

Coral Demographics 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

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.*, 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.

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 the U.S. Caribbean and FGBNMS.

General Task Description

Coral demographic surveys will occur at a subset of the fish/LPI sample sites. The demographic surveys typically take longer to complete than fish and 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).

Coral Demographic Transect Information

Establishing the transect

1. The Demographic and LPI divers will use the same transect as the Fish diver (Appendix I).
 - a. Benthic divers follow behind the Fish diver at a distance to avoid influencing swimming behavior of fishes (*i.e.*, the LPI diver starts when the Fish diver is near the 5m mark, or as visibility allows, then the Demographic diver starts).
 - b. The Fish 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 along the bottom so that it moves as little as possible.
 - c. The Fish diver will avoid wrapping the tape around substrate or biotic objects, as this will distort sampling distances and locations for the benthic diver.
 - d. At Fish + LPI + Demographic sites, LPI diver may assist the Demographic diver to finish the coral demographic survey within depth/time limits of dive.
 - i. If LPI diver assists Demographic diver in survey completion, LPI diver begins his/her demographic survey at the tenth meter of the survey and works until s/he finishes a complete meter and meets Demographic diver. LPI and Demographic divers will coordinate to avoid duplicating counts.
 - ii. To ensure that all space is surveyed, there will be no surveys of partial meters.
 - e. Bottom time may be highly variable between sites, depending on the density of corals and the number of Demographic surveyors.
2. 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.***

3. Demographic survey area is 10m long by 1m wide (Appendix I). This is less than the size of the fish and LPI surveys.
- This survey area is consistent with existing demographic monitoring programs including AGRRA, CREMP, SCREAM and FRRP.
 - The demographic survey is conducted along the **LEFT** edge of the transect line.
 - 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.
 - Every effort will be made to complete the entire 10m x 1m belt transect.
 - 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).
 - The survey starts at meter marker zero (0) and proceeds to meter marker 10, unless the starting point (0m) is not on hardbottom. If the 0m on the transect tape is not on hardbottom, see **DECISION RULE** below.

Demo diver		Site ID		Demo #2 diver		Page _____ of _____	
Fish diver		Date		Sheet completed by DEMO diver	(circle one)	Transect Completion (m)	
LPI Diver		Time		1	2	Start	End
						% HB of survey	

Figure 1. Location of transect completion component on the NCRMP Coral Demographic datasheet.

DECISION RULE (Figure 2):

- If the beginning of the survey (tape=0m) is located on softbottom (sand, mud, seagrass), the coral survey will start at the first encounter with hardbottom on the **LEFT** side of the tape. Round down to the nearest whole meter to start the survey.
 - The first encounter is determined when hardbottom is present within the 1m width survey area. Hardbottom does not have to be present directly under the tape for it to be considered present in the survey area.
 - For example, if the 0m point on the survey tape is in sand and the reef/hardbottom starts at 6.3m, the coral survey starting point should move to 6m and continue to the 16m mark for a total of 10m.

CAUTION: If the coral survey starting point is moved from 0, this may impact bottom times. Be extremely cautious of your dive time and air supply!

- If no hardbottom exists between 0 and 10m, the demographic survey should be terminated and an alternate selected.
- Regardless of where survey starts, always record survey start and end locations on the datasheet (Figure 1).

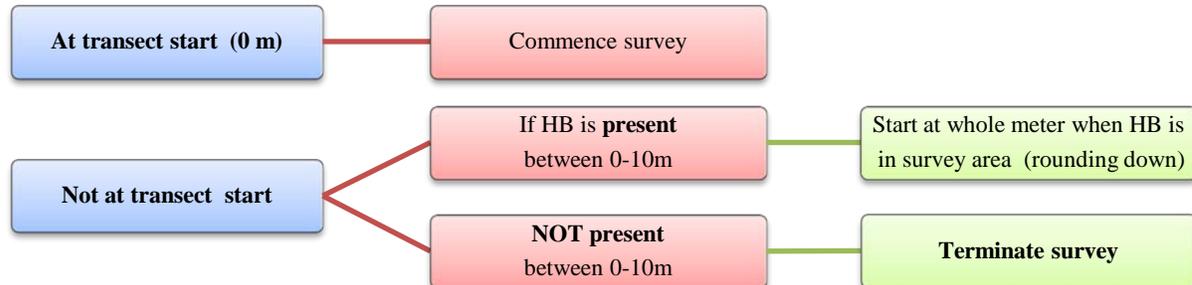


Figure 2. Decision rule for coral demographic survey.

4. 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. *Logistics and station information* – Names of all divers, station, date, time of survey and diver checks (Figure 3).
 - a. Note the locations to indicate a secondary Demographic surveyor, number of datasheets associated with station, and ownership of datasheet.

NCRMP Coral Demographic Datasheet						Page _____ of _____	
Demo diver		Site ID		Demo #2 diver		Transect Completion (m)	
Fish diver		Date		Sheet completed by DEMO diver	(circle one)	Start	End
LPI Diver		Time			1 2	% HB of survey	

Figure 3. NCRMP coral demographic datasheet header with logistic and station information.

2. *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 4).
 - a. Record each individual on datasheet (Figure 5).
 - b. Thickets/clumps. If the skeletal unit is connected, identify as one individual. If not, then record them as multiple individuals (Appendix III).
 - 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.

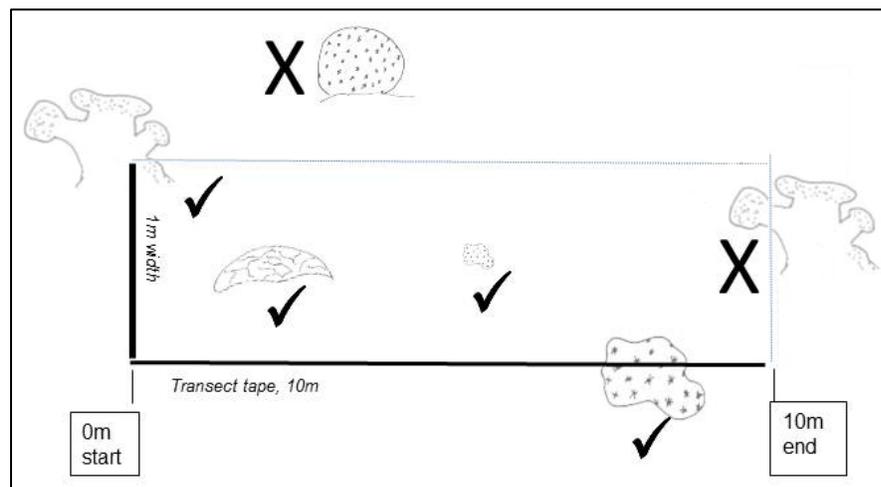


Figure 4. Schematic of example 10m x 1m transect area. Corals with all or part of colony (excluding branches) within transect area are included (✓). Corals entirely outside of the transect area are not included (X).

Coral Dimensions				Old mort. (%)	Recent mort. (%)	Bleach- Total, Partial, None (T, P, N)	Disease- Present (P), Absent (A)
Coral ID	Max Diam (cm)	Perp Diam (cm)	Height (cm)				

Figure 5. 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 4):
 - 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 6 and 7, Appendix III).
 - 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 6). Maximum diameter length is to be greater than perpendicular diameter width.

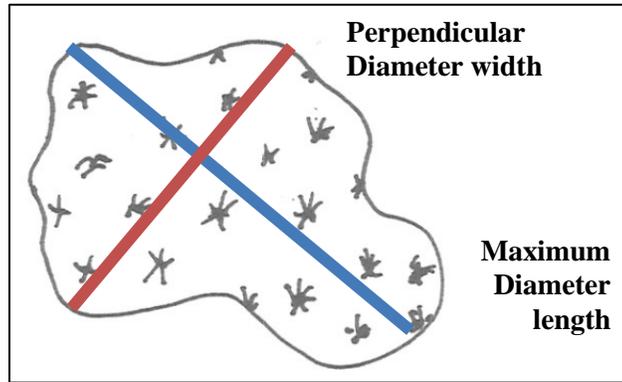


Figure 6. Measurements of perpendicular diameter length and maximum diameter width.

- c. Height – Measure the **height** (cm) of the skeletal unit (Figure 7).
- 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 1.0cm.

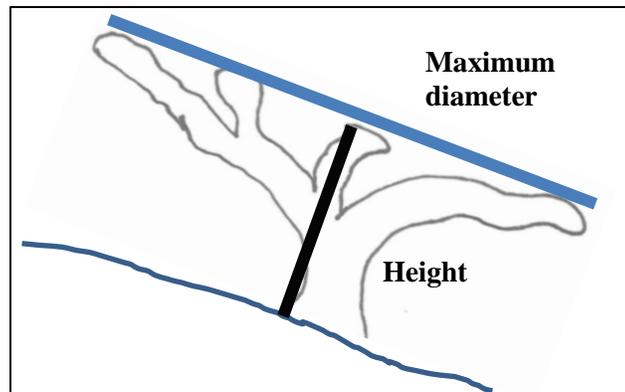


Figure 7. Height and width measurements perpendicular to plane of growth. Colony is shown on a sloped reef.

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 8). 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.
 - iii. **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].

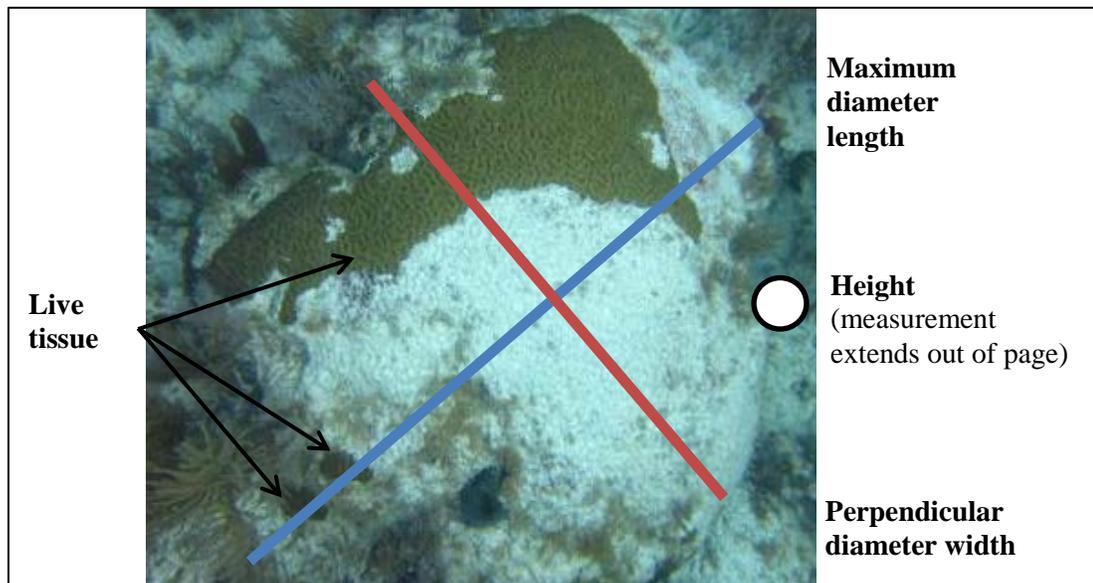


Figure 8. Entire skeletal unit is measured for dimensions [maximum diameter (blue), perpendicular diameter (red) and height (circle).] Estimate % old mortality (~70%).

- b. Bleaching (T/P/N) – Note if any coral bleaching is present or absent (Figure 9).
- 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. 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 9. 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 (Figure10).
- i. **Present (P):** Any form of coral disease is noticeable on the colony, (See Figure 10 for examples).
 - ii. **Absent (A):** No disease is evident.

¹ NOTE: *Siderastrea siderea* and *S. radicans* may appear bright blue rather than white when bleached.

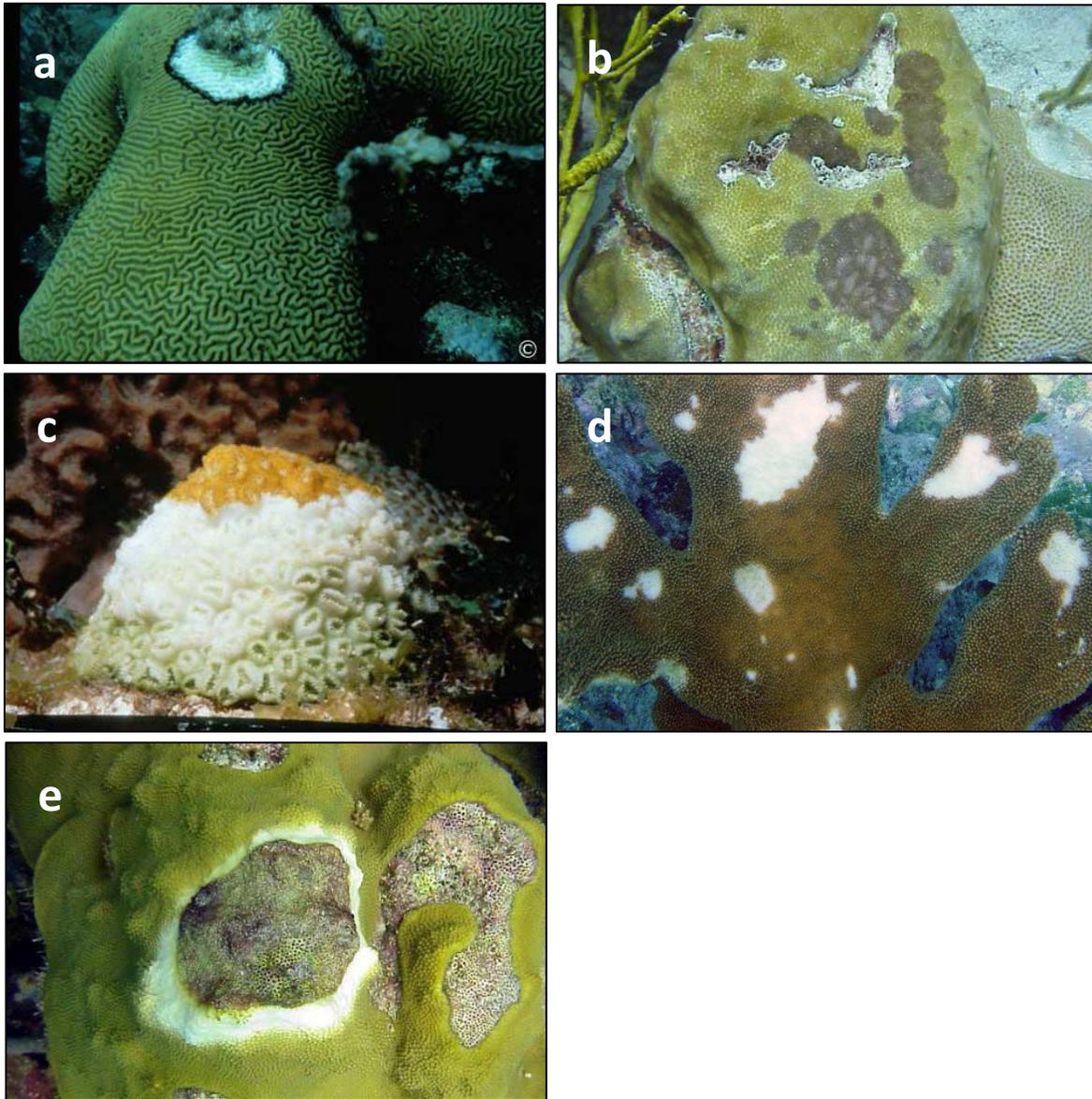


Figure 10. Examples of coral diseases: a) black band, b) dark spots, c) white plague, d) white pox, and e) yellow band.

- A summary of NCRMP coral demographic sampling components are illustrated in Figure 11.

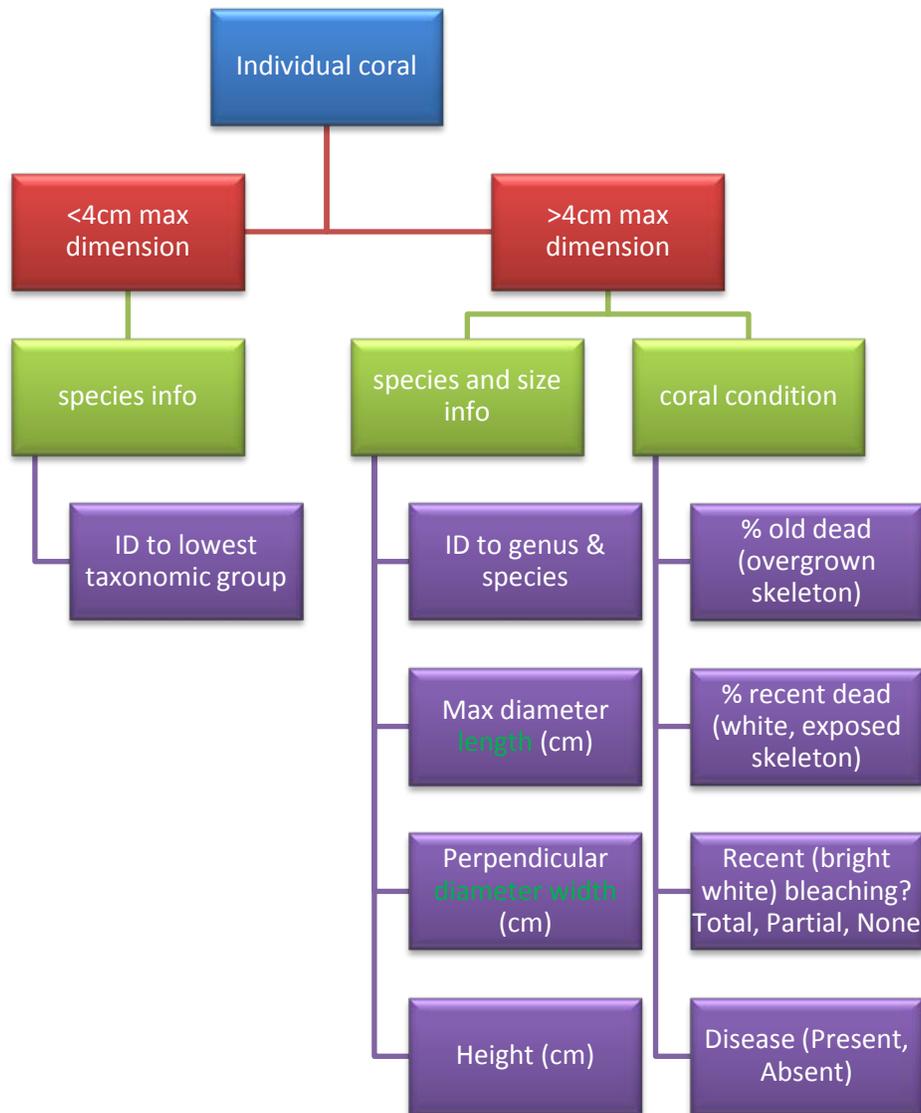


Figure 11. Summary of NCRMP coral demographic sampling.

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 II).

- 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

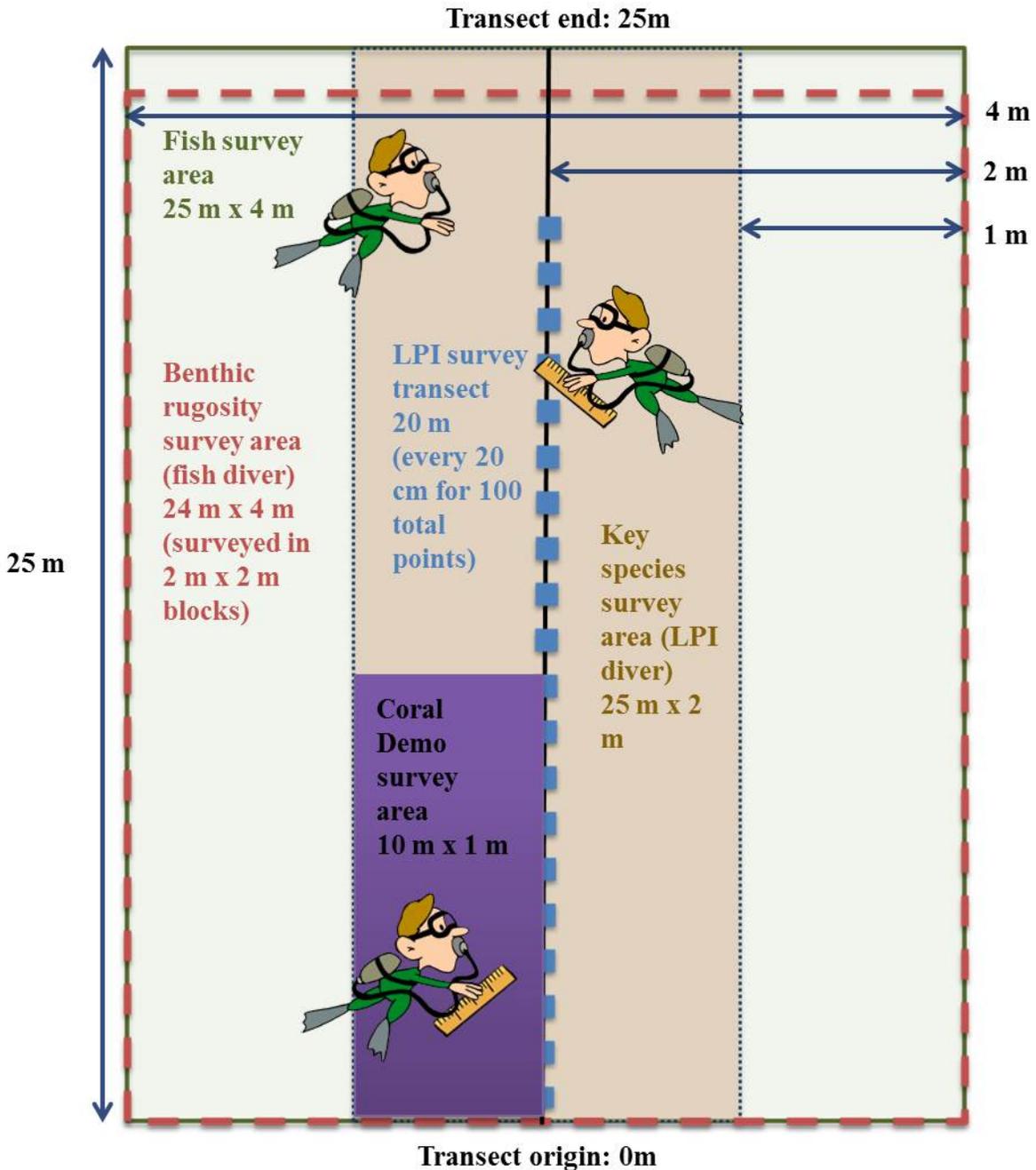
At end of survey, when divers are on boat, the dive team exchanges datasheets for review by checking for completeness and legibility. A diver cannot review his/her own datasheet. After the datasheet has been reviewed, the reviewer initials the “checked by diver” box (Figure 1).

1. *Fish datasheet* – Review includes, at a minimum, verifying the following:
 - a. Completeness and legibility of all logistics information; including random heading(s) and reason for change is circled, if applicable.
 - b. Completeness and legibility of all species codes, bin size class marks and size numbers (for select species and individuals >35cm).
 - c. 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 – 24 total tick marks.
2. *LPI datasheet* – Review includes, at a minimum, verifying the following:
 - a. Completeness and legibility of all logistics information.
 - b. Confirmation of observed habitat type with dive team and 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.

3. *Coral Demographic datasheet* – Review includes, at a minimum, verifying the following:
 - d. Completeness and legibility of all logistics information; including identification of second Demographic surveyor (if applicable).
 - e. Completeness and legibility of transect start and end locations (integer).
 - f. Completeness and legibility of percent hardbottom of survey component.
 - g. Annotation in “Notes” section reporting the presence of multiple datasheets utilized for data collection (if applicable).

Appendix I.

Diagram of all surveys indicating size of each respective survey area. 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, long-spined sea urchins) and topographic complexity will be surveyed as the divers return to the transect origin.



Appendix III.

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*

