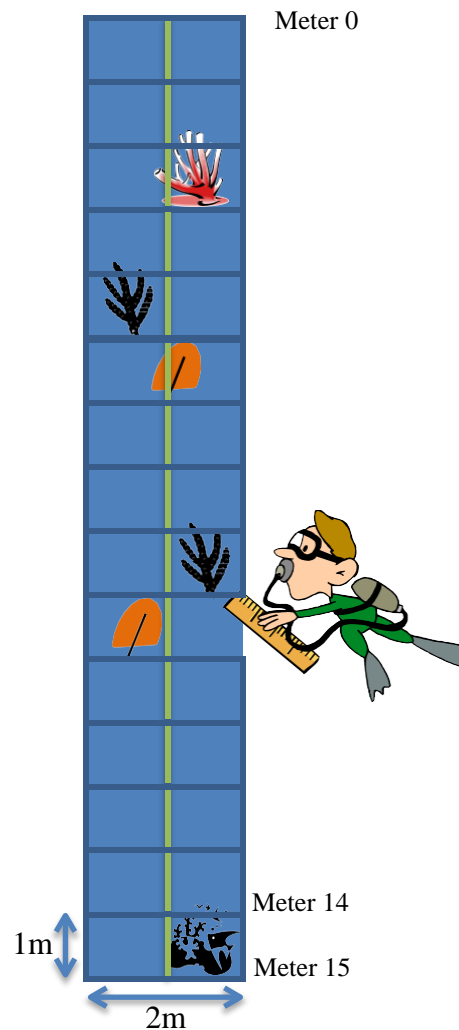


Figure 10. Example of the 1m x 2m grids for measuring topographic complexity along a 15-m x 2-m belt transect survey area for reef fishes in the Atlantic, Caribbean and Gulf of Mexico.

Macroinvertebrate counts

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 11; Appendix I: Figure B).

Macroinverts count	
15x2m	
<i>P. argus</i>	
<i>L. gigas</i>	
<i>D. antillarum</i>	

Figure 11. Macroinvertebrate section on Benthic Assessment datasheet.

- Survey area lies within the 15m x 2m transect (Appendix I: Figure B). This is also the same transect area surveyed for ESA-listed coral species presence-absence.
- A 15m x 2m transect area provides density estimates of numbers of organisms of each species per 30m², while ensuring that all area is thoroughly surveyed.
- If no search occurs, denote this with a large “X” through the entire Count column. *This is critical to record at those sites where, due to logistics, the macroinvertebrate counts could not be completed, which is entirely different from a survey where no organisms were encountered within the 15m x 2m survey area.*

ESA-listed coral species

Presence-absence within the 15m x 2m belt transect of all seven (7) Atlantic/Caribbean coral species listed on the ESA will be recorded at each site (Figure 12).

Presence(1)/Absence(0) 15x2m	
<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 12. ESA coral section on Benthic Assessment datasheet.

- This survey area lies within the 15m x 2m transect (Appendix I: Figure B). This is also the same transect area that is surveyed for the macroinvertebrate counts.
- Presence or absence is recorded for each of these Atlantic/Caribbean ESA-listed scleractinian coral species: *Acropora palmata*, *A. cervicornis*, *Dendrogyra cylindrus*, *Orbicella annularis*, *O. faveolata*, *O. franksi*, and *Mycetophyllia ferox*.
 - PRESENCE** of species – denoted by a “1” (one).
 - ABSENCE** of species – denoted by a “0” (zero).
- c. Photograph any colonies that are of uncertain identity and verify.
- 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. *This is critical to record at those sites where, due to logistics, the ESA- listed coral presence-absence surveys could not be completed, which is entirely different from a survey where species were absent (not encountered) within the 15m x 2m survey area.*

Photographs

The Benthic Assessment diver photographs the site survey area. Photos will include the specific transect survey area for general site characterization. Additional photos may include divers conducting surveys, unique features, and for species identification purposes.

1. Station Documentation: at least five photographs per station
 - a. Take one photograph of 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, and other divers.
2. For the process for downloading and storing site photographs, refer to *Photo Documentation Manual*.

Assisting with the Coral Demographics Surveys

The Benthic Assessment diver will **always** bring a Coral Demographic datasheet and a PVC meter stick to facilitate assisting Demographic diver in data collection.

1. When the Benthic Assessment diver assists the Coral Demographic diver in the demographic survey, Benthic Assessment diver starts her/his demographic survey at the tenth meter and works toward the Demographic diver.
2. Benthic Assessment and Coral Demographic divers will coordinate to avoid duplicating counts, and will meet at a full meter.
3. Benthic Assessment divers will be familiar with Coral Demographics Survey Protocol (Refer to *Coral Demographic Survey Protocol for Florida: 2018*).

Data sheet review

At end of survey, when divers are on boat, the dive team exchanges datasheets for review by checking for completeness and legibility. A diver cannot review his/her own datasheet.

1. *Benthic Assessment datasheet* – Review includes, at a minimum, verifying the following:
 - a. Completeness and legibility of all logistics information.
 - b. Confirmation of correct observed habitat type with dive team and it is circled.

- c. Completeness and legibility of macroinvertebrate records. NOTE: All boxes are to be filled out. If this component was not conducted, “X” through section is required.
 - d. Completeness and legibility of ESA-listed coral records. NOTE: All boxes are to be filled out. If this component was not conducted, “X” through section is required.
 - e. Completeness and legibility of all Topographic Complexity records.
 - i. Stratum slope – Minimum and maximum depth (recorded in ft).
 - ii. Maximum vertical relief (recorded in cm)
 - iii. Surface area topography – 15 total tick marks.
2. *Coral Demographic datasheet* – Review includes, at a minimum, verifying the following:
- a. Completeness and legibility of all logistics information; including identification of second Demographic 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).

Datasheet preparation for data entry

Prior to data entry, recorded points on the datasheet **MUST** be tallied and binned by biota and substrate type as indicated on the Benthic Assessment datasheet and noted in the designated area on the LPI datasheet (Figure 13).

1. Tallied values are required for data entry into online database.

2. Divers are to **verify total number of points** in “binned” section of datasheet so that the **total equals** the number of points recorded on the datasheets.

Figure 13. Binned LPI section of Benthic 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.*

Categories Data Entry Counts							
Corals (sp)	H	S	R		H	S	R
				Bare			
				Turf w sed			
				Turf no sed			
				Dictyota			
				Halimeda			
				Lobophora			
				Macro - fleshy			
				Macro - calc			
				CCA			
				Peysonnellia			
				Ramificrasta			
				Gorg - upright			
				Gorg - encrust			
				Sponge - other			
				Sponge - Clionna			
				Cyano/Diatom			
				Millepora			
				Palythoa			
				Seagrass			
				Other			

Appendix I. Illustrations of survey placement and survey areas

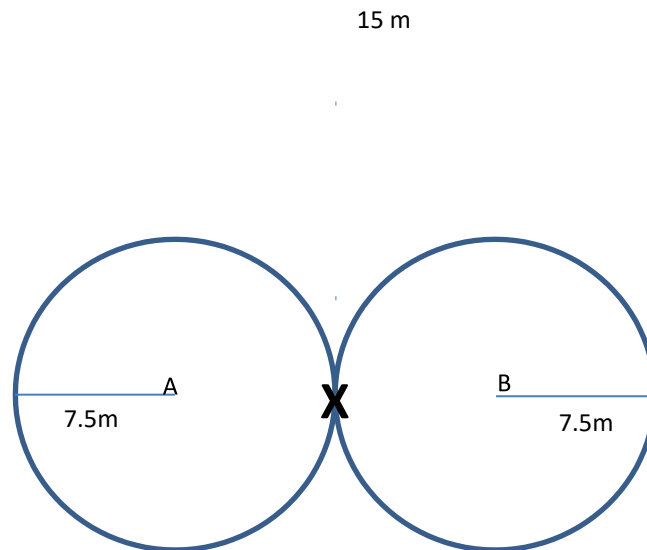


Figure A. Suggested placement of survey areas if continuous hardbottom. A and B represent two fish divers.

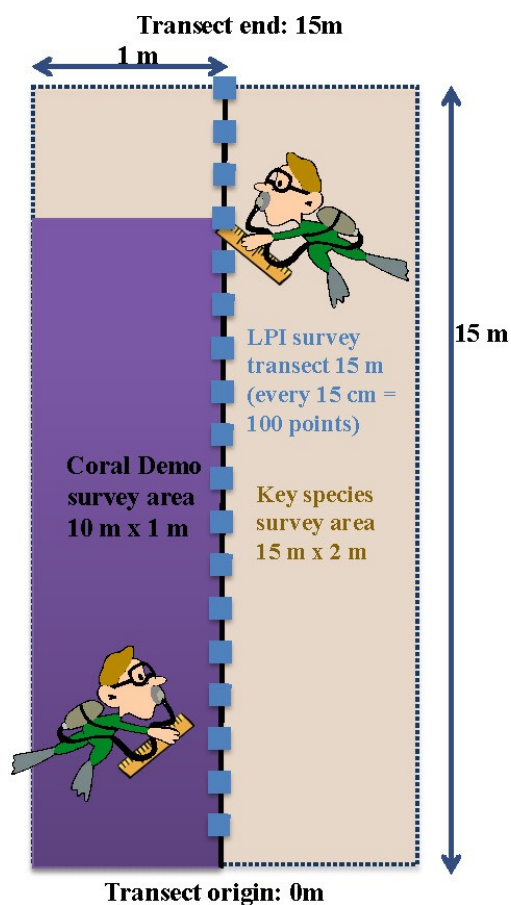


Figure B. Diagram of benthic surveys (including key species (ESA and macroinvertebrate) surveys) indicating size of each respective survey area.

Appendix III. Benthic Assessment Datasheet

Example 1: Caribbean datasheet

NCRMP Line Point Intercept Datasheet															
Diver: _____		Boatlog/Manger: _____		Buddy: _____		Field ID: _____		Date : _____							
Habitat: <i>Bedrock</i> <i>Pavement</i> <i>Agg. Reef</i> <i>Patch Reef</i> <i>Scat. Coral/Rock in Sand</i>		Meters Complete: _____ m													
Record biotic and abiotic code every 15cm			Habitat code: H - Hardbottom S - Soft R - Rubble			Rugosity									
Meter	Cover	Hab	Meter	Cover	Hab	Meter	Cover	Hab	15x2m						
0.15			5.70			11.25			Min depth (ft)						
0.30			5.85			11.40			Max depth (ft)						
0.45			6m			11.55			Max vert ht (cm)						
0.60			6.15			11.70			Relief						
0.75			6.30			11.85			15x2m (bin by 1x2 m; 15 total ticks)						
0.90			6.45			12m			0 - 19 cm						
1.05m			6.60			12.15			20 - 49 cm						
1.20			6.75			12.30			50 - 99 cm						
1.35			6.90			12.45			100 - 149 cm						
1.50			7.05			12.60			150 - 199 cm						
1.65			7.20			12.75			≥ 200 cm						
1.80			7.35			12.90			Macroinverts count						
1.95			7.50			13.05m			15x2m						
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			Presence(1)/Absence(0)						
2.70			8.25			13.80			15x2m						
2.85			8.40			13.95			<i>A. cervicornis</i>						
3.0m			8.55			14.1m			<i>A. palmata</i>						
3.15			8.70			14.25			<i>D. cylindrus</i>						
3.30			8.85			14.40			<i>O. annularis</i>						
3.45			9m			14.55			<i>O. faveolata</i>						
3.60			9.15			14.70			<i>O. franksi</i>						
3.75			9.30			14.85			<i>M. ferox</i>						
3.90			9.45			15m									
4.05m			9.60			Categories Data Entry Counts									
4.20			9.75			Corals (sp)	H	S	R						
4.35			9.90												
4.50			10.05m						Bare						
4.65			10.20						Turf w sed						
4.80			10.35						Turf no sed						
4.95			10.50						Dictyota						
5.1m			10.65						Halimeda						
5.25			10.80						Lobophora						
5.40			10.95						Macro - fleshy						
5.55			11.1m						Macro - calc						
Notes									CCA						
									Peysonnellia						
									Ramicrusta						
									Gorg - upright						
									Gorg - encrust						
									Sponge - other						
									Sponge - Clionna						
									Cyano/Diatom						
									Millepora						
									Palythoa						
									Seagrass						
									Other						
						Circle method type						Combined	Separate		

Example 2: Gulf of Mexico datasheet**NCRMP Benthic Assessment / Line Point Intercept Datasheet**

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

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			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 w sed			
4.65			10.20							Turf no sed			
4.80			10.35							Dictyota			
4.95			10.50							Halimeda			
5.1m			10.65							Lobophora			
5.25			10.80							Macro - fleshy			
5.40			10.95							Macro - calc			
5.55			11.1m							CCA			
Notes										Peysonnelia			
										Ramicrusta			
										Gorg - upright			
										Gorg - encrust			
										Sponge - other			
										Sponge - Clionna			
										Cyano/Diatom			
										Millepora			
										Palythoa			
										Seagrass			
Circle method type										Other			
Combined													
Separate													

Example 3: Florida datasheet

NCRMP Benthic Assessment / Line Point Intercept Datasheet

Diver: _____ Boatlog/Manger: _____
 Buddy: _____ Field ID: _____ Date: _____ Sample Time: _____
 Habitat: *Contiguous S&G* *Contiguous* *Other Isolated* *Rubble* (*Matrix*) (*Sand*) Meters Complete: _____m
 Coral Disease with Tissue Loss: ☐None ☐Not Sampled ☐Fast (>1cm) ☐Slow (<1cm)

Record biotic and abiotic code every 15cm			Habitat code: H - Hardbottom S - Soft R - Rubble			Rugosity			
Meter	Cover	Hab	Meter	Cover	Hab	Meter	Cover	Hab	15x2m
0.15			5.70			11.25			Min depth (ft)
0.30			5.85			11.40			Max depth (ft)
0.45			6m			11.55			Max vert ht (cm)
0.60			6.15			11.70			Relief
0.75			6.30			11.85			15x2m (bin by 1x2 m; 15 total ticks)
0.90			6.45			12m			0 - 19 cm
1.05m			6.60			12.15			20 - 49 cm
1.20			6.75			12.30			50 - 99 cm
1.35			6.90			12.45			100 - 149 cm
1.50			7.05			12.60			150 - 199 cm
1.65			7.20			12.75			≥ 200 cm
1.80			7.35			12.90			Macroinverts count
1.95			7.50			13.05m			15x2m
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			Presence(1)/Absence(0)
2.70			8.25			13.80			15x2m
2.85			8.40			13.95			<i>A. cervicornis</i>
3.0m			8.55			14.1m			<i>A. palmata</i>
3.15			8.70			14.25			<i>D. cylindrus</i>
3.30			8.85			14.40			<i>O. annularis</i>
3.45			9m			14.55			<i>O. faveolata</i>
3.60			9.15			14.70			<i>O. franksi</i>
3.75			9.30			14.85			<i>M. ferox</i>
3.90			9.45			15m			
4.05m			9.60			Categories Data Entry Counts			
4.20			9.75			Corals (sp)	H	S	R
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									

Circle method type Combined Separate

Appendix IV. 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 *Ramicrosta* species
6. *Peyssonellia*
7. *Ramicrosta* 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. caribaeorum* and *P. mammilosa*
13. Seagrasses – all species combined
14. Other – include hydroids, anemones, corallimorpharians, zoanthids other than *Palythoa*, bryozoans, and tunicates

Appendix V. Examples of benthic categories for LPI surveys.

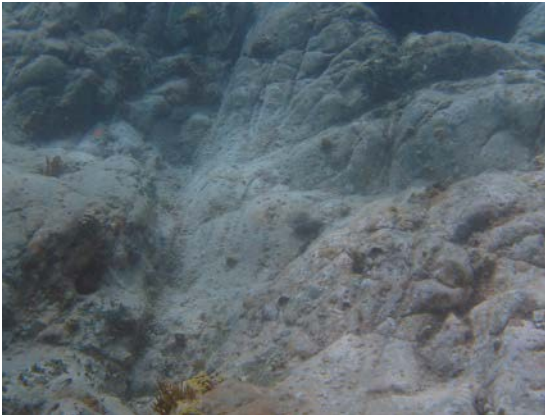
1. Scleractinian Corals (to species)



2c. Bare Rubble



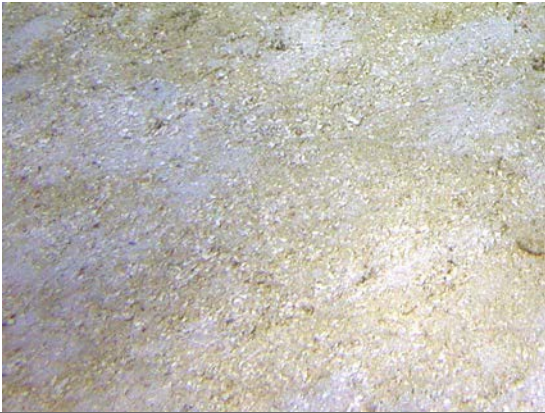
2a. Bare Hardbottom



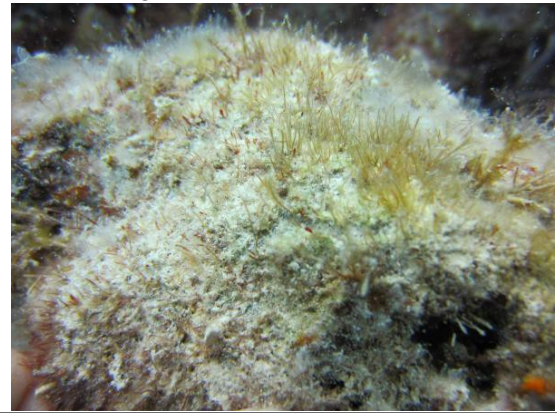
3a. Turf Algae (no sediment)



2b. Bare Soft (Uncolonized sand)

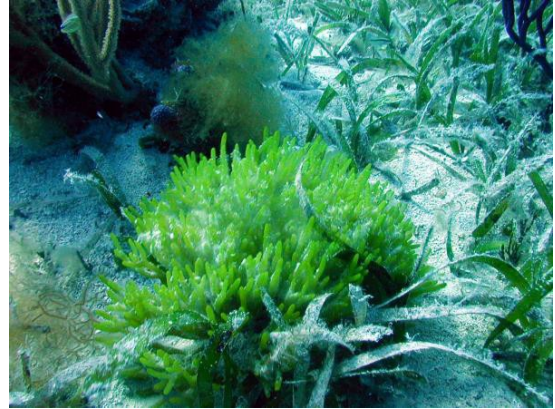


3b. Turf Algae with Sediment



Appendix V. continued4a. Macroalgae - *Dictyota*

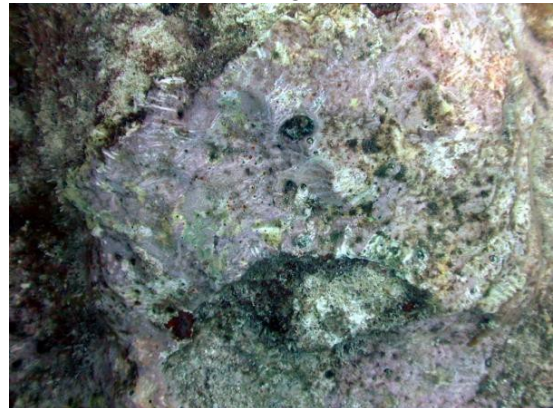
4d. Macroalgae – Other Non-calcareous

4b. Macroalgae - *Halimeda*

4e. Macroalgae – Other Calcareous

4c. Macroalgae - *Lobophora*

5. Crustose Coralline Algae (CCA)



Appendix V. continued

6. *Peyssonnelia*



8b. Gorgonian - Encrusting



7. *Ramificrasta*

9a. Sponges – *Cliona* spp.



8a. Gorgonian - Upright

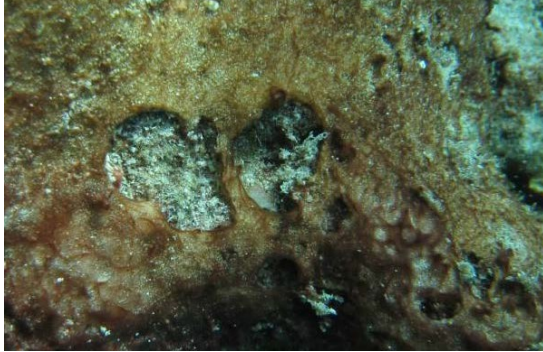


9b. Sponges - Other



Appendix V. continued

10. Cyanobacteria/Diatoms



14. Other (anemones)

11. Milleporid Hydrocorals (*Millepora*)

14. Other (corallimorpharians)



12. Palythoa (colonial zoanthid)



14. Other (zoanthids)



13. Seagrass

