

# **Coral Demographics Survey Protocol for the U.S. Caribbean and Gulf of Mexico: 2017**

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.

This coral demographics protocol was devised to provide more detailed and species-specific insight ('signal magnitude') for coral populations than is provided by percent cover. Specifics of the protocol are based closely on other long-established monitoring programs in the Atlantic region, including Atlantic and Gulf Rapid Reef Assessment (AGRRA, Caribbean-wide), Sanctuary Coral Reef Ecosystem Assessment and Monitoring (SCREAM, Florida), Florida Reef Resilience Program (FRRP, Florida), Coral Reef Evaluation and Monitoring Project (CREMP, Florida) and the U.S. Virgin Islands Territorial Coral Reef Monitoring Program (TCRMP, USVI). However, the sampling resolution may not capture the population structure of rare or uncommon corals, including currently-listed Endangered Species Act (ESA) species.

Precise designations of coral condition (*e.g.*, specific disease types, minor bleaching/paling conditions) are specifically not included due to the low temporal resolution of the NCRMP sampling (*i.e.*, biennial and potentially not seasonally consistent). The survey protocol is designed to capture the most easily recognized colony conditions likely to be encountered, specifically recent mortality (*i.e.*, dead white skeleton) and bright-white bleaching on a partial or an entire coral colony.

For the 2017 Caribbean and Gulf of Mexico field sampling, the benthic (Benthic Assessment and Coral Demographic) surveys will be completed on the same dive as the fish surveys (Appendix I, Figure A).

## **Goal of Coral Demographics Surveys**

The goal of the coral demographic surveys is to collect and report information on species composition, density, size, abundance, and specific parameters of condition (% live vs. dead, bleaching, disease) of non-juvenile scleractinian corals (>4 cm maximum diameter), and of overall species diversity (all corals) using 10m x 1m belt transects in a stratified random sampling design in 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 of the Benthic Assessment surveys, including the Line Point-Intercept (LPI) survey (Appendix I; Refer to *Benthic Assessment Protocols for the U.S. Caribbean and Gulf of Mexico: 2017*).

## General Task Description

The demographic surveys typically take longer to complete than benthic assessment surveys, particularly within dense coral habitats. There are two possible task allocation scenarios for coral demographic collection:

1. 1 Demographic diver:
  - Demographic diver collects all coral demographic data in a single 10m x 1m belt transect area per site.
2. 1 Demographic and 1 Benthic Assessment diver:
  - When the Benthic Assessment diver completes the assessment surveys, s/he will coordinate with the Demographic diver to assist with completing the demographic transect (if Benthic Assessment divers' benthic ID 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\*\***

## Coral Demographic Transect and Station Information

Coral Demographic surveys will be conducted with Benthic Assessment 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*

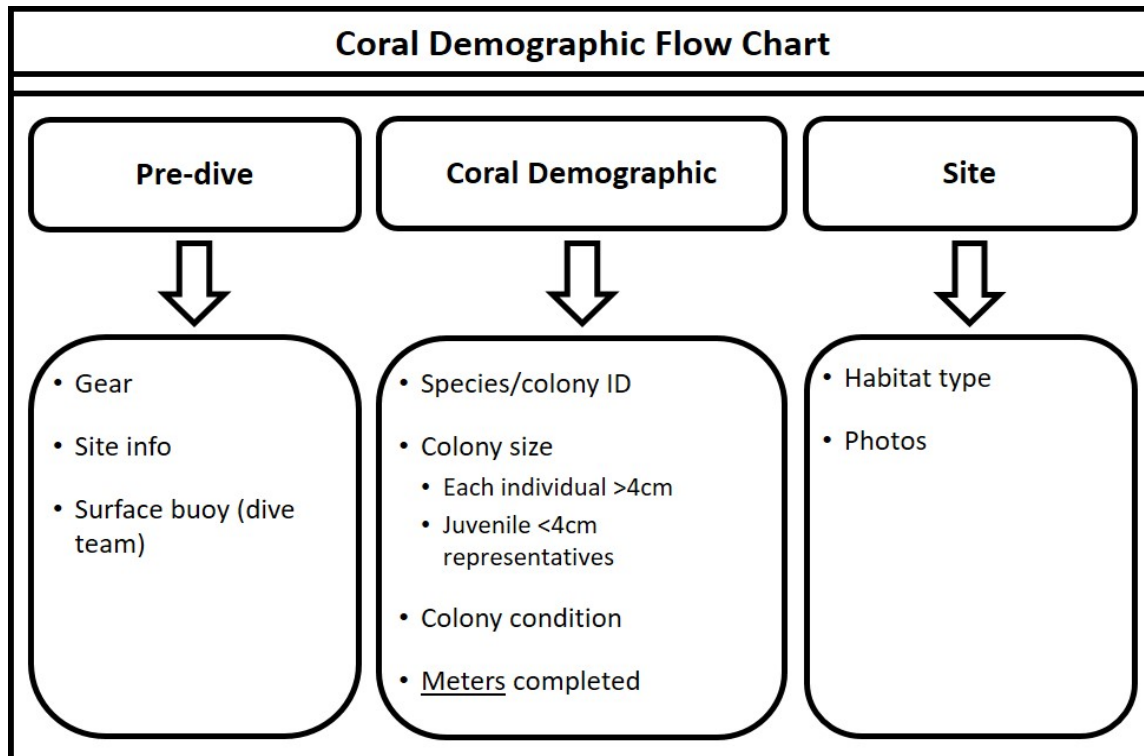
1. The Demographic diver collects the following information within the 10x1m transect (Appendix II):
  - a. *Percent cover of hardbottom* – The percent hardbottom cover within the survey area will be recorded.
  - b. *Species/colony information* – Identification and additional colony information of all visible scleractinian corals in survey area will be recorded.

**IMPORTANT:** A new datasheet is to be used for each demographic survey, one survey per sheet (*i.e.*, do not record data for survey Y on the back of survey X's datasheet). ***This is critical for data management.***

2. Demographic survey area is 10m long by 1m wide (Appendix I). This is less than the size of the benthic assessment surveys.
  - a. This survey area is consistent with existing demographic monitoring programs including AGRRA, CREMP, SCREAM and FRRP.
  - b. The demographic survey is conducted along the **LEFT** edge of the transect line.
    - i. This means the area of the survey is to the left side of the tape. Do not split the survey area ½ on either side of the transect tape.
  - c. Every effort will be made to complete the entire 10m x 1m belt transect.
    - i. **If the whole belt transect area cannot be completed, finish at a whole meter and note the meters of completion on the datasheet** (Appendix III).
  - d. The survey starts at meter marker zero (0) and proceeds to meter marker 10.
3. When a coral demographic survey area is split between two Demographic surveyors:
  - a. A transect will only be split by opposite ends (horizontally). Surveyors will work opposite ends (meter marker 0 and meter marker 10, respectively), and will coordinate to avoid duplicating counts upon convergence.
    - i. A transect will not be split width-wise (vertically) between surveyors. This minimizes the potential for double-counting colonies.
  - b. One diver will be the Demographic “lead” diver and will be responsible for all the demographic data entry for both divers (the lead Demographic diver will enter all the demographic data in one survey into the offline database module).
    - i. On each datasheet used for the survey, the “lead” Demographic diver will enumerate and record the total number of datasheets for the survey (Appendix III).
  - c. The name of the second Demographic diver will be recorded on ALL datasheets associated with that dive site.

## Coral Demographic Sequence of events

Benthic Assessment data collection occurs in (3) phases: (1) Pre-dive, (2) Coral Demographic and (3) site assessments (Figure 2).



**Figure 2.** Coral Demographic 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

Data collected are consistent with one or more of the following programmatic methodologies: AGRRA, CREMP, FRRP, SCREAM and TCRMP.

1. *Logistic and station information* – Names of all divers, Field ID, date, time of survey, mission data manager and meters completed (Figures 4-6; 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 Viehman recorded the **Field ID** 12001X. According to the boat/dive log (Figure 3), Viehman is diver X for site 1200 (and 1 used for all Caribbean and Gulf of Mexico fish surveys).

NCRMP Coral Demographic Datasheet					Page ____ of ____	
Diver: <u>Viehman</u>	Boatlog/Manager: <u>Hile</u>	Start Time: <u>1100</u>	Sheet filled by (circle diver): Demo LPI			
Buddy: <u>Edwards</u>	Field ID: <u>12001X</u>	Date: <u>4/12/2016</u>	Meters completed: _____m			
Habitat: <u>Bedrock</u> <u>Pavement</u> <u>Agg. Reef</u> <u>Patch Reef</u> <u>Scat. Coral/Rock in Sand</u>			% HB of survey: _____			

**Figure 4.** NCRMP Coral Demographic datasheet header with logistic and station information.

1. *Observed habitat type* – Identification of the habitat type observed at the diver scale (not mapped category, Figure 5 and 6). Circle selection from the following categories (circle **one** on the Fish/Habitat datasheet). At the surface, the diver should discuss with their buddy and other team members and try to come to a consensus. If a consensus is not achieved divers should note that in the Field/Boat Log. **NOTE: habitat types are different in the U.S. Caribbean and Flower Garden Banks (Appendix IV).**

NCRMP Coral Demographic Datasheet					Page ____ of ____
Diver: <u>Viehman</u>	Boatlog/Manager: <u>Hile</u>	Start Time: <u>1100</u>	Sheet filled by (circle diver): Demo LPI		
Buddy: <u>Edwards</u>	Field ID: <u>12001X</u>	Date: <u>4/12/2016</u>	Meters completed: ____m		
Habitat: <u>Bedrock</u> <u>Pavement</u> <u>Agg. Reef</u> <u>Patch Reef</u> <u>Scat. Coral/Rock in Sand</u> % HB of survey: ____					

**Figure 5.** Hardbottom categories of observed habitat type (Appendix IV) on the datasheet for Caribbean locations.

NCRMP Coral Demographic Datasheet					Page ____ of ____
Diver: <u>Viehman</u>	Boatlog/Manager: <u>Hile</u>	Start Time: <u>1100</u>	Sheet filled by (circle diver): Demo LPI		
Buddy: <u>Edwards</u>	Field ID: <u>12001X</u>	Date: <u>4/12/2016</u>	Meters completed: ____m		
Habitat: <u>Low Relief</u> <u>High Relief</u> % HB of survey: ____					

**Figure 6.** Hardbottom categories of observed habitat type (Appendix IV) on the datasheet for Gulf of Mexico locations.

## Field equipment

- Demographics datasheet, clipboard, pencil, spare pencil
  - One survey per datasheet
- Small rigid measuring instrument, marked in cm (*e.g.*, “Flexiruler”)
- 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 1m PVC, marked in units or with measuring tape securely attached)
- Camera, battery, housing (optional)



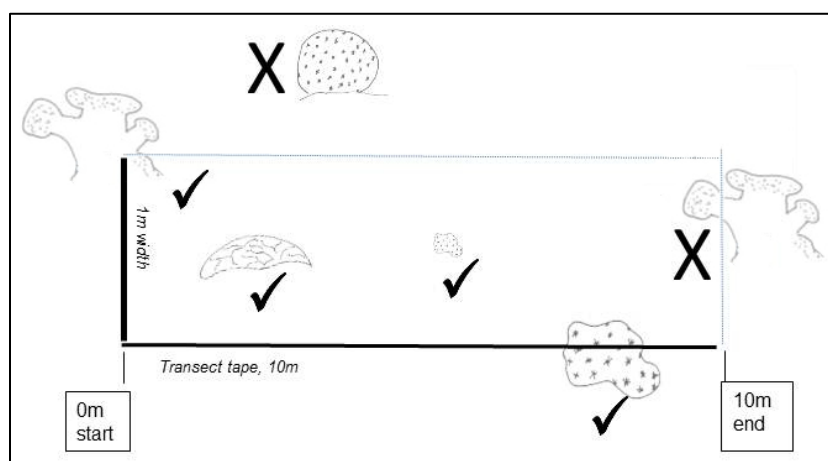
## Coral Demographic Survey Protocols

Coral demographic data are collected on the following information:

1. *Species/colony identification* – Each individual scleractinian coral colony ***with all or any part of the living colony or skeletal unit within the transect area*** will be identified (Figure 7).
  - a. Record each individual on datasheet (Figure 7).
  - b. Thickets/clumps. If the skeletal unit is connected, identify as one individual. If not, then record them as multiple individuals (Appendix V).
  - c. Species such as *Acropora cervicornis*, *Acropora palmata*, *Eusmilia fastigiata*, *Porites porites*, *Madracis* spp. or *Orbicella annularis* may have large colony areas by these criteria.
  - d. All visible corals of any size will be identified to the species level (Figure 8). If species-level identification is not possible, take photo for later analysis.

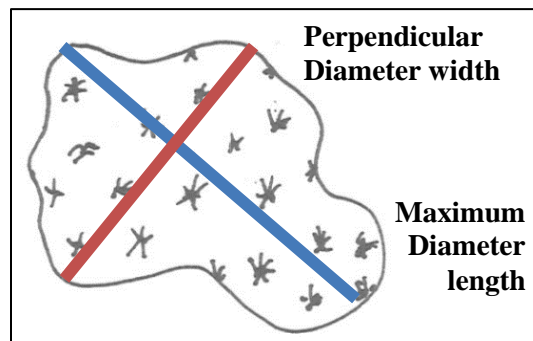
Habitat: <i>Bedrock</i> <i>Pavement</i> <i>Agg. Reef</i> <i>Patch Reef</i> <i>Scat. Coral/Rock in Sand</i>										% HB of survey: _____							
M	Coral ID	Max Diam (cm)	Max Perp Diam (cm)	Height (cm)	Old mort. (%)	Recent mort. (%)	Bleach (T,P,N)	Disease (P,A)	M	Coral ID	Max Diam (cm)	Max Perp Diam (cm)	Height (cm)	Old mort. (%)	Recent mort. (%)	Bleach (T,P,N)	Disease (P,A)

**Figure 7.** Datasheet section showing coral identification, dimensions, condition categories and data entry.



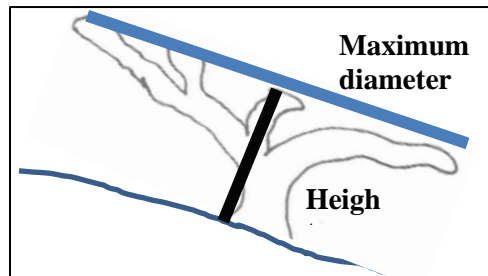
**Figure 7.** Schematic of example 10m x 1m transect area. Corals with all or part of colony (excluding branches) within transect area are included (✓). Corals entirely outside of the transect area are not included (X).

- e. When a scleractinian colony **smaller than 4 cm maximum dimension** ( $< 4\text{cm}$ ) of a species that is not present as a larger, measured colony is encountered in the transect area (Figure 7):
  - i. Identify the coral to lowest possible taxonomic resolution and record on datasheet.
  - ii. Specific size measurements and colony condition (bleached and diseased information) **are not recorded for juveniles**. Draw a line through the rest of the row, and continue to the next coral.
  - iii. Data will be used for species richness calculations only, not density, so any juveniles of a species only need to be recorded once per transect, regardless of the number of times encountered.
- f. When a scleractinian colony **with a maximum skeletal dimension of greater than 4 cm** ( $>4\text{ cm}$ ) is encountered in the transect area, continue with ALL of the following measurements (#4 and #5).
  4. *Coral colony size measurements* - Measure entire coral (skeleton + live tissue) on a planar dimension (2D) to three (3) exact dimensions (cm).
    - Measurements made to the nearest whole centimeter (cm).
    - Do not bin, estimate, or aggregate measurements. For example, measurements of length, width, and height of a colony might be 5cm x 3cm x 2cm, respectively.
      - a. Maximum diameter Length – Measure the maximum diameter (cm) of identifiable skeletal unit (Figures 9 and 10).
        - i. Measure location where diameter of skeletal unit is widest
        - ii. Measure skeletal unit, not just the live tissue
      - b. Maximum perpendicular diameter width – Measure the **perpendicular diameter** of skeletal unit at its' greatest width (Figure 9). Maximum diameter length is to be greater than perpendicular diameter width.



**Figure 9.** Measurements of maximum diameter length and perpendicular diameter width.

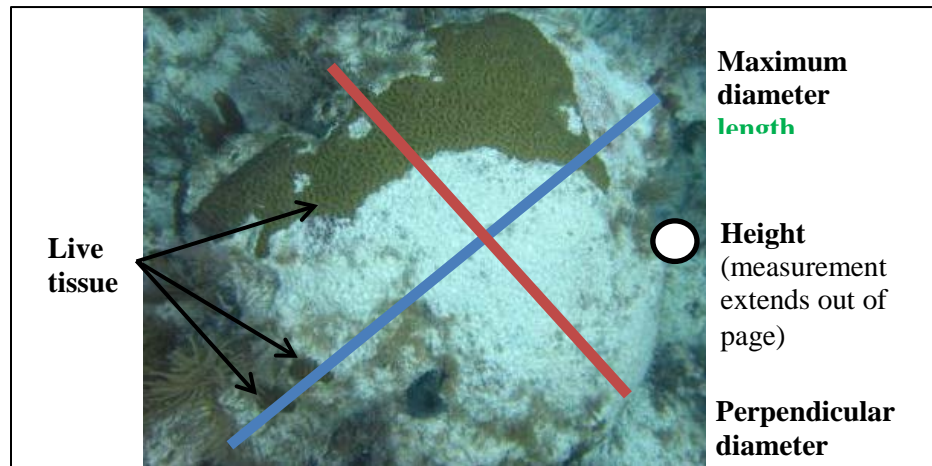
- c. Height – Measure the **height** (cm) of the skeletal unit (Figure 10).
- i. Height is measured from the base of the skeletal unit perpendicular to plane of growth.
    1. If colony is growing on a slope, measure perpendicular to the slope
    2. Measure linearly (*i.e.*, do not drape tape across the colony)
    3. If the colony has an encrusting morphology, the minimum height of the colony should be reported as 1.0 cm.



**Figure 10.** Height and width measurements perpendicular to plane of growth. Colony is shown on a sloped reef.

5. *Coral condition measurements* – For each measured coral, the total colony area (3D) is assessed for mortality, bleaching and disease. NOTE: these measurements are not collected for juvenile colonies.
  - Estimate the percent dead skeletal cover (partial mortality estimate for each colony) based on skeletal structure. Skeletal structure = (old or recent) mortality + live tissue. Assess the entire colony, including underneath sides of branching corals.
  - Consider how species and morphology influence normal tissue location (*e.g.*, not on columnar colonies such as *Eusmilia fastigiata* and *Orbicella annularis*).
- a. Mortality – Estimates of old and recent mortality are collected, if applicable (Figure 11). Only include corals that have living tissue present, *i.e.*, total mortality (% old + % recent) is less than 100. **If total mortality is 100%, do not record the colony.**
  - i. **Old mortality (%)** – Estimate the old mortality as a percentage of the total colony size (**NOT** as a percentage of total mortality).
  - ii. **Recent Mortality (%)** - Estimate the recent mortality as a percentage of the total colony size (**NOT** as a percentage of total mortality).
    1. Recent mortality is defined as **exposed white bare skeleton** that does not have bleached tissue present and is not colonized by algae or other organisms.
    2. A theoretical colony with an encrusting morphology with dimensions of 10cm x 10cm with one-quarter of the colony recently dead would be scored as 25% recent mortality.

**NOTE:** The diseased area of coral colonies **SHOULD NOT** be recorded as partial mortality, unless the diseased area **HAS NO LIVING TISSUE** [i.e., the coral skeleton (calyx) structure **IS CLEARLY VISIBLE** in the diseased area].



**Figure 11.** Entire skeletal unit is measured for dimensions [max diameter (blue), perpendicular diameter (red) and height (circle).] Estimate % old mortality (~70%).

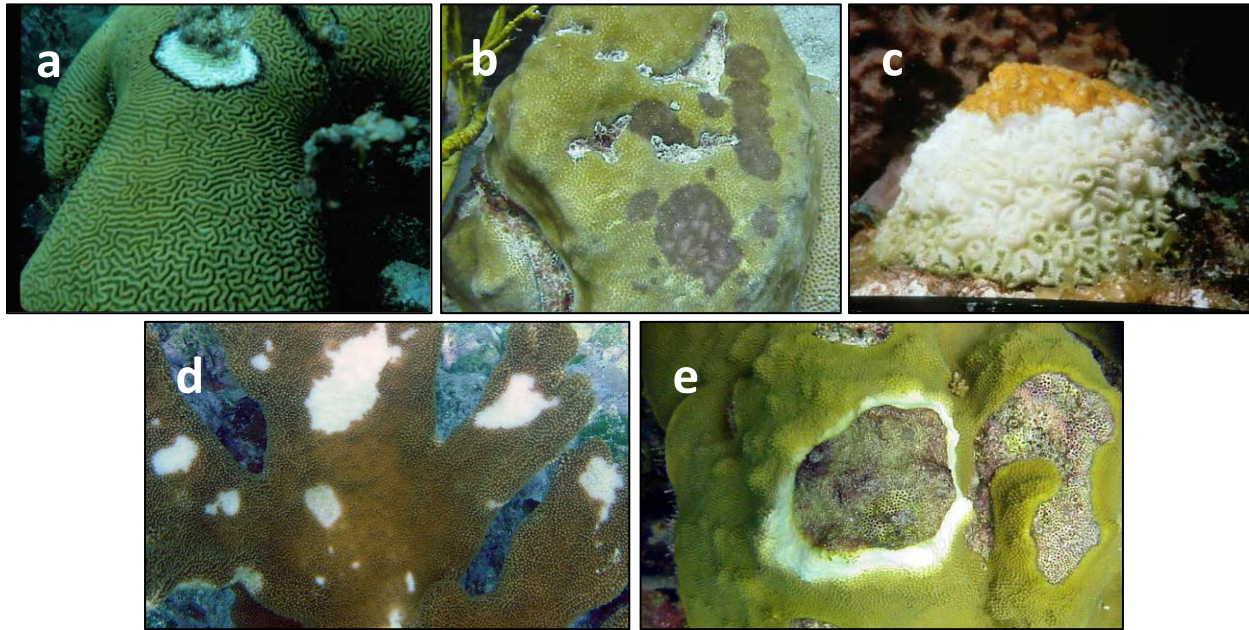
- b. Bleaching (T/P/N) – Note if any coral bleaching is present or absent (Figure 12).
- i. **Total bleaching (T): bright-white** bleaching over the entire colony<sup>1</sup>
    1. Bleaching is defined as bright white tissue.
    2. Other conditions such as various shades of paling or disease are *not* included.
  - ii. **Partial bleaching (P): bright-white** bleaching over a part of the colony
  - iii. **No bleaching (N):** no bleaching present. Use this code to indicate **no bleaching**. Do not leave this item blank.
    1. If a colony is exhibiting any apparent “discoloration” of tissue, unless it is partially or completely white, this condition should be scored as “No bleaching”.



**Figure 12.** Partially bleached *Orbicella* coral colony. Because pigment is still visible around the lower right and upper left margins of the colony, this bleaching condition is scored as *partially bleached*.

<sup>1</sup> NOTE: *Siderastrea siderea* and *S. radians* may appear bright blue rather than white when bleached.

- c. Coral Disease (P/A) – Note if any coral disease is present or absent (Figure 13).
- Present (P):** Any form of coral disease is noticeable on the colony, (See Figure 11 for examples).
  - Absent (A):** No disease is evident.



**Figure 13.** Examples of coral diseases: a) black band, b) dark spots, c) white plague, d) white pox, and e) yellow band.

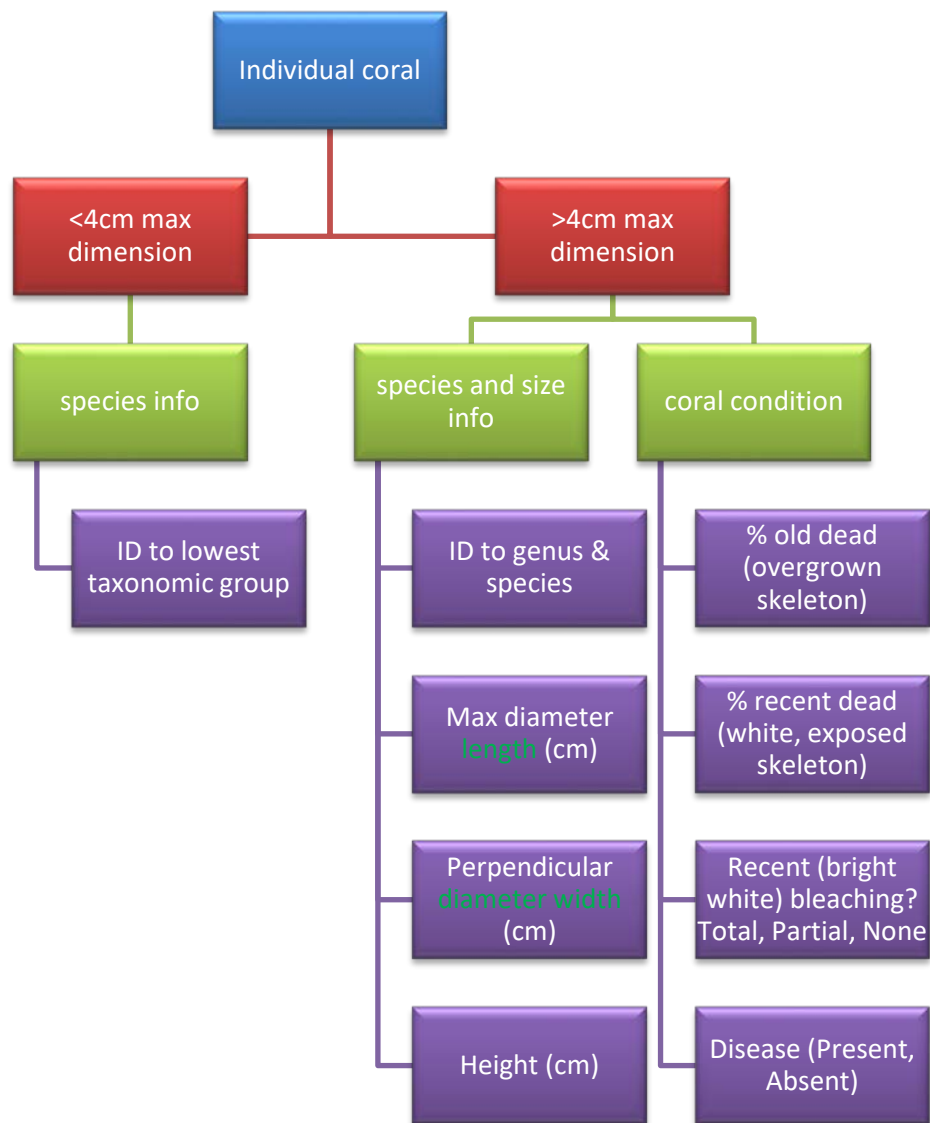
6. *Percent hardbottom* – Record the total percent hardbottom within the 10x1m transect area to the nearest whole number (Figure 14).

NCRMP Coral Demographic Datasheet					Page ____ of ____
Diver: _____	Boatlog/Manager: _____	Start Time: _____	Sheet filled by (circle diver): Demo LPI		
Buddy: _____	Field ID: _____	Date: _____	Meters completed: _____	m	
Habitat: <i>Bedrock</i> <i>Pavement</i> <i>Agg. Reef</i> <i>Patch Reef</i> <i>Scat. Coral/Rock in Sand</i>			% HB of survey: _____		

**Figure 14.** Location of the percent hardbottom and meters completed sections on the Coral Demographic datasheet.

- A summary of NCRMP coral demographic sampling components are illustrated in Figure 15.





**Figure 15.** Summary of NCRM coral demographic sampling.

## Notes

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

- Used to indicate any field observation that may be important, such as presence of an ecological incident (*e.g.*, disease).
- If data collection requires more than one datasheet (both sides), the diver will indicate the presence of multiple sheets in the NOTES section of the datasheet.
- Notes are not entered into the database, but they are catalogued separately for reference.



## Assisted 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.

## 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).

## Appendix I. Illustrations of survey placement and survey areas

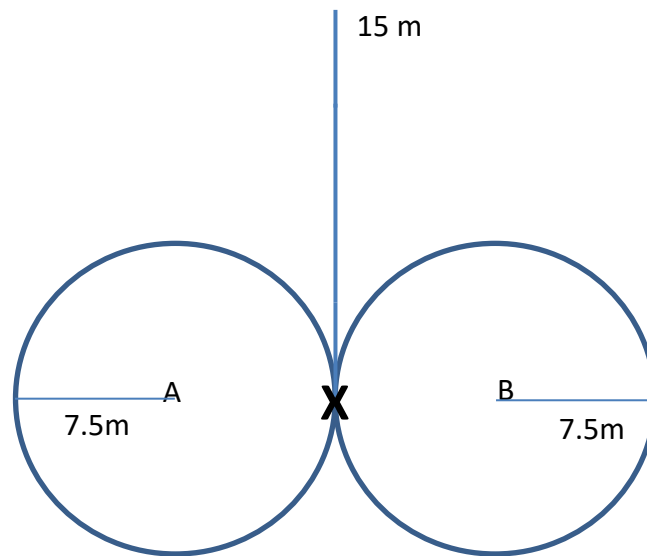


Figure A. Suggested placement of survey areas if continuous hardbottom. A and B represent two fish divers.

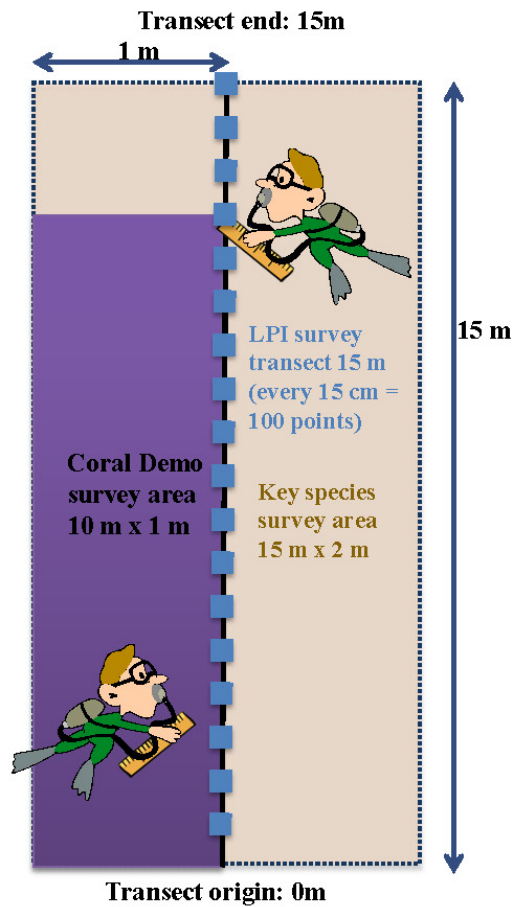


Figure B. Diagram of benthic surveys indicating size of each respective survey area.







## Appendix IV. Habitat Types

### *U.S. Caribbean habitat types<sup>2</sup>*

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 (dense coverage of macroalgae, hard coral, gorgonians, and other sessile invertebrates) or uncolonized (often covered by a thin sand veneer with sparse coverage of biota (macroalgae, hard coral, etc.).

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.

#### *Individual Patch Reef*

Usually circular or oblong. High relief. Isolated by other formations by sand, seagrass. At the scale of the transect, may look like aggregate reef or even pavement.

#### *Aggregate Patch Reef*

Circular or oblong features not big enough to map individually. The cluster of hardbottom is >10% of the entire polygon. Where there is a halo, the halo is part of the polygon.

Pavement: Flat, low-relief, solid carbonate rock. May be colonized (dense coverage of macroalgae, hard coral, gorgonians, and other sessile invertebrates) or uncolonized (often covered by a thin sand veneer with sparse coverage of biota (macroalgae, hard coral, etc.).

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).

### *Gulf of Mexico (Flower Garden Banks National Marine Sanctuary) habitat types*

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.

---

<sup>2</sup> Adapted 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.



## Appendix V. Categories and definitions

- **Skeletal unit:** A coral colony is identified as a ‘skeletal unit’, which could contain one or more live patches of tissue.
- **Individual:** Thickets/clumps of corals, *e.g.*, thickets of branching scleractinian coral species such as *Acropora*, *Madracis*, and *Porites* that are connected by skeletal units (or indistinguishable) are counted and measured as a single colony (*protocol source*: AGRRA).

Small *Acropora cervicornis* thicket



Small *Acropora palmata* thicket



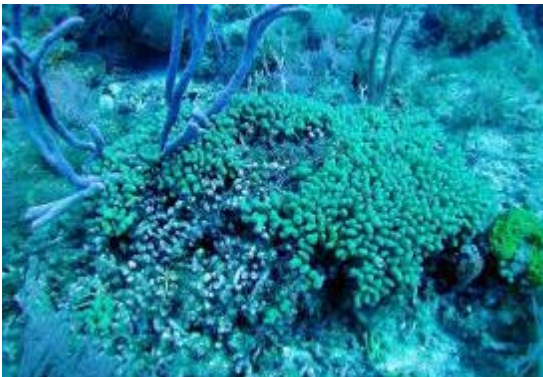
Skeletal unit of *Eusmilia fastigiata*



Skeletal unit of *Orbicella annularis*



Skeletal unit of *Madracis auretenra*



Skeletal unit of *Porites porites*

