

Line Point-Intercept (LPI) Survey Protocol for the U.S. Caribbean and Flower Garden Banks National Marine Sanctuary

National Coral Reef Monitoring Program (NCRMP)
Coral Reef Conservation Program (CRCP), National Oceanic and Atmospheric Administration
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Introduction

NCRMP is a broad spatial snapshot for reef condition (*i.e.* fish species composition/density/size, benthic cover, and coral density/size/condition) to provide context for local-scale studies of tropical reef ecosystems. Data collection will occur at stratified random sites where the sampling domain for each region (*e.g.* Puerto Rico, USVI, Flower Garden Banks and Florida) is partitioned by habitat type and depth, sub-regional location (*e.g.* along-shelf position) and management zone. NCRMP is intended to supplement local monitoring efforts by providing large-scale data on reef fishes and the benthos.

The LPI sampling is designed to provide resolution of benthic cover estimates for ecologically important cover types/groups (*e.g.* macroalgae, turf algae, crustose coralline algae, corals, sponges, sand/sediment, etc.). More detailed information on scleractinian corals, specifically density, size, and condition (percent mortality and bleaching) measurements, is being collected via the NCRMP Coral Demographics sampling.

Goal of LPI Surveys

The goal of these surveys is to provide a measure of percent cover of biotic and abiotic components of the benthos, using the Line Point-Intercept (LPI) method in a stratified random sampling design in hard bottom and coral reef habitats in the U.S. Atlantic and Caribbean. Surveys are concurrent with and along the same transect as fish surveys.

Likely task allocation scenarios

- 1 LPI diver:
 - LPI diver collects LPI data and completes key species survey.
 - No demographic data are collected during this survey.
- 1 LPI diver + 1 Demographics diver:
 - Upon completion of the LPI transect, the LPI diver will coordinate with the coral demographic diver and assist with completing the demographic transect (if LPI benthic ID skills allow), if bottom time and/or bottom complexity dictate.
 - It is a higher priority for the demographic transect to be completed than for the LPI diver to complete the key species survey (*i.e.* macro-invertebrate [spiny

lobster, queen conch, *Diadema* urchin] counts and coral ESA presence-absence). However, every effort should be made, in cases where LPI and coral demographic surveys are concurrently conducted at a site, to complete both surveys completely.

Line Point-Intercept (LPI) Transect Information

1. Line Point-Intercept (LPI) transects will be surveyed at all fish survey sites: 25m transect (PR, USVI, FGBNMS) or 15m diameter (RVC) cylinder (FL) (Appendix I).
 - a. Where fish transects (not RVC cylinders) are used, the LPI diver (and Demographic diver, if present) will use the same transect as the fish diver (Appendix I).
 - i. Benthic divers will follow along behind the fish diver at a distance to avoid influencing swimming behavior of fishes (*i.e.* the LPI diver should start when the fish diver is near the 5m mark, then the Demographic diver will start).
 - ii. The fish diver will tie off start of transect tape and continue to keep the transect tape relatively taut throughout survey.
 - iii. The fish diver may use weights to secure the transect tape along the bottom.
 - iv. The fish diver should avoid wrapping the tape around substrate or biotic object, as this will distort sampling distances and locations for the benthic diver.
 - v. At Fish + LPI + Demographic sites, LPI diver may assist demo diver to finish demo transect within depth/time limits of dive. Demographic data completion has higher priority than key species (macro-invertebrates and ESA-proposed corals species) data collection, but if possible, key species surveys should be completed at all LPI sites.
 - 1) If LPI diver assists Demographic diver in survey completion, LPI diver starts her/his survey at 10 m and works until s/he finishes a complete meter and meets Demographic diver. LPI and Demographic divers will coordinate to avoid duplicating counts.
 - 2) To ensure that all space is surveyed, there should be no surveys of partial meters.
 - b. Where RVC fish cylinders are used (*e.g.* Florida), the LPI diver will establish the transect using a random compass heading and in close proximity (*i.e.* safe diver distance) to the fish surveyor.
 - i. Details are in development and will be added to this protocol when they are complete.

2. Locating the sample site(s) and survey area(s).

Divers are deployed together and maintain contact with each other throughout the entire census.

- a. Prior to entering the water, one of the benthic divers obtains a random compass heading for the transect and records the compass bearing (0-360°) on the datasheet.
 - b. Navigate to previously selected sites using a handheld GPS unit.
 - c. Where appropriate, the boat can drop a weighted float that will mark the start of the transect.
 - i. Dropping a float in the VINP and VICR is not an option so divers are dropped as close to the GPS position as possible.
 - d. Divers will descend as rapidly but safely as possible to maintain relative proximity to the centroid position.
 - e. The only instance where the transect should deviate from the designated path is to stay above 99 ft.
 - f. Do not alter the predetermined course if the centroid is not on hardbottom or the bearing does not cover hardbottom.
 - i. If it becomes apparent that no hardbottom is in the vision of the dive team (*i.e.*, continuous sand, seagrass or limited visibility), then the dive will be terminated and an alternate site selected.
 - ii. If hardbottom is observed in the vicinity of the site, then the dive continues as planned- starting on the centroid, or close approximation, and on the predetermined random bearing.
 - iii. On-site, do not avoid structural features within a habitat such as a sand patch or an anchor as these are "real" features of the habitats.
3. The LPI diver is responsible for collecting the following information:
- a. LPI data: 100 points, at 20cm intervals, starting at the 20cm mark and ending at the 20m mark along the transect tape.
 - b. Macro-invertebrate counts (spiny lobster, queen conch, *Diadema* urchins) in a 25m x 2m belt transect area AFTER completing the LPI survey, concurrently when the LPI diver is swimming from meter marker 25 (*i.e.*, the end of the transect tape) to meter marker 0 (*i.e.*, the beginning of the transect tape).

- c. Presence-absence of nine (9) ESA candidate scleractinian coral species in a 25m x 2m belt transect area AFTER completing the LPI survey and concurrently with the macro-invertebrate (*i.e.* lobster, conch, urchin) counts.
 - d. Underwater photographs of the general survey area, including the transect seascape, as well as interesting features and species identification questions.
4. LPI transects will start at 20cm from the beginning (marker 0) of the transect tape and continue to the 20m marker. Sand patches and other non-hard-bottom features will not be skipped, and 100 points (one point every 20 cm) will be collected along the 20m section of the transect.
- a. Note that the 20m LPI transect survey length is less than the 25m fish belt transect length (Appendix I).
 - b. One hundred data (100) points for benthic cover will be collected along the 20m transect length, with data collected at 20cm intervals. The estimated average time for completion is 15-20 min (5-7 points scored per minute).
 - i. The LPI diver will frequently check the number of marks while collecting data; for example, at every meter marker, there should be multiples of five points accounted for on the data sheet. If there are an incorrect number of data points at any meter, the LPI diver will try to correct the count while still on the transect.
 - ii. At the end of the LPI survey, if there are <100 or >100 data points, effort is made by LPI diver to correct the count while still on the transect. If 100 points ± 5 (95 to 105 points) are collected, data are acceptable and may be entered into database.
 - iii. Come back to the boat with 100, or do not come back. ☺ Disclaimer: This statement is not endorsed by the NOAA Dive Program.

Field Equipment

1. LPI and Demo datasheets, clipboard, pencil (and spare pencil)
2. Instrument to aid in locating exact point under transect tape (*e.g.*, PVC stick, ruler)
3. Slide marker to keep point location along transect (optional, *e.g.*, clothes pin)
4. Camera (battery, housing)
5. 50cm or 1m PVC stick or other rigid measuring device for key species surveys to accurately determine a 1m linear distance out from the transect tape

Notes for field equipment for fish divers:

1. Each fish diver may need a few weights (ankle, soft) to periodically place along the 25m transect tape to hold it down to the substrate.
2. Each fish diver must securely tie off the beginning and end of the 25m transect tape.

Line Point-Intercept Survey Protocols

1. Complete datasheet header (Figure 1).
 - a. Fill in all categories legibly
 - b. Circle habitat type observed at diver scale (not mapped category)

LPI Diver		Fish Diver		Demo Diver	
Site ID		Date		Time	
Habitat type	Bedrock	Linear	Patch	Pavement	Scattered Coral/Rock

Figure 1. NCRMP LPI datasheet header.

Photographs of the site

2. While the LPI diver waits for the fish surveyor to proceed down the transect (giving at least a 5m head-start), the LPI diver should take underwater photographs of the general survey area, including the specific transect survey area for general site characterization, as well as of other divers conducting surveys, along with unique features, and for species identification purposes.
 - a. Prior to taking any photographs of the site, one photograph should be taken of the slate to include the site name and date.
 - b. Photographs should be oriented just left, forward, and just right of transect.
 - c. Photographs may also be taken of anything unusual (*e.g.* rare fish, bleached or rare corals) and for species identification clarification.
 - d. The process for downloading and storing site photographs is detailed in a separate document titled “Photo Documentation Manual”.

Line Point Intercept Point Identification

3. At 20cm intervals along the transect tape, identify and categorize the substratum type according to protocol/available data sheet options (Figure 2, Appendix II). Identify each point for the substrate type and the biotic organism (if any).
 - a. Abiotic/substratum categories include hard (*i.e.*, hard-bottom or reef), soft (*i.e.*, sand or mud), and rubble (Figure 2, Appendix II).
 - b. Biotic categories include coral, bare, algal turf, etc., as shown in Figure 2 and Appendix II.
 - c. Example #1: if a point falls on bare sand, one mark is recorded in the “Soft” column along the “Bare” row.
 - d. Example #2: if a point falls on turf algae growing on hard-bottom with no sand trapped in the turf filaments, one mark is recorded in the “Hard-bottom” column along the “TURF-no sediment” row.
4. Exercise caution when identifying a particular point to evaluate. The most objective way to score a point along the transect is to use a straight edge (*e.g.*, pencil) and vertically orientate it downward toward the substratum. Bias, subjectivity and “artificial selection” of favored substrates (*e.g.*, corals) should be avoided. However, the point should be identified quickly – no ‘dithering’.
5. Record the first abiotic/biotic bottom type encountered.
 - a. Gorgonian branches are not valid points, but gorgonian holdfasts are valid points. In other words, canopy cover by “soft” branching organisms such as gorgonians, branching *Millepora*, and sponges is not scored unless the point intercepts a holdfast/attachment point. The approach for assessing benthic cover is not considering “canopy” cover above the actual substratum.
 - i. When a point falls on encrusting *Millepora* growing on a gorgonian, it is scored as gorgonian ONLY IF the point falls on the holdfast of the gorgonian. The vertical, flexible “fan” area of the sea fan is not a valid point.
 - ii. This same point is scored as *Millepora* when the point falls on the attachment point of an encrusting or branching *Millepora* colony.
 - b. Branching corals (*e.g.* *Acropora* spp.) are valid points.
 - c. Algae (*e.g.* *Sargassum*, *Dictyota*) are valid points.
 - i. Example #1: a patch of *Dictyota* macroalgae growing on and covering CCA would be scored as *Dictyota*.
 - ii. Example #2: If a branching *Sargassum* plant were intersected by the transect, only the holdfast should be scored if the transect tape intersects the algal holdfast.

Categories: one tick every 20cm	Hardbottom	Soft	Rubble
Coral (to Genus)			
Bare			
TURF-no sediment			
TURF w/sediment			
MACRO-Dictyota			
MACRO-Halimeda			
MACRO-Lobophora			
MACRO-other fleshy			
MACRO-other calcareous			
CCA			
<i>Peysonnellia</i>			
GORG upright			
GORG encrusting			
SPONGE other			
SPONGE Cliona spp			
CYANOBACT/DIATOM			
<i>Millepora</i>			
PALYTHOA			
SEAGRASS			
Other			

Figure 2. Abiotic and biotic section of LPI datasheet.

AFTER completing the LPI survey, the LPI diver may assist the coral demographic diver in completing the demographic transect within depth/time limits of the dive and if LPI diver benthic ID skills allow. If there is no need to assist the demographic diver, the LPI diver will conduct the Macro-invertebrates counts and the Endangered Species Act proposed coral species presence/absence survey in a 25m x 2m belt transect (25m in length, 1m on each transect side).

Assisting with the Demographics Surveys

6. If LPI and Demographic surveys are being conducted at a site, LPI diver should bring a Demo datasheet with him/her to facilitate assisting Demo diver in data collection.
7. If LPI diver assists Demographic diver in survey completion, LPI diver starts her/his survey at 10 m and works until s/he finishes a complete meter and meets Demographic diver. LPI and Demographic divers will coordinate to avoid duplicating counts.
8. To ensure that all space is surveyed, there should be no surveys of partial meters.
9. LPI diver needs to be familiar with Coral Demographics Survey Protocol.

Macro-invertebrates counts

10. All Caribbean spiny lobster (*Panulirus argus* and *P. guttatus*), queen conch (*Strombus gigas*), and long-spined sea urchins (*Diadema antillarum*) are counted within the 25m x 2m belt transect (Figure 3).
 - a. This survey area lies within the 25m x 4m fish belt transect area and is defined as the full length of the transect (*i.e.* 25m length) with a width of one meter on each side of the transect tape (Appendix I). This is also the same transect area that is surveyed for the ESA proposed coral species presence-absence.
 - b. A 25m x 2m belt transect area provides density estimates of numbers of organisms of each species per 50 m², while ensuring that all area is thoroughly surveyed.
 - c. If no search occurs, denote this with an “X” in the Count column. ***This is critical to record at those sites where, due to logistics, the macro-invertebrate counts could not be completed, which is entirely different from a survey where no organisms were encountered.***

Macroinvertebrates on 25x2 transect	
Count	
Lobster	
Conch	
Diadema	

Figure 3. Macro-invertebrate section on LPI datasheet.

Endangered Species Act proposed coral species presence-absence

11. Presence-absence within the 25m x 2m belt transect of all nine (9) Atlantic/Caribbean coral species proposed to be ESA-listed will be recorded at each site (Figure 4).
 - a. This transect lies within the 25m x 4m fish belt transect and is defined as the full length of the transect (*i.e.*, 25m length) with a width of one meter on each side of the transect tape (Appendix I). This is the same belt transect area that is surveyed for numbers of spiny lobster, queen conch, and *Diadema* urchins as described above.
 - b. Atlantic/Caribbean ESA-proposed scleractinian coral species are *Acropora palmata*, *A. cervicornis*, *Agaricia lamarcki*, *Dendrogyra cylindrus*, *Dichocoenia stokesi*, *Montastraea annularis*, *M. faveolata*, *M. franksi*, and *Mycetophyllia ferox*.
 - c. Photograph any colonies that are of uncertain identity and verify.
 - d. Presence is denoted by a “1” (one).
 - e. Absence is denoted by a “0” (zero).
 - f. If no search occurs, denote this with an “X” on the data sheet. ***This is critical to record at those sites where, due to logistics, the ESA-proposed or listed coral presence-absence surveys could not be completed, which is entirely different from a survey where species were absent (not encountered) within the 25m x 2m belt transect survey area.***

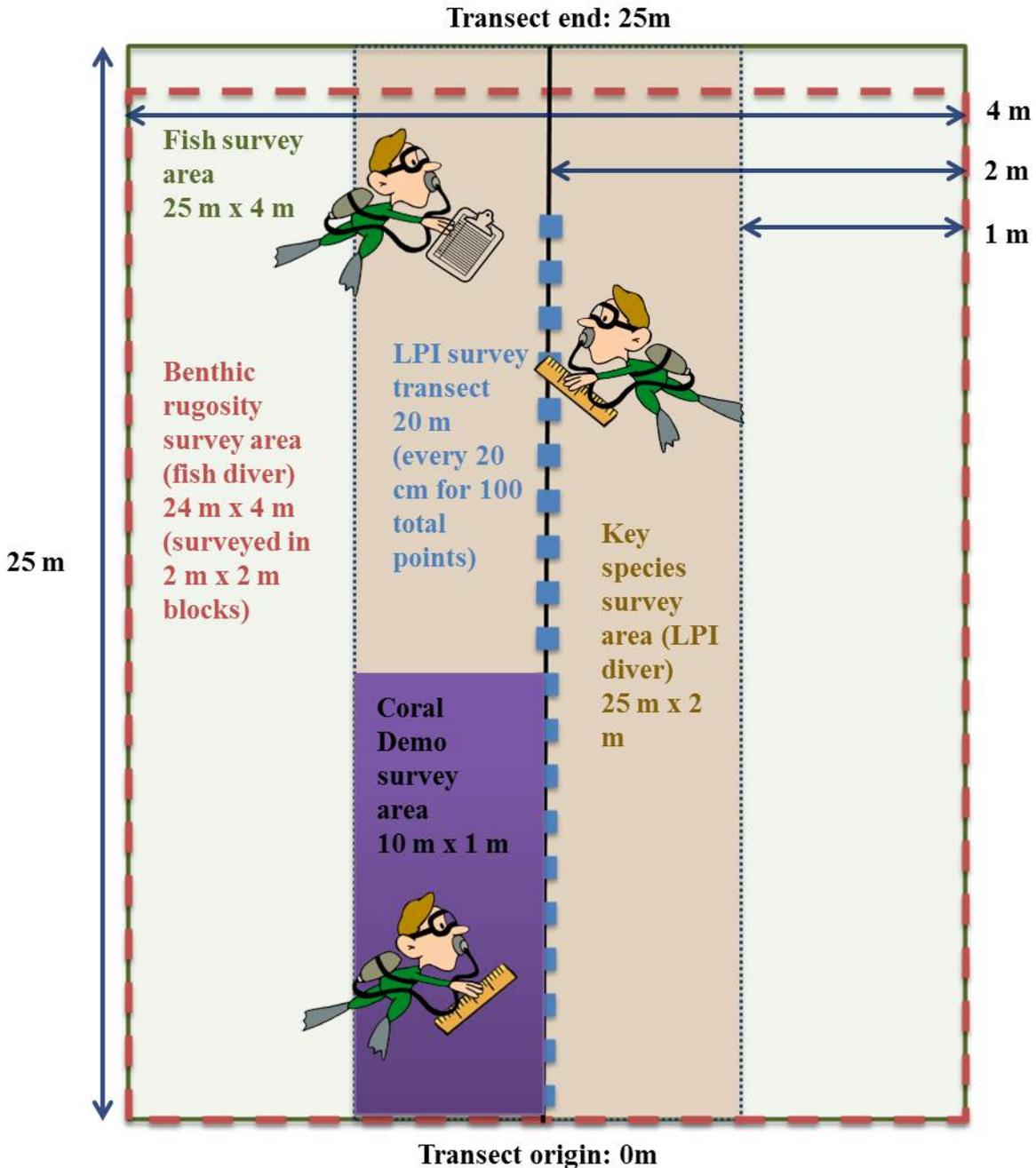
Presence(1)/Absence(0) on 25x2 transect	
A. palmata	
A.cervicornis	
D. cylindrus	
M. ferox	
A. lamarcki	
M. annularis	
M. franksi	
M. faveolata	
D. stokesii	

Figure 4. LPI datasheet section naming ESA-listed and proposed coral species.

Appendix I.

Diagram of all surveys

Size of each survey area is also indicated. Fish, LPI and Coral Demographics will be surveyed as the divers move out away from the transect origin. Other invertebrates (*e.g.* spiny lobster, queen conch, *Diadema* urchins) and topographic complexity will be surveyed as the divers return to the transect origin.



Appendix II.

Categories and definitions

1. Corals: scleractinian corals to genus
2. Bare Substratum (hard-bottom, rubble, or sand)
 - a. Hard-bottom = uncolonized, with or without dusting/ veneer of sand < 2.5 cm (1 inch) deep
 - b. Soft = bare sand, depth of ≥ 2.5 cm (1 inch)
 - c. Rubble = uncolonized; > 2.5 cm 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 *Peysonnellia* species
6. *Peysonnellia*
7. Gorgonians
 - a. Upright - basal attachment only. Do not record branch canopy cover.
 - b. Encrusting – includes *Briareum asbestinum* and *Erythropodium caribaeorum*
8. 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.
9. Cyanobacteria/Diatoms
10. *Millepora* - milleporid hydrocorals
11. *Palythoa* - colonial zoanthids, including both *P. caribaeorum* and *P. mammilosa*
12. Seagrasses – all species combined
13. Other - include hydroids, anemones, corallimorpharians, zoanthids other than *Palythoa*, bryozoans, and tunicates

Appendix III. Examples of benthic categories for LPI surveys.

1. Scleractinian Corals (to Genus)



2c. Bare Rubble



2a. Bare Hard-bottom



3a. Turf Algae (no sediment)



2b. Bare Soft (Uncolonized sand)



3b. Turf Algae with Sediment



Appendix III. continued

4a. Macroalgae - *Dictyota*



4d. Macroalgae – Other Non-calcareous



4b. Macroalgae - *Halimeda*



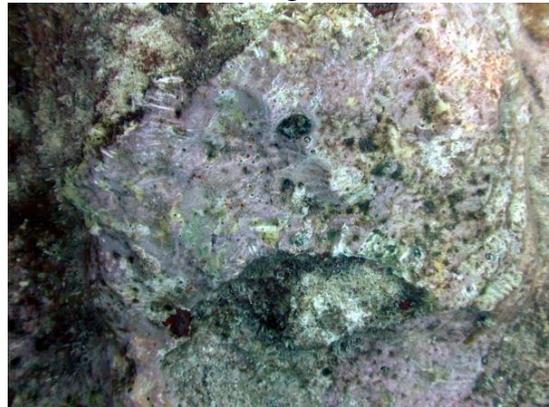
4e. Macroalgae – Other Calcareous



4c. Macroalgae - *Lobophora*



5. Crustose Coralline Algae (CCA)



Appendix III. continued

6. *Peysonnelia*



8a. Sponges – *Cliona* spp.



7a. Gorgonian - Upright



8b. Sponges - Other



7b. Gorgonian - Encrusting



9. Cyanobacteria/Diatoms



Appendix III. continued

10. Milleporid Hydrocorals (*Millepora*)



13. Other (anemones)



11. Palythoa (colonial zoanthid)



13. Other (corallimorpharians)



12. Seagrass



13. Other (zoanthids)



NCRMP Line Point-Intercept Datasheet

LPI Diver	Fish Diver	Demo Diver	
Site ID	Date	Time	
Habitat type	Bedrock Linear Patch Pavement Scattered Coral/Rock		
Categories: one tick every 20cm	Hardbottom	Soft	Rubble
Coral (to Genus)	Macroinvertebrates on 25x2 transect		
	Count		
	Lobster		
	Conch		
	Diadema		
	Presence(1)/Absence(0) on 25x2 transect		
Bare			
TURF-no sediment			
TURF w/sediment			
MACRO- <i>Dictyota</i>			
MACRO- <i>Halimeda</i>			
MACRO- <i>Lobophora</i>			
MACRO-other fleshy			
MACRO-other calcareous			
CCA			
<i>Peysonnellia</i>			
GORG upright			
GORG encrusting			
SPONGE other			
SPONGE <i>Cliona</i> spp			
CYANOBACT/DIATOM			
<i>Millepora</i>			
PALYTHOA			
SEAGRASS			
Other			
NOTES			