

National Coral Reef Monitoring Program (NCRMP)

Coral Demographics Survey Field Protocols for U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, U.S. Virgin Islands

2022

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

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Introduction

The National Coral Reef Monitoring Program (NCRMP)'s biological sampling provides a biennial ecological characterization of general reef condition for reef fishes, corals, and benthic habitat (*i.e.*, fish species composition, density, and size; coral species composition, density, size, condition; and benthic community cover) at a broad spatial scale (CRCP 2021). In the U.S. Atlantic, NCRMP biological sampling includes coral reef and hardbottom habitats in Florida, Flower Garden Banks, Puerto Rico, and the U.S. Virgin Islands. NCRMP conducts surveys at stratified random sites where the sampling domain for each geographic region is partitioned by habitat type and depth, sub-regional location (e.g., along-shelf position), and management zone.

NCRMP surveying provides data from a broader geographic context that complements a mosaic of regional and local (site-specific) coral reef monitoring. For corals and benthic communities, NCRMP data are compatible with stratified random sampling programs (Florida Reef Resilience Program's Disturbance Response Monitoring (DRM, Florida; 2005–present), and Sanctuary Coral Reef Ecosystem Assessment and Monitoring [SCREAM, Florida; 1999–2011]). Coral reef monitoring is also led by each region in programs that include the Coral Reef Evaluation and Monitoring Project (CREMP, Florida), the U.S. Virgin Islands Territorial Coral Reef Monitoring Program (TCRMP, USVI), and the Puerto Rico Coral Monitoring Program [PR CRMP]). Other sampling programs occur Caribbean-wide (e.g., Atlantic and Gulf Rapid Reef Assessment [AGRRA, Caribbean-wide]).

NCRMP Coral Demographics Survey Summary

NCRMP Coral Demographic surveys are designed to collect and report data on scleractinian coral species composition, density, size, abundance, and specific parameters of condition (% live and dead, bleaching, disease) of non-juvenile scleractinian corals (≥ 4 cm maximum diameter), and overall species diversity (all scleractinian corals). The survey also includes data collection per colony within the survey area for percent of colony with recent mortality (*i.e.*, dead white skeleton), percent of old mortality, bleaching (*i.e.*, total bleaching of the entire colony, partial bleaching of the colony, or paling), coral disease (present or absent), and whether the colony is identifiable as a restored/outplanted coral (*i.e.*, No, Yes, Unknown). Exact identification or precise designations of specific coral diseases (e.g., named disease types) are not recorded because (1) low temporal resolution of the NCRMP's biennial sampling

may not coincide with episodic disease outbreaks, and (2) visual symptoms of various coral diseases are often indistinguishable in the field and can require collection of tissue samples for accurate disease identification.

At each NCRMP Benthic survey site, a single Coral Demographics Survey is conducted within a 10 x 1m belt transect area. A NCRMP Benthic survey includes one Coral Demographics survey and one Benthic Community Assessment survey (CRCP 2022a). NCRMP Benthic surveys may occur at all or a subset of NCRMP Fish surveys. Benthic surveys may be conducted concurrently with co-located NCRMP Fish surveys (CRCP 2022b), or Benthic and Fish surveys may occur at separate field visits.

This protocol includes an overview of the field methodology, including pre-dive, site orientation, and the coral demographics survey, as well as an overview of data accessibility and use.

NCRMP Coral Demographics Survey: Sequence of Events

NCRMP Coral Demographics data collection occurs in three phases: (1) Pre-dive, (2) Site information, and (3) Coral Demographics survey (Figure 1).

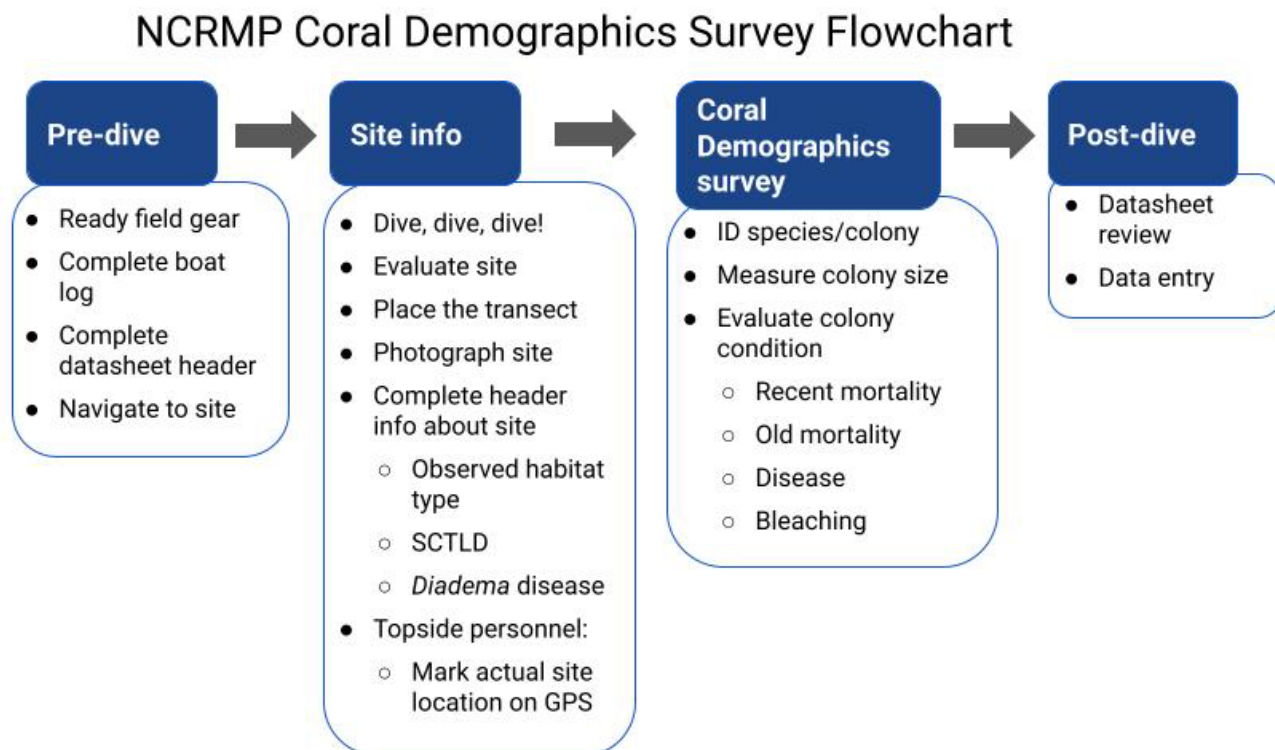


Figure 1. Coral Demographics survey sequence of effort.

Pre-dive

The pre-dive phase consists of organizing field equipment to take underwater and filling out station information on two datasheets prior to entering the water: the boat/dive log, and the Coral Demographics datasheet (Figure 2 and 3). This phase may occur while the vessel is navigating to the site (detailed in **General Site Information** section).

Organize field equipment

The following field gear will be organized to take on the dive.

1. Demographics datasheet
 - One survey per datasheet
2. Clipboard, pencil, spare pencil
3. Small rigid measuring instrument, marked in cm (e.g., “Flexiruler”)
4. 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)
5. Benthic team camera (with charged battery, and space on memory card) and housing.

Complete Boat Log

Prior to the dive, key fields to record on the boat log for station information include the following (Figure 2).

1. *Site* – The 4-digit station number.
2. *Station* – (1) All regions are now 1-stage
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 Community Assessment data is assigned the code ‘J’; the diver collecting Coral Demographics 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 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 2. Example of boat log with station information filled out. DOD = Dive of the day. In this example, 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 Demographics diver). Notice for the second dive of the day, Viehman is assigned diver J for the benthic team and Blondeau is diver X.

Fill out top of the datasheet

The following information should be filled out legibly on the NCRMP Coral Demographics datasheet (Figures 3; Appendix III). Logistic and station information (Figure 3):

- Names of all divers,
- Field ID – a unique alpha-numeric number
- FIELD ID = (SITE #) + (STATION #) + (TEAM letter)**
- Date,
- Time of survey,
- Mission data manager,
- Number of survey meters completed.

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|--|-------------------------------|--|--|--------------------------|
| Diver: <u>K. Edwards</u> | Boat/Manager: <u>Blondeau</u> | Start Time: <u>1035</u> | Sheet filled by (circle diver): Demo LPI | |
| Buddy: <u>S. Viehman</u> | Field ID: <u>3000 1 X</u> | Date: <u>6/1/2022</u> | | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | | Meters completed: _____m |
| Habitat: <u>Bedrock</u> <u>Pavement</u> <u>Aggregate Reef</u> <u>Patch Reef</u> <u>Scat. Coral/Rock in Sand</u> | | | | % HB of survey: _____ |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled | | Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | | |

Figure 3. NCRMP Coral Demographics Survey datasheet header with logistic and station information.

General Site Information

This phase includes vessel navigation to the site and surveyors recording the station information on the boatlog and datasheet. Navigating to the site may occur simultaneously with the pre-dive steps (detailed in the previous section). When divers enter the water, they locate the survey site, and in coordination with the Fish and Coral Demographics divers, establish the survey transect. While the Benthic Community Assessment diver lays the transect tape, the Coral Demographics diver photographs the datasheet with header information (including site number) and cardinal directions at the site. During the survey, the Coral Demographics diver completes the remainder of the datasheet header information.

Navigate to the Site

Once in the field, the vessel captain navigates to the pre-selected NCRMP 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 their dive buddy and should make frequent visual contact through the entire dive, including during surveys****

1. Each vessel will have up to three **(3)** GPS units:
 - a. One **(GPS 1)** for vessel navigation to sites, and
 - b. Each boat will have one dive flag/float with a GPS unit attached **(GPS 2)**. This setup is unique for each boat and will be used by the diver 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 1; Appendix II).
 - c. If using a GPS unit other than handheld to navigate to the sites, a handheld GPS **(GPS 3)** is used to collect topside waypoints (see #3 below).
2. Dive teams enter the water at provided GPS coordinates, descend to the bottom, affix the surface float line to the bottom, set up survey areas, and begin data collection.
 - a. If the 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).

****Vessel operators will safely mark waypoint, after divers have descended****

4. After completion of all surveys or at the end of the dive, all divers convene at the affixed float line and begin their ascent to the surface together.

Establishing the Survey – Evaluating the Site

1. Locate hardbottom. As the team descends and assesses the site, the lead 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 at the site (no hardbottom at all, *e.g.*, continuous sand or seagrass combined with limited visibility),
 1. The dive will be terminated and an alternate site selected,
 2. Do not swim around searching for hardbottom – this is not reconnaissance.
2. Locate the survey site. If the team(s) deploy directly over the expected hardbottom habitat, they establish cylinders where they touch down on the bottom.
 - a. If the expected hardbottom habitat is not directly beneath them during descent, divers will swim to the expected habitat if it is 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 hardbottom different from that which was expected, but observe the expected habitat type within visible range from where deployed, they will swim to expected habitat for sampling.
 - b. If divers enter the water over hardbottom different from that expected and do not observe expected habitat type nearby, they will establish cylinders where deployed and indicate the alternate habitat on the datasheet and boat log.
3. Establish the survey site. When a benthic team (Benthic Community Assessment and Coral Demographics divers) deploys with the Fish team (pair of RVC fish divers), they establish the survey adjacent to the cylinders if possible, using the same anchor point for the belt transect (Appendix I, Figure A). Additional information on establishing the survey site is provided in the following section *Coral Demographics Surveys*.
 - a. If hardbottom is patchy, the benthic team may swim to nearby hardbottom feature to start transect, remaining in visual context with the Fish divers and the surface float.
 - b. **Establish the Benthic Survey transect**
 - c. **Secure transect tape.** The Benthic Community Assessment diver secures the transect tape and the surface float line or reel.
 - d. **Lay out the transect.** The Benthic Community Assessment diver reels out the transect to a length greater than 15m, secures the tape so that it is taut, and weights as needed (Figure 4).
 - i. If the site is pavement or scattered coral in sand, soft weights may be used to weigh down the transect tape at the beginning and end to keep the transect in place.
 - ii. The diver will avoid wrapping the tape around substrate or biotic objects within the survey area, for this would distort sampling distances and locations for the benthic divers. Weights will not be placed on live coral.
 - iii. The end of the tape should be tied or clipped so that the transect tape is as taut as possible.

-
- iv. If current is present at depth, transect tape may be aligned to face the current. If currents are too strong, the survey should be terminated.
4. **Photograph the site.** At least five photographs are taken per site. The Coral Demographics diver coordinates with the Benthic Community Assessment diver on who will take the site photographs (and subsequently upload, organize, and re-label the images). In a typical situation, the Coral Demographics diver takes the site photographs while the Benthic Community Assessment diver lays the transect tape
- Take one photograph of the station and logistic information at the top of the datasheet prior to taking any photographs of the site. The station name, date, time and heading information should be clear and legible in the photograph.
 - Take four site photographs at the four cardinal compass headings (i.e., N 0°, E 90°, S 180° and W 270°).
 - Additional photographs may be taken of anything unusual (e.g., rare fish, bleached or rare corals), for species identification purposes, unique site features, putative SCTLD, *Diadema antillarum* mortality, and divers working.
5. **Termination of dive due to conditions.** Certain environmental conditions are not safe for operations. When any of the following conditions are met, surveys should be automatically terminated and alternate sites selected.
- Conditions are unsafe,
 - Visibility is less than 5m,
 - Bottom currents are strong enough that the divers cannot safely maintain a stationary position, or
 - Depth of the survey site is greater than 99ft.

Terminate a dive when any of the following conditions are met

- Conditions are unsafe,
- Visibility is low (<5m),
- Currents are strong, or
- Depth >99ft.

**** ALWAYS indicate on boat logs why and when the dive was terminated ****

NCRMP Coral Demographics Survey

Coral Demographics Data Collection

1. **Survey area.** The NCRMP Coral Demographics survey area is 10m long by 1m wide (Figure 4).
 - a. This begins at meter mark 0 and concludes at meter mark 10 on the transect.
 - b. The demographic survey is conducted along the **LEFT** side of the transect. Do not split the survey area ½ on either side of the transect tape.

- c. Complete the entire 10 x 1m Coral Demographics survey belt transect if possible. If the whole belt transect area cannot be completed, finish at a whole meter and note the meters of completion on the datasheet (Figure 5; Appendix III). For a fully completed survey, 10 (m) should be entered.

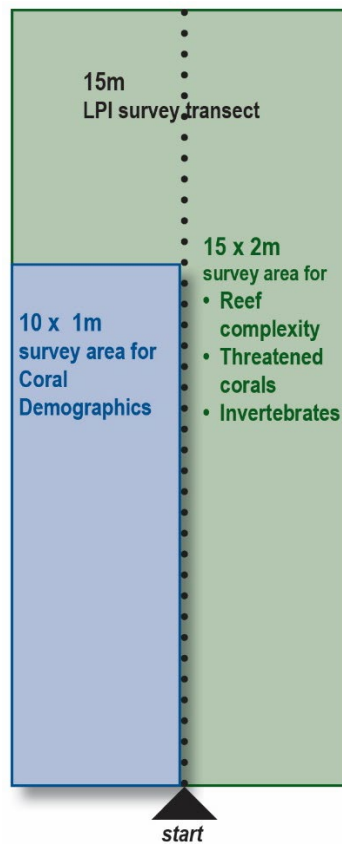


Figure 4. Diagram of NCRMP Coral Demographics survey area, Benthic Community Assessment survey area, and Benthic Community Assessment survey area for reef complexity, Threatened corals, and invertebrates. The size of each respective survey area is represented.

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|--|---------------------|-------------------|---|-------------------|
| Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI | |
| Buddy: _____ | Field ID: _____ | Date: _____ | | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | Meters completed: _____m | |
| Habitat: Contiguous S&G Contiguous Other Isolated Rubble Matrix (Sand) | | | % HB of survey: _____ | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled | | | Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1m <input type="checkbox"/> Unknown <input type="checkbox"/> None | |

Figure 5. The NCRMP Coral Demographics survey area is 10 x 1m. The surveyor completes the datasheet at the end of the dive with the meters completed. If the survey is complete, this should be 10.

Datasheet header information for the site

1. *Datasheet* – 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 important for data management.*

2. *Complete site-level header information* – The following header data entries may be scoped out during the dive and completed after the transect survey is finished and prior to ending the dive.
3. *Observed habitat type* – Post-dive, the diver enters the habitat type(s) observed during the dive. This may be different from the mapped habitat (Figure 5).
 - Circle selection from the habitat categories (circle one on the Fish/Habitat datasheet).
 - Immediately after the dive, the diver should discuss with their buddy and other team members and try to come to a consensus. If consensus is not achieved, divers should note that in the Field/Boat Log.
 - **NOTE:** habitat types are different across regions (Appendix IV).

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|--|--------------|---------------------|-------------------|--|
| (a) | Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI |
| | Buddy: _____ | Field ID: _____ | Date: _____ | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | | |
| Habitat: <u>Bedrock</u> <u>Pavement</u> <u>Aggregate Reef</u> <u>Patch Reef</u> <u>Scat. Coral/Rock in Sand</u> | | | | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | | | | |
| Meters completed: _____m | | | | |
| % HB of survey: _____ | | | | |

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|--|--------------|---------------------|-------------------|--|
| (b) | Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI |
| | Buddy: _____ | Field ID: _____ | Date: _____ | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | | |
| Habitat: <u>High Relief</u> <u>Low Relief</u> | | | | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | | | | |
| Meters completed: _____m | | | | |
| % HB of survey: _____ | | | | |

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|--|--------------|---------------------|-------------------|--|
| (c) | Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI |
| | Buddy: _____ | Field ID: _____ | Date: _____ | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | | |
| Habitat: <u>Contiguous S&G</u> <u>Contiguous Other</u> <u>Isolated</u> <u>Rubble</u> <u>Matrix (Sand)</u> | | | | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | | | | |
| Meters completed: _____m | | | | |
| % HB of survey: _____ | | | | |

Figure 6. Hardbottom categories of observed habitat type (Appendix IV) on the datasheet for Puerto Rico and the U.S. Virgin Islands, (b) Flower Garden Banks, and (c) Florida regions.

4. *Coral Disease with Tissue Loss* – Stony Coral Tissue Loss Disease is prevalent in many locations in Florida and the Caribbean. This header field provides a high-level observation of the site-level presence of recent mortality and associated coral tissue loss related to disease at the site level and is an indicator for SCTLD (Figure 7).

Each diver is to note 1 of the 4 options with an ‘X’ in the appropriate box:

- **None** – no disease with tissue loss is observed at the site.
- **Not Sampled** – diver did not include this measurement.
- **Fast (>1cm)** – tissue loss due to disease is observed on at least 1 coral colony at the site and the maximum width of recent mortality (uncolonized dead skeleton) is >1cm in width/diameter, therefore rate of disease spread is considered fast (acute). This rate can be indicative of Stony Coral Tissue Loss Disease.

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

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|---|---------------------|-------------------|---|-------------------|
| Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI | |
| Buddy: _____ | Field ID: _____ | Date: _____ | | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | Meters completed: _____m | |
| Habitat: Contiguous S&G Contiguous Other Isolated Rubble Matrix (Sand) | | | % HB of survey: _____ | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled | | | Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | |

Figure 7. Coral Disease with Tissue Loss at the site level within the header information on the NCRMP Coral Demographics datasheet.

5. *Diadema antillarum* - Presence noted of any Diseased/Dead *Diadema* observed at the site level (Figure 8). If divers do not look for Diseased/Dead *Diadema*. If no box is checked, then no diseased or dead *Diadema* were observed.

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|---|---------------------|-------------------|---|-------------------|
| Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI | |
| Buddy: _____ | Field ID: _____ | Date: _____ | | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | Meters completed: _____m | |
| Habitat: Contiguous S&G Contiguous Other Isolated Rubble Matrix (Sand) | | | % HB of survey: _____ | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled | | | Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | |

Figure 8. Presence of *Diadema* diseased/dead urchins at the site level within the header information on the NCRMP Coral Demographics datasheet.

6. *Restoration Site* – This notes the presence of coral restoration (i.e., outplanting) evident at the survey site “at site” or within the Coral Demographics 10 x 1m transect survey area “in 10 x 1m” (Figure 9). Restoration or outplanting may be indicated by epoxy or cement at the base of corals along with tagged corals and by the species (e.g., Acroporids). It is possible to check both boxes for the “at site” and “in 10 x 1m” Coral Demographics Survey area.

- If the diver suspects restoration but is unsure, then “Unknown” should be checked. If there is no evidence of restoration at either the site or within the Coral Demographics survey area, the “None” box should be checked.
- The survey site is defined as anywhere in the visible range of the dive site. This is not reconnaissance to seek out coral restoration, but to note presence of these corals observed outside the transect.

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|---|---------------------|-------------------|---|-------------------|
| Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI | |
| Buddy: _____ | Field ID: _____ | Date: _____ | | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | Meters completed: _____m | |
| Habitat: Contiguous S&G Contiguous Other Isolated Rubble Matrix (Sand) | | | % HB of survey: _____ | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled | | | Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | |

Figure 9. Evidence of coral restoration. This can be at the site level and/or within the Coral Demographics survey area. It may also be marked as “Unknown” or “None” within the header information on the NCRMP Coral Demographics datasheet.

7. *Percent cover of hardbottom* – A visual estimate of the percent hardbottom cover within the 10x1m Coral Demographics survey area will be recorded (Figure 10).

| NCRMP Coral Demographics Datasheet | | | | Page ____ of ____ |
|--|---------------------|--|--|-------------------|
| Diver: _____ | Boat/Manager: _____ | Start Time: _____ | Sheet filled by (circle diver): Demo LPI | |
| Buddy: _____ | Field ID: _____ | Date: _____ | | |
| Coral Disease with Tissue Loss: <input type="checkbox"/> None <input type="checkbox"/> Not Sampled <input type="checkbox"/> Fast (>1cm) <input type="checkbox"/> Slow (<1cm) | | | Meters completed: _____m | |
| Habitat: Contiguous S&G Contiguous Other Isolated Rubble Matrix (Sand) | | | % HB of survey: _____ | |
| Diadema <input type="checkbox"/> Diseased/Dead <input type="checkbox"/> Not Sampled | | Coral restoration <input type="checkbox"/> at site <input type="checkbox"/> in 10 x 1 m <input type="checkbox"/> None <input type="checkbox"/> Unknown | | |

Figure 10. Location of the percent hardbottom sections on the Coral Demographic datasheet.

Coral Demographic Survey Methodology

Coral demographics data are summarized in Figure 11. Additional details on survey methodology follow.

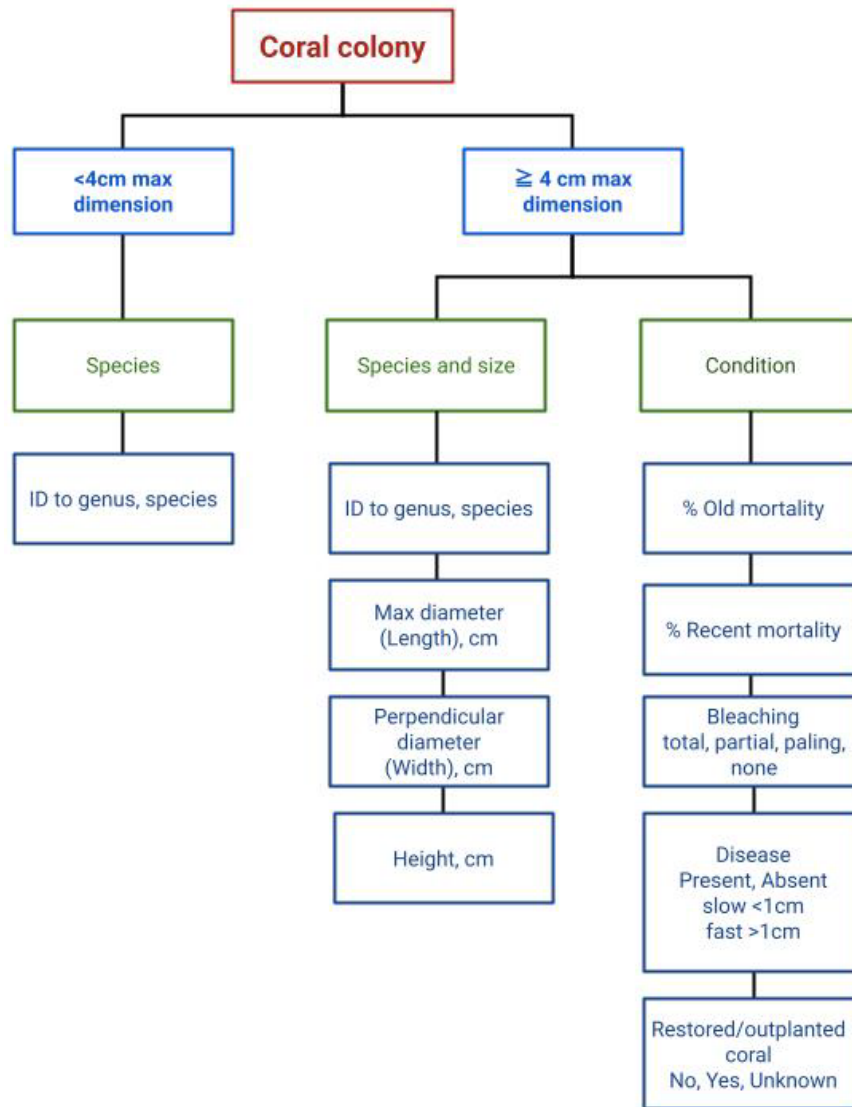


Figure 11. Summary of NCRMP coral demographic sampling.

1. *Species/colony identification* – Each individual scleractinian coral colony with all or any part of the living colony within the transect area will be identified (Figure 12).
 - a. Record each individual on the datasheet (Figure 13).
 - b. Thickets/clumps. If the skeletal unit is connected, identify as one individual. If not, then record them as multiple individuals (Appendix V). Species such as *Acropora cervicornis*, *A. palmata*, *Eusmilia fastigiata*, *Porites porites*, *Madracis* spp., or *Orbicella annularis* may have large colony areas by these criteria.
 - c. All visible corals of any size will be identified to the species level (Figures 15). If species-level identification is not possible, take photos for later analysis.

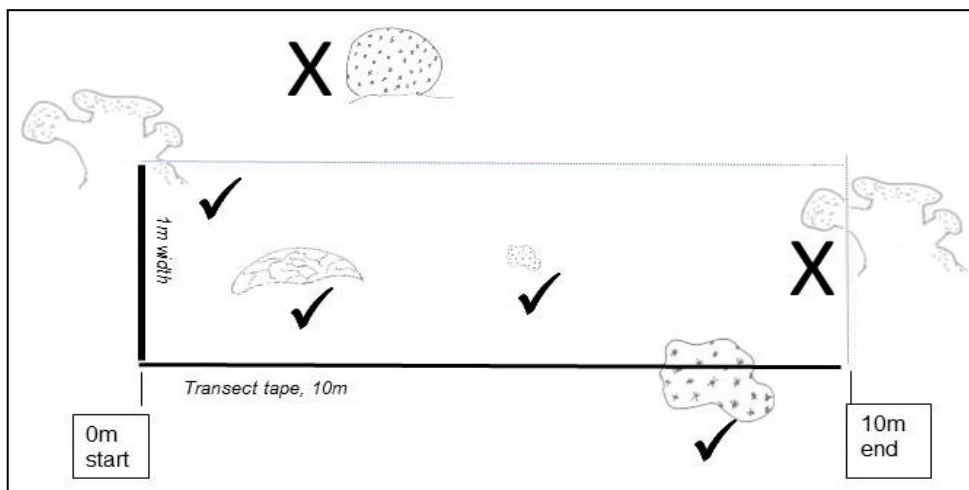


Figure 12. Schematic of example 10 x 1 m transect area. Corals with all or part of colony (excluding branches) within transect area are included (✓). Corals entirely outside of the transect area are not included (X).

| M | Coral ID | Max Diam (cm) | Max Perp Diam (cm) | Height (cm) | Old mort. (%) | Recent mort. (%) | Bleach T, PB P, N ¹ | Dis P, A S, F ² | Rest N Y U | M | Coral ID | Max Diam (cm) | Max Perp Diam (cm) | Height (cm) | Old mort. (%) | Recent mort. (%) | Bleach T, PB P, N ¹ | Dis P, A S, F ² | Rest N Y U |
|---|----------|---------------|--------------------|-------------|---------------|------------------|--------------------------------|----------------------------|------------|---|----------|---------------|--------------------|-------------|---------------|------------------|--------------------------------|----------------------------|------------|
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Figure 13. Datasheet section showing coral identification, dimensions, condition categories.

1. **Corals <4cm.** For a scleractinian colony that is *less than 4 cm maximum dimension (<4cm)* of a species that is not present as a larger, measured colony is encountered in the transect area:
 - a. Identify the coral to the lowest possible taxonomic resolution and record it on the datasheet.
 - b. 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.
 - c. 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.

2. **Corals <4cm.** For a scleractinian colony **with a maximum skeletal dimension ≥ 4 cm** is encountered in the transect area, continue with ALL the following measurements.

- i. *Coral colony size measurements* – Measure entire coral colony (skeleton + live tissue) on a planar dimension (2D) to three (3) exact dimensions (cm). Measurements are 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 5 x 3 x 2cm, respectively. Maximum diameter (length)
Measure the maximum diameter (cm) of identifiable skeletal unit (Figure 14).
 - Measure location where diameter of skeletal unit is widest
 - Measure skeletal unit, not just the live tissue
- ii. *Maximum perpendicular diameter* (width) – Measure the **perpendicular diameter** of the skeletal unit at its greatest width (Figure 14). Maximum diameter length should always be greater than perpendicular diameter width.

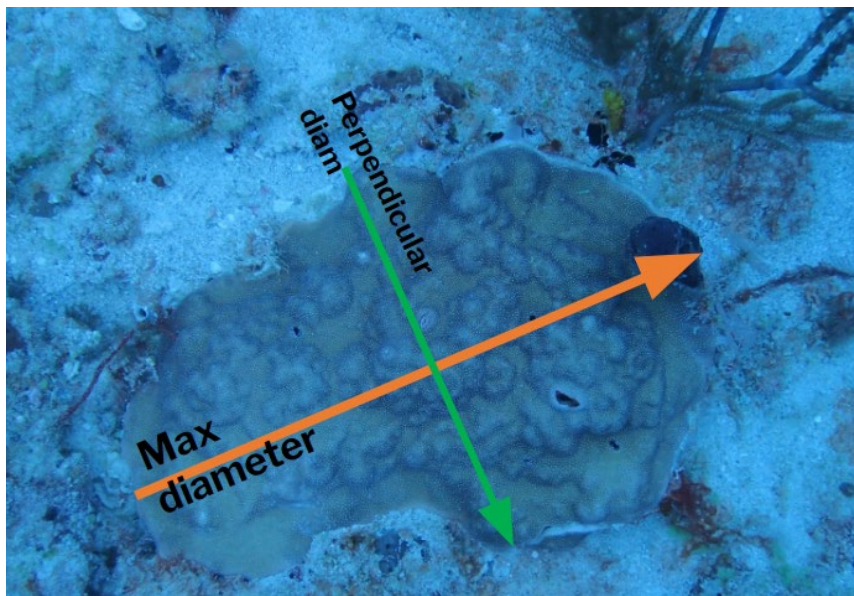


Figure 14. Measurements of maximum diameter length and perpendicular diameter width.

- iii. *Height* – Measure the **height** (cm) of the skeletal unit (Figure 15). Height is measured from the base of the skeletal unit perpendicular to the plane of growth.
 - If colony is growing on a slope, measure perpendicular to the slope
 - Measure linearly (*i.e.*, do not drape tape across the colony)
 - If the colony has an encrusting morphology, the minimum height of the colony should be reported as 1.0 cm.

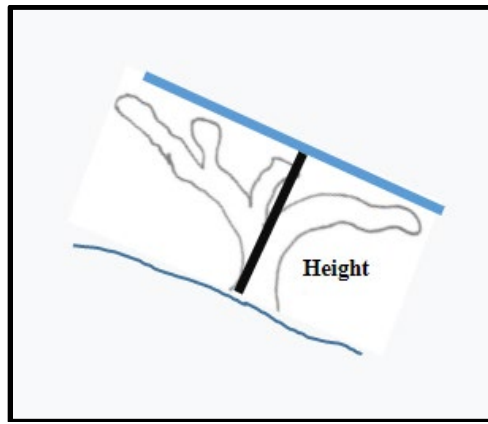


Figure 15. Height (black line) and width (blue line) measurements perpendicular to the plane of growth. Colony is shown on a sloped reef.

- b. *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.**
 - i. 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.
 - ii. Consider how species and morphology influence normal tissue location (e.g., not on columnar colonies such as *Eusmilia fastigiata* and *Orbicella annularis*).
- c. *Mortality* – Estimates of old and recent mortality are collected, if applicable (Figure 16). 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).
 - Recent mortality is defined as the **exposed white bare skeleton of a coral colony** that does not have bleached tissue present and is not colonized by algae or other organisms.

Example: A theoretical colony with an encrusting morphology with dimensions of 10 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].

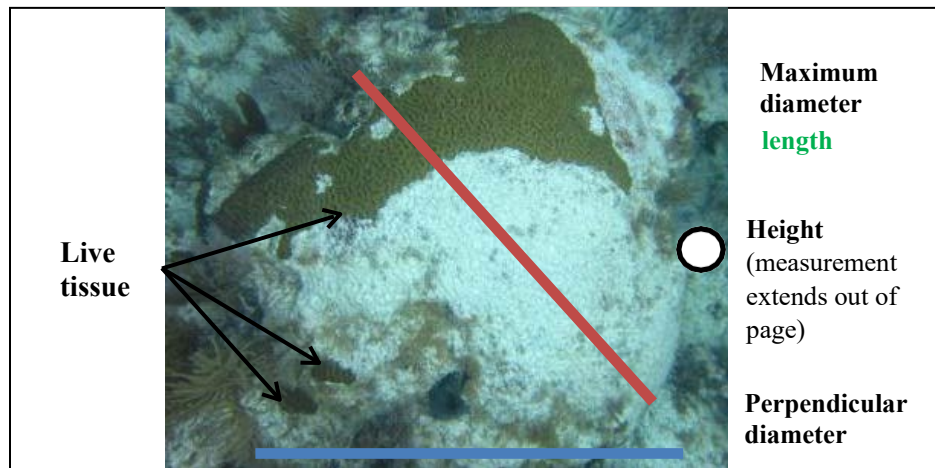


Figure 16. Entire skeletal unit is measured for dimensions: max diameter (blue), perpendicular diameter (red), and height (circle). Estimate % old mortality (approximately 70%).

- d. *Bleaching (T/PB/P/N)* – Note if any coral bleaching is present or absent (Figure 17). Bleached coral is defined as bright white tissue.
- Total bleaching (T): bright-white** bleaching over the entire colony.
NOTE: *Siderastrea siderea* and *S. radians* may appear bright blue rather than white when bleached.
 - Partial bleaching (PB): bright-white** bleaching over a part of the colony
 - Paling (P):** a condition where areas of coral tissue experience a loss of zooxanthellae in response to stress so that the coral colony appears lighter or paler in color.
 - No bleaching (N):** no bleaching present.



Figure 17. 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 (PB)*.

- e. *Coral Disease (P/A/S/F)* – Note if any coral disease is present or absent, or if tissue loss is slow or fast (Figure 18).
- Present (P):** Coral disease is noticeable but unidentifiable, on the colony and it does not exhibit tissue loss (See Figure 11 for examples).
 - Absent (A):** No disease is evident.
 - Slow Tissue Loss (S):** recent mortality tissue loss associated with disease is present, and maximum band/focus of tissue loss < 1 cm in width
 - Fast Tissue loss (F):** recent mortality tissue loss associated with disease is present, and includes maximum band/focus of tissue loss > 1 cm in width.

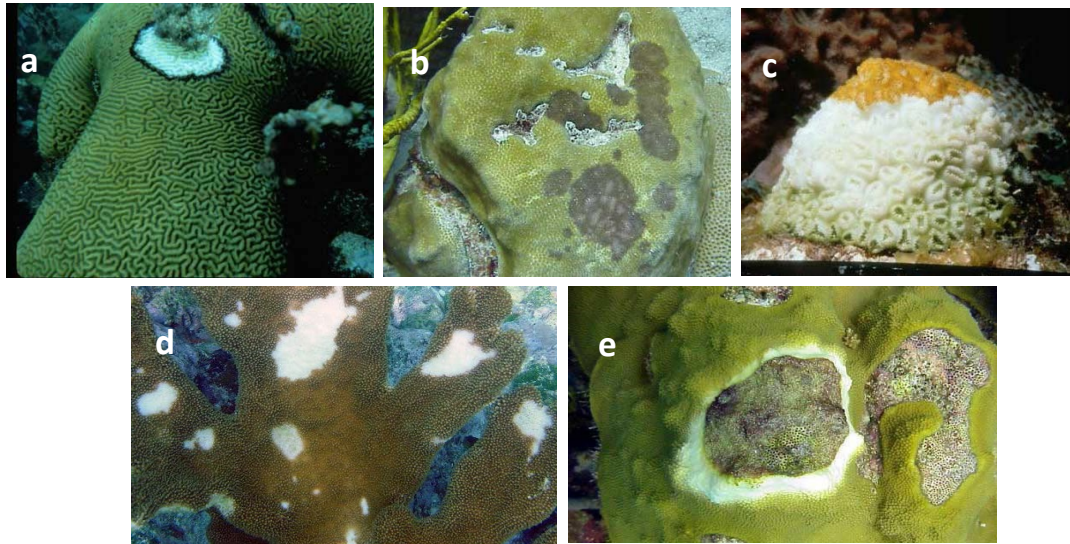


Figure 18. Examples of coral diseases: a) black band, b) dark spots, c) white plague, d) white pox, and e) yellow band.

- f. *Restored coral (N/Y/U)* – Purpose is to note if a coral colony is an outplant (i.e., a restored coral). This could be indicated by a tag, obvious attachment to the substrate (e.g., cable tie, cement base), or other obvious indicator.
- No (N):** The colony is a natural wild colony and shows no indicators of being an outplant.
 - Yes (Y):** The colony shows indicators that it is an outplanted colony.
 - Unknown (U):** The diver thinks that the colony has been restored, but is uncertain because no obvious indicators exist.

Assisted Coral Demographics Surveys

The Coral Demographics surveys typically take longer to complete than Benthic Community Assessment surveys, particularly within dense coral habitats. There are two potential scenarios for collection of Coral Demographics data:

- Coral Demographics data collection is completed solely by the Coral Demographics Diver**
Demographics diver collects all Coral Demographics survey data within the transect area per site (e.g., at sites with relatively low coral density).

2. Benthic Community Assessment Diver assists Coral Demographics Diver

After the Benthic Community Assessment diver completes their data collection, they may coordinate and assist the Coral Demographics diver with completing the Coral Demographics survey.

- a. This survey assistance is only if all of the following conditions are met:
 - i. Dive time is available,
 - ii. The Coral Demographics diver needs assistance (e.g., at high density coral sites),
 - iii. The Benthic Community Assessment Diver has the requisite skills in Caribbean scleractinian coral species identification, and
 - iv. The Benthic Community Assessment Diver has completed the requisite training in NCRMP Coral Demographics protocols.
- b. The Benthic Community Assessment diver will **always** bring a Coral Demographics datasheet, ruler, and a PVC meter stick to facilitate assisting Demographic diver in data collection.
- c. The Benthic Community Assessment diver will do the following:
 - i. Coordinate with the Coral Demographics diver to avoid duplicating counts,
 - ii. Confirm with the Coral Demographics diver that the demographic transect ends at 10m,
 - iii. Start the demographic survey at the tenth meter,
 - iv. Work towards the Coral Demographics diver,
 - v. Meet the Coral Demographics diver at a full meter
- d. The meter range surveyed by each diver will be written on each respective datasheet.
- e. The name of both divers contributing to Coral Demographics surveys will be recorded on ALL datasheets associated with that dive site.

Post-dive: Data

Data sheet review

When divers return to the vessel after the underwater survey, the dive team exchanges datasheets for review by checking for completeness and legibility. A diver should not review his/her own datasheet.

1. *Coral Demographics datasheet* – Review verifies the following:
 - a. Completeness and legibility of all data fields; including identification of second Demographics 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).

-
2. *Benthic Community Assessment datasheet* – Review includes, at a minimum, verifying the following:
- Completeness and legibility of all logistics information.
 - Confirmation of the correct observed habitat type with the dive team and that it is circled.
 - 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.
 - Completeness and legibility of ESA-listed or threatened coral records. NOTE: All boxes are to be filled out. If this component was not conducted, “X” through section is required.
 - Completeness and legibility of all Topographic Complexity records.
 - Stratum slope – Minimum and maximum depth (recorded in ft).
 - Meters complete relief reported (target 15)
 - Surface area topography – 15 absolute measurements (whole cm).

Data Entry

After returning from the field, divers enter data into the NCRMP data entry file.

- The Coral Demographics diver is responsible for all the Coral Demographics survey data entry for the site, even if the Benthic Assessment diver assists in Coral Demographics data collection.
- On each datasheet used for the survey, the Coral Demographics diver will enumerate and record the total number of datasheets for the survey (Appendix III).
- The Benthic Community Assessment diver and the Coral Demographics diver will coordinate on who leads photo uploading, organizing, labeling, and sharing.

NCRMP Benthic Community Assessment Data Accessibility and Use

NCRMP Coral Demographics Data is publicly accessible in multiple locations.

Coral Reef Conservation Program website: <https://www.coris.noaa.gov/monitoring/biological.html>

Benthic (Benthic Community Assessment and Coral Demographic) analyses scripts are open source and available at NCRMP Benthic R package (Groves and Viehman 2019):

https://github.com/shgroves/NCRMP_benthics

NCRMP data should be cited in all publications. In addition, the following acknowledgement should be included: "NOAA's National Coral Reef Monitoring Program (NCRMP) data was funded by NOAA's Coral Reef Conservation Program, project #743."

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CRCP. 2021. National Coral Reef Monitoring Plan. NOAA Coral Conservation Program. Silver Spring, MD. 39 pp. doi: 10.25923/fqkq-w497

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CRCP. 2022b. Reef Visual Census (RVC) Fish Survey Protocols U.S. Atlantic: Florida, Flower Garden Banks, Puerto Rico, and U.S. Virgin Islands–2022. NOAA Coral Reef Conservation Program. 21 pp. doi: 10.25923/1baa-5g44

Acknowledgements

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Appendices

Appendix I. Illustrations of NCRMP survey placement and survey areas

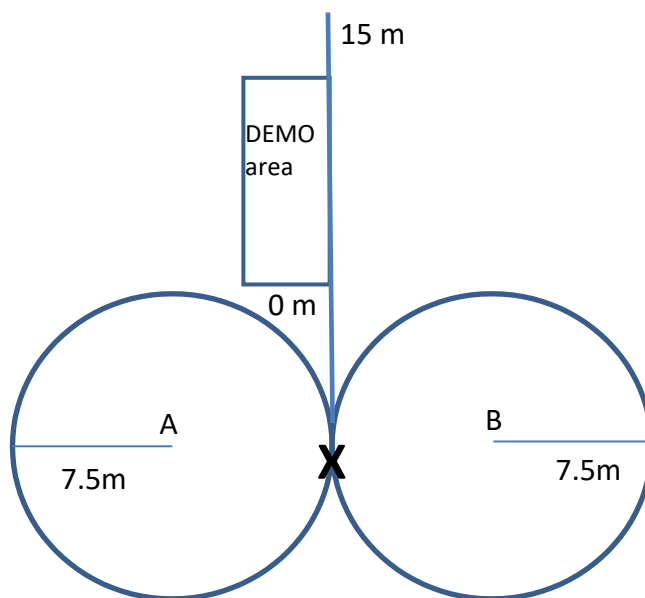


Figure A. Suggested placement of NCRMP Fish and Benthic survey areas if surveys are co-located and hardbottom habitat is continuous. A and B represent two fish divers.

NCRMP

Supervisor's Dive Log

Page _____ of _____

[illegible]

DOD= # dive of day

Example 1: Puerto Rico and U.S. Virgin Islands datasheet

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Example 2: Flower Garden Banks datasheet

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Example 3: Florida datasheet

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Appendix IV. NCRMP habitat type classifications

Puerto Rico and U.S. Virgin Islands¹

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 or uncolonized (often covered by a thin sand veneer with sparse coverage of biota).

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.

Pavement: Flat, low-relief, solid carbonate rock. May be colonized or uncolonized (often covered by a thin sand veneer with sparse coverage of biota).

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).

Flower Garden Banks

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.

Florida Reef Tract²

Contiguous Spur & Groove: A continuing reef structure with well-defined spur (hardbottom) and groove (sand channel) formations. Can be low or high relief spur and groove.

Contiguous Other: Contiguous low relief hardbottom.

Isolated: Larger reef formations that are isolated by sand, seagrass or other habitats; e.g., patch reefs, rocky outcrops, pinnacles.

Rubble: Scattered rocks and small isolated coral heads in sand or seagrass.

¹Adapted from:

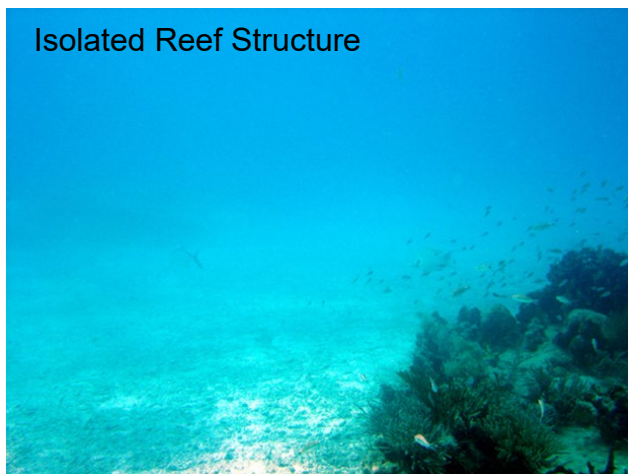
Kendall, M.S., C.R. Kruer, K.R. Buja, J.D. Christensen, M. Finkbeiner, R.A. Warner, and M.E. Monaco. 2001. Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands. NOAA Technical Memorandum NOS NCCOS CCMA 152. Silver Spring, MD. 46 pp.

²Adapted from:

Brandt, M. E., N. Zurcher, A. Acosta, J. S. Ault, J. A. Bohnsack, M. W. Feeley, D. E. Harper, J. H. Hunt, T. Kellison, D. B. McClellan, M. E. Patterson, and S. G. Smith. 2009. A cooperative multi-agency reef fish monitoring protocol for the Florida Keys coral reef ecosystem. Natural Resource Report NPS/SFCN/NRR—2009/150. National Park Service, Fort Collins, Colorado

Appendix IV. NCRMP habitat type classifications

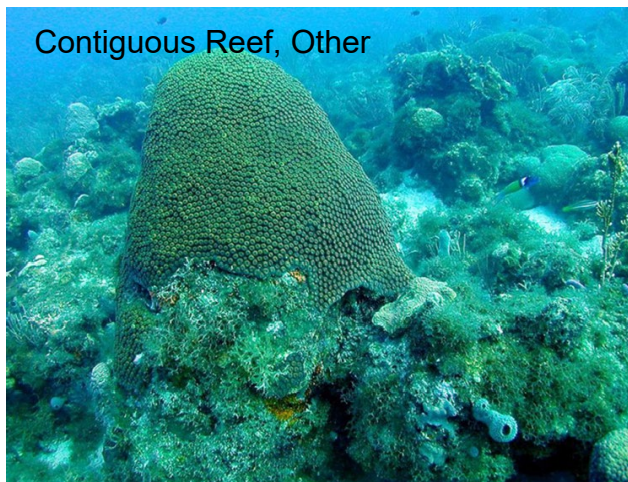
Isolated Reef Structure



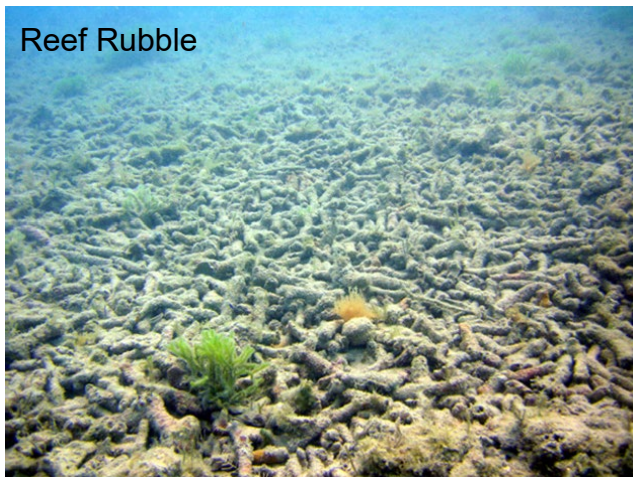
Contiguous Reef, Spur & Groove



Contiguous Reef, Other



Reef Rubble



Appendix V. Field Identification Definitions and Examples

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*

