

Coral Demographics Survey Protocol for the Atlantic, U.S. Caribbean and Gulf of Mexico: 2016

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.

The 2016 Coral Demographic protocols have minor differences than previous versions (years) as a result of NCRMP standardization throughout the project's regions (*e.g.* Florida and Pacific regions). Specific differences in methodologies between regions, where applicable, are noted within the protocols.

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 Line Point-Intercept

(LPI) surveys (Appendix I; Refer to *Line Point-Intercept Survey Protocol for the Atlantic, U.S. Caribbean and Gulf of Mexico: 2016*).

Coral Demographic and LPI surveys may be completed on the same dive as fish surveys (Appendix I, Figure A). If the surveys are implemented simultaneously then the benthic team should set up the transect on the appropriate habitat with the least amount of interference with the fish surveys. If the benthic survey is implemented without a fish team, then the transect can be established on the appropriate habitat.

General Task Description

The demographic surveys typically take longer to complete than LPI 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 LPI diver:
 - When the LPI diver completes the LPI transect, s/he will coordinate with the Demographic diver to assist with completing the demographic transect (if LPI 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 contact with each other throughout the entire census.

1. Each boat will have up to three GPS units when collecting fish and benthic data simultaneously, otherwise only 1 dive flag/float with GPS required for 1 team:
 - a. One for navigation to sites, and
 - b. One GPS unit attached to dive flag/float carried by each team deployed, uniquely identified for each team, benthic and/or fish.
 - i. Each dive team will have dive flag/float and GPS. Record each team's unique GPS # and dive flag numbers on the daily boat log (Figure 1; Appendix II).
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.
3. As the dive team(s) deploy from the vessel, the boat captain will use the navigational GPS to take a waypoint of the surface float/flag(s) and record the coordinates on the boat log (Appendix II).

****Boat driver should take extreme care to avoid divers in the water.*****Recording the station information*

Station information is recorded Station information is to be recorded in two primary locations prior to entering the water: (1) *Boat/Dive log* and (2) *datasheet* (Figure 1 and Figure 3; Appendix II and III). The log and data sheet are to have the same information recorded on both.

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. Always ‘1’ and ‘2 for Florida (2-stage)
 - b. Always ‘1’ for Caribbean and FGBNMS (1-stage)
3. *Team (Team member assignment)* – Letter code identifying the type of data is being collected by the diver within their dive group.
 - a. Fish (A/B) – A two-diver fish team consists of a Diver A and Diver B.
 - b. Benthic (J/X) – The diver collecting Demographic data is assigned the code ‘X’; divers collecting LPI data is assigned ‘J’.

** Codes are assigned to diver positions on within the team and type of data collect; therefore, diver team codes will change by station.

Example: Figure 1 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 (LPI diver) and Viehman is X (Demo diver). Notice for the second dive of the day, Viehman is assigned diver J for the benthic team.

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

Figure 1. Example of boat log with specific station information filled out. DOD = Dive of the day.

Evaluating the site

1. As the team descends and assesses the site, the benthic team ascertains the presence of hardbottom and observed habitat type at the site.
 - a. Hardbottom presence/absence
 - i. Absent – If hardbottom is absent from the site (*i.e.*, continuous sand or seagrass combined with limited visibility),
 1. Then the dive will be terminated and an alternate selected,
 2. **Do not swim around looking for hardbottom.**
 - ii. Present – If hardbottom is present, continue habitat type assessment
 - b. Observed habitat type – If the team(s) deploy over hardbottom they are to establish the transect where deployed.
 - i. If necessary, during descent, divers will swim to appropriate habitat
 1. If divers enter the water over sand, they will swim to nearby reef habitat for sampling.
 2. If divers enter the water over hardbottom different from that expected **and** observe expected habitat type nearby, they will swim to habitat for sampling.
 - ii. If divers enter the water over hardbottom different from that expected and **do not** observe expected habitat type nearby, they will establish the transect where deployed and indicate the habitat type on the datasheet and boat log.
2. **Terminating the dive** – surveys should be terminated and alternates chosen under the following conditions:
 - a. **Visibility is less than 2 m**, the dive should be terminated and an alternate selected.
 - b. **Bottom currents are strong enough that the divers cannot maintain a stationary position**, the dive should be terminated and an alternate selected.
 - c. **Depth of the selected site is greater than 99 ft**, then the team should terminate the dive and choose an alternate.

Reasons to terminate a dive:

- Visibility (> 2m)
- Strong currents
- Depth (> 99ft)

Coral Demographic Transect Information

Coral Demographic surveys will be conducted with LPI at a subset of fish survey sites.

Establishing transect

1. Fish team present

- a. If hardbottom is present, benthic team will establish the transect as close to the fish team as possible without overlap or interference of the fish cylinder (Appendix I: Figure A).
- b. Benthic team will tie off surface float and transect tape. The LPI diver secures the start of transect tape and continues to keep the transect tape relatively taut throughout survey, using weights clipped to the transect tape (Figure 2).
- c. The LPI diver will avoid wrapping the tape around substrate or biotic object, as this will distort sampling distances and locations for the benthic divers.
- d. The end of the tape should be tied or clipped so that the transect tape is as tight as possible.
- e. If current is present at depth, transect tape may be aligned to face the current. If currents are too strong, survey should be terminated.
- f. 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.



Figure 2. Example of weight attached to transect tape.

2. Fish team absent

- a. If hardbottom is present, benthic team will tie off surface float and transect tape. The LPI diver secures the start of transect tape and continues to keep the tape relatively taut throughout survey, using weights clipped to the tape (Figure 2).
- b. The LPI diver will avoid wrapping the tape around substrate or biotic object, as this will distort sampling distances and locations for the benthic divers.

- c. The end of the tape should be tied or clipped so that the transect tape is as tight as possible.
 - d. If current is present at depth, transect tape may be aligned to face the current. If currents are too strong, survey should be terminated.
 - e. 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 the transect in place.
3. Method type – Indicate whether the benthic survey was conducted with fish team present (combined) or absent (separate) in the **notes section of the datasheet** (Appendix III). Circle selection.

Data collection

1. The Demographic diver collects the following information (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 LPI 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 (Figure 1).
 - 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. Both divers will record their own start and end positions on data sheet (Figure 1).
- c. 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 (Figure 3).
- d. The name of the second Demographic diver will be recorded on ALL datasheets associated with that dive site.

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

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 3 & 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.

FIELD ID = (SITE #) + (STATION #) + (TEAM letter)

Example for Florida (Figure 3): Diver Edwards recorded the **Field ID** 12001J. According to the boat/dive log (Figure 1), Edwards is diver J for site 1200.

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

Figure 3. NCRM coral demographic datasheet header with logistic and station information for Florida.

Example (Figure 3): Coral Demographic diver Viehman recorded the **Field ID** 12001X. According to the boat/dive log (Figure 1), Viehman is diver X for site 1200.

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: <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 4. NCRMP coral demographic datasheet header with logistic and station information for Caribbean and Gulf of Mexico.

2. *Observed habitat type* – Identification of the habitat type observed at the diver scale (not mapped category, Figure 5). Circle selection.

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: <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 5. Hardbottom categories of observed habitat type on the LPI datasheet.

3. *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 5).
 - a. Record each individual on datasheet (Figure 6).
 - b. Thickets/clumps. If the skeletal unit is connected, identify as one individual. If not, then record them as multiple individuals (Appendix IV).
 - 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 5). If species-level identification is not possible, take photo for later analysis.

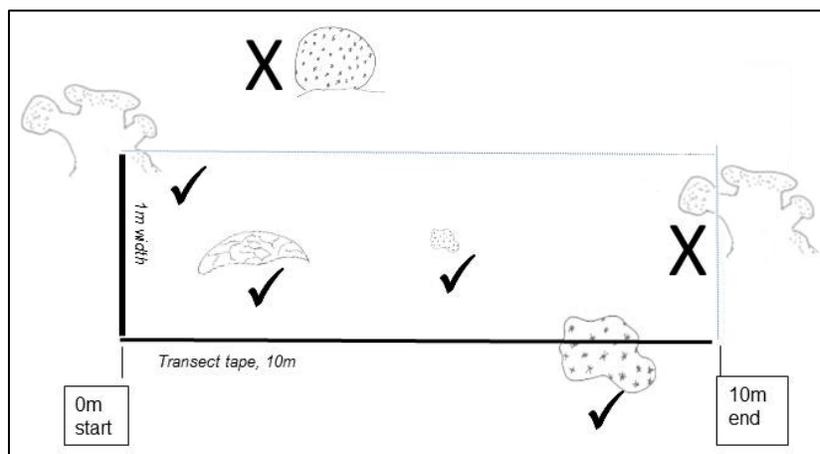


Figure 5. Schematic of example 10m x 1m transect area. Corals with all or part of colony (excluding branches) within transect area are included (✓). Corals entirely outside of the transect area are not included (X).

Coral ID	Max Diam (cm)	Max Perp Diam (cm)	Height (cm)	Old mort. (%)	Recent mort. (%)	Bleach - (T, P, N)	Disease Pres (P), Abs (A)	Coral ID	Max Diam (cm)	Max Perp Diam (cm)	Height (cm)	Old mort. (%)	Recent mort. (%)	Bleach - (T, P, N)	Disease Pres (P), Abs (A)

Figure 6. Datasheet section showing coral identification, dimensions, condition categories and data entry.

- e. When a scleractinian colony **smaller than 4 cm maximum dimension** (< 4cm) of a species that is not present as a larger, measured colony is encountered in the transect area (Figure 5):
 - i. Identify the coral to lowest possible taxonomic resolution and record on datasheet.
 - ii. Bleached and diseased information **is 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 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 7 and 8, Appendix IV).
 - 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 7). Maximum diameter length is to be greater than perpendicular diameter width.

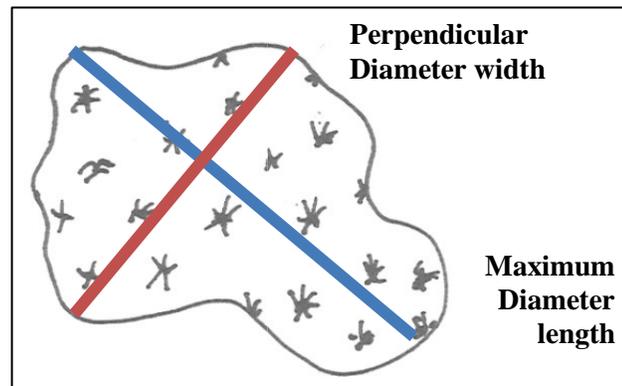


Figure 7. Measurements of maximum diameter length and perpendicular diameter width.

- c. Height – Measure the **height** (cm) of the skeletal unit (Figure 8).
- 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.

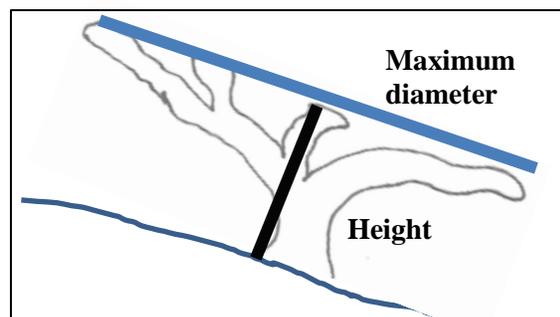


Figure 8. Height and width measurements perpendicular to plane of growth. Colony is shown on a sloped reef.

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 9). 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].

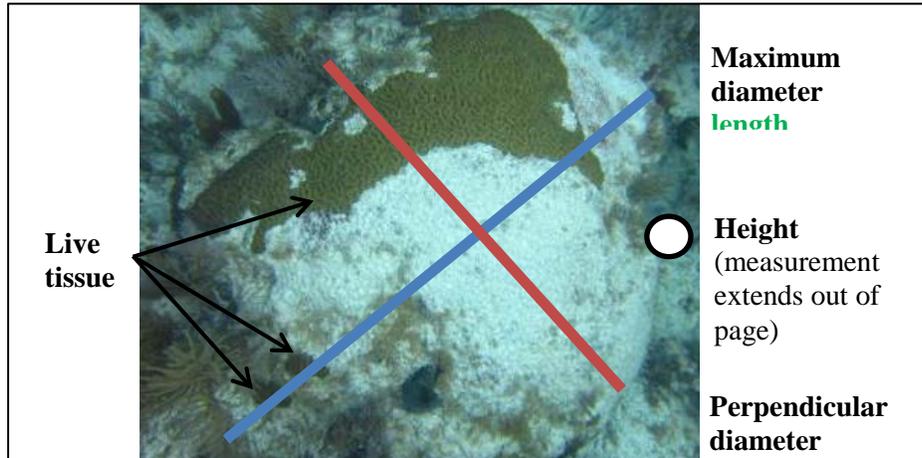


Figure 9. Entire skeletal unit is measured for dimensions [max diameter (blue), perpendicular diameter (red) and height (circle).] Estimate % old mortality (~70%).

- b. **Bleaching (T/P/N)** – Note if any coral bleaching is present or absent (Figure 10).
 - i. **Total bleaching (T): bright-white** bleaching over the entire colony¹
 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 NOTE: *Siderastrea siderea* and *S. radians* may appear bright blue rather than white when bleached.

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 10. 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*.

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

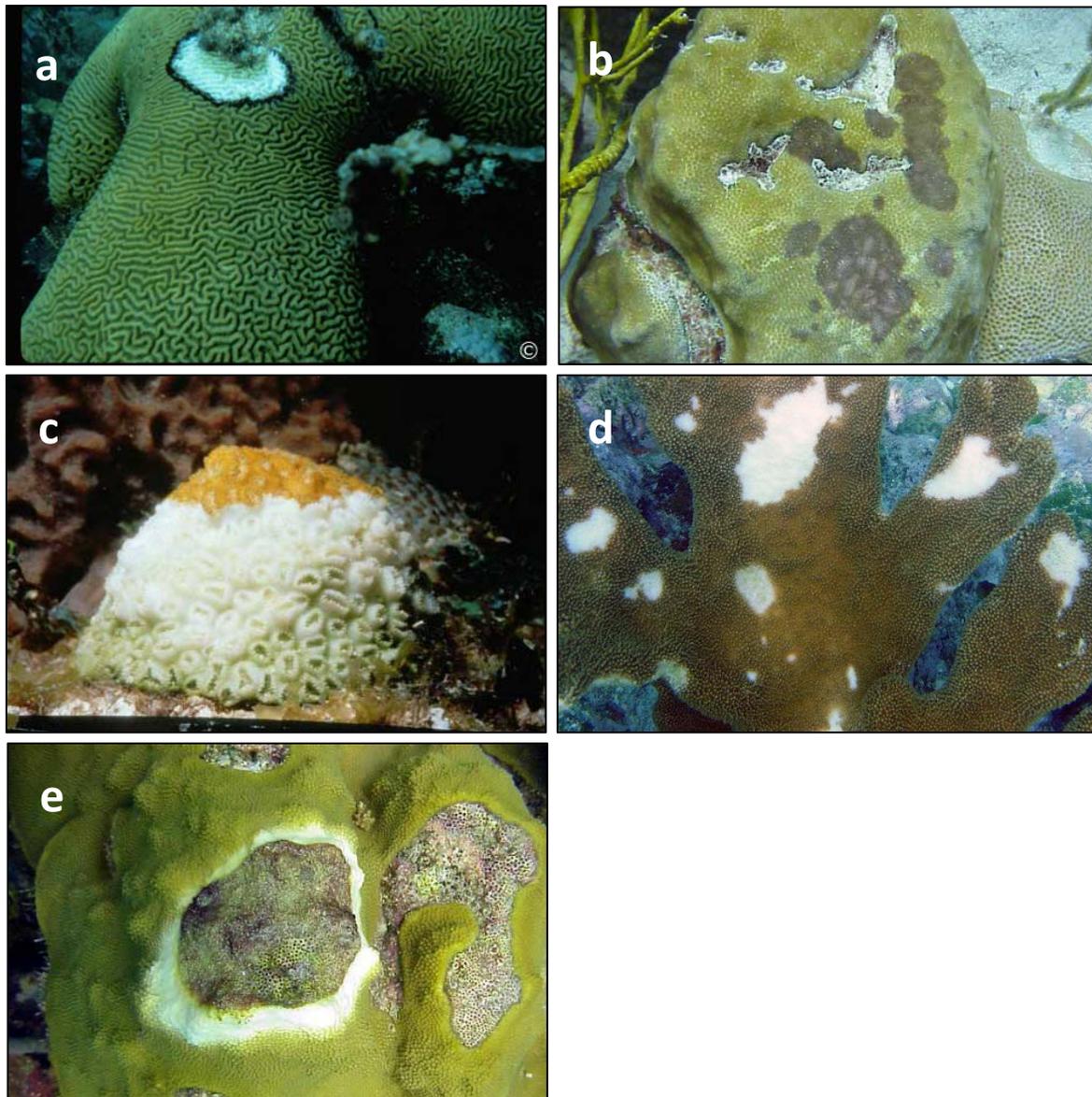


Figure 11. Examples of coral diseases: a) black band, b) dark spots, c) white plague, d) white pox, and e) yellow band.

- A summary of NCRMP coral demographic sampling components are illustrated in Figure 12.

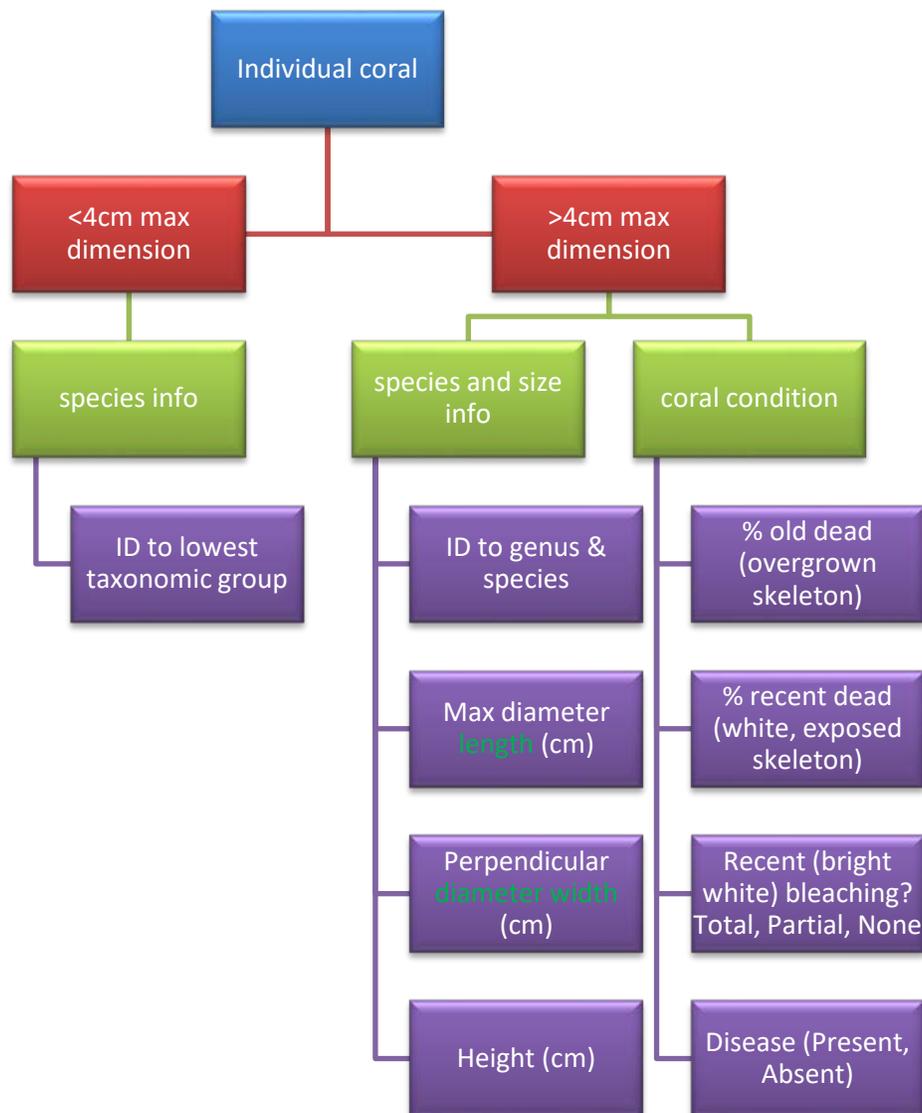


Figure 12. Summary of NCRMP coral demographic sampling.

6. *Photographs* – The Demographic diver may choose to take additional photos of anything unusual (*e.g.*, rare fish, bleached or rare corals), for species identification purposes, unique site features, and other divers. If the Demographic diver does take photographs, the following should be done:
 - a. Station Documentation
 - i. One photograph is taken of the site name and date on the datasheet prior to taking any photographs of the site.
 - b. For the process for downloading and storing site photographs, refer to *Photo Documentation Manual*.

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.

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. *LPI 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

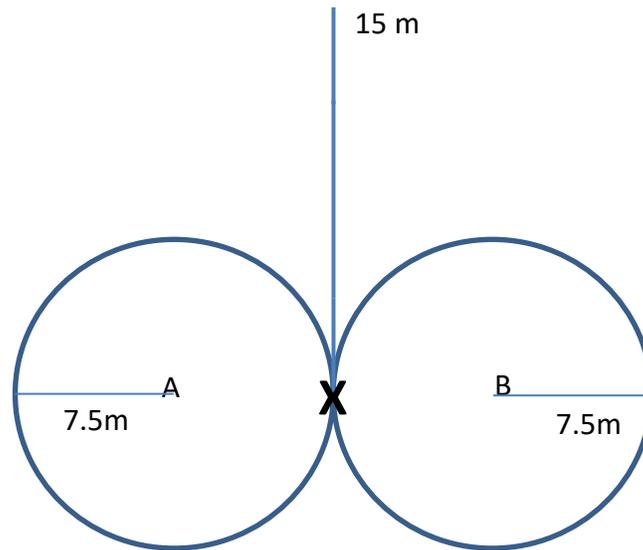


Figure A. Suggested placement of survey areas if continuous hardbottom. A and B represent two fish divers.

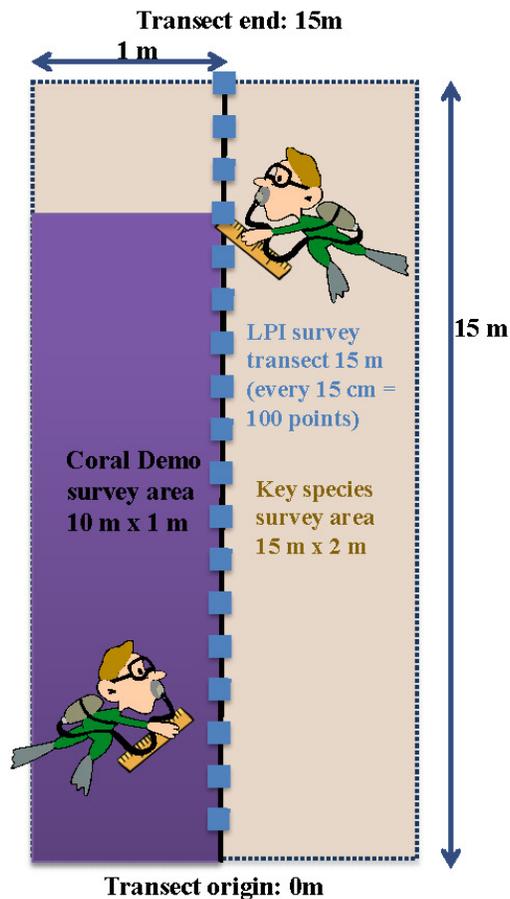


Figure B. Diagram of benthic surveys indicating size of each respective survey area.

Appendix IV. 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*

