MarineGEO Coral Reef Habitat Monitoring Protocol

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MarineGEO
THE TENNENBAUM
MARINE OBSERVATORIES NETWORK

Smithsonian Institution

Introduction

In this document, we provide MarineGEO's standard survey design for sampling coral reef habitats, including key measurements of benthic cover, coral demographics, fish communities, and other properties of the ecosystem. Additionally, we provide define best practices for site selection, layout, and workflow. The methods in this protocol were adapted from Reef Life Survey (visual census, benthic photoquadrats), the IUCN Resilience Assessment of Coral Reefs rapid assessment protocol (coral demographics and conditions), and the CRTR Coral Disease Handbook (coral conditions assessment structure).

Additional copies of this document, protocols, field datasheets, and data entry spreadsheets can be found at https://doi.org/10.25573/serc.14714175.

Measured Parameters:
The MarineGEO coral reef modules address the GOOS Essential Ocean Variables of "Hard Coral Cover and Composition" and "Fish Abundance and Distribution" as well as the emerging EOV "Invertebrate Abundance and Distribution." (see supplementary table).

Core Protocols:
Core protocols are required for MarineGEO partners. Recommended activities are strongly encouraged.

Required Protocols:

- Sampling Event & Environmental Monitoring (temperature, salinity, turbidity)
  - https://doi.org/10.25573/serc.14555511
- Visual census (fish and mobile invertebrate abundance, length, composition)
  - https://doi.org/10.25573/serc.14717796
- Photoquadrats (benthic cover)
  - https://doi.org/10.25573/serc.14717823
- Coral demographics (scleractinian community composition, signs of bleaching and disease)
- Predation (bait loss; 'Squidpops')
  - https://doi.org/10.25573/serc.14717802
- Herbivory (bait loss; 'Weedpops' or 'Ulva pops')
  - https://doi.org/10.25573/serc.14717808
- Substrate Rugosity

Requirements

Number of Personnel: 2 people

Estimated Total Time Per Location:

Preparation: 2 people x 1 hour
Field work: 2 people x 3 hours (split into 2 x 90min dives)
Post-processing: 1 person x 2 hours
Data processing: 1 person x 2 hours

Replication: At least six (6) coral reef sites

Materials:

- ☐ Hand-held GPS unit
- ☐ 1 50-m transect tape with 1-m markers
- ☐ 2 cinderblocks, rebar posts, or other semi-permanent transect markers
- ☐ Waterproof camera
- ☐ All materials from Core modules (see individual protocols)

Methods

Fully review this and any additional protocols necessary for the sampling excursion. Address any questions or concerns to marinegeo-protocols@si.edu before beginning this protocol.

Preparation:

1. Download copies of the protocols, field data sheets, and data entry templates for each module.
2. Familiarize yourself with the methods (including data preparation and submission) of each protocol, and consult instructional videos at https://marinegeo.github.io/ (if available).
3. Contact marinegeo-protocols@si.edu to schedule a brief conference to discuss your project and address any questions before proceeding to the next steps.
4. Acquire all the necessary permits required to sample at your sites.
5. Review and follow the safety requirements from your institution. MarineGEO is not responsible for any loss or injury incurred during sampling.

Site Selection:

1. Identify six coral reef sites (locations) to sample. Sites should be:
    a. representative of your region;
    b. large enough to deploy a 50-m transect (<10% over sand);
    c. accessible (we recommend 10m depth or shallower);

2. Contact marinegeo-protocols@si.edu to verify your sites with our team and to receive permanent standard MarineGEO site codes before heading to the field.
3. Record GPS coordinates at each sampling location.
4. Use the MarineGEO Sampling Event & Environmental Monitoring Protocol to record all relevant site information. Take a context photo of your site at a fixed location (as described in metadata protocol) and any other photographic documentation that helps to capture site conditions during your sampling effort.
5. Lay out a 50m transect tape.
6. Try to keep the transect over biotic cover and hardbottom; avoid large areas of soft sediment.
7. Lay the transect out along a depth contour so that the difference between the shallowest and deepest point along the transect tape is no greater than 3m.
8. Avoid the edge of the reef. Whenever possible, lay out the transect with at least 5m of colonized hard bottom on either side of the tape.
9. Mark the position of the transect with durable infrastructure so that it can be relocated in the future: this transect is intended to be permanent (i.e., sampled repeatedly).
    a. We recommend marking the ends of the transects with cinderblocks or rebar.
    b. Hammering cattle tags into the substrate at ~2-3m intervals along the transect will help to lay the tape accurately for repeated surveys. Marking the tags with flagging tape makes them easier to relocate.
10. Follow MarineGEO HOBO logger protocol to deploy temperature loggers to the permanent transect markers.

Fieldwork: Day 1

1. Record metadata and measure environmental conditions according to the MarineGEO Sampling Event & Environmental Monitoring Protocol.
2. Deploy predation assay (n =25 ‘Squidpops’) and herbivory assay (n =25 ‘Weedpops’), with replicates spaced roughly 2m apart. Assays should be not be deployed within the fish visual census area (Figure 1).
3. Locate the fixed start point of the transect. Run the transect tape to the fixed end point (using cattle tags to relocate).
4. Use Coral Demographics protocol to survey the species composition and health of the scleractinian coral community within a 1 m belt along the first 30 m of the transect.
5. Use Coral Reef Photoquadrats protocol to take benthic photos (n = 26) every 2 meters along the entire 50m transect including meter marker 0 and 50.
6. Use Rugosity protocol to measure the distance that 5m of chain extends from meter markers 0, 10, 20, 30, and 40 along the transect.
7. One hour after deployment, score bait loss from the predation and herbivory assays.

Fieldwork: Day 2

1. Return to the site.
2. Score 24-h bait loss from predation assay and herbivory assay. Retrieve stakes and any associated markers.
3. Use visual census protocol to conduct fish and mobile invertebrate surveys.

Sample post-processing:

1. Clarify your fish visual census fieldsheet as soon as possible after conducting the survey. Make sure that all species are identified to the highest possible resolution. You may need to reference your photos to identify uncommon species.
2. Download benthic photoquadrat images and back them up locally before submitting. Following benthic photoquadrat protocol, use CoralNET to score benthic images.

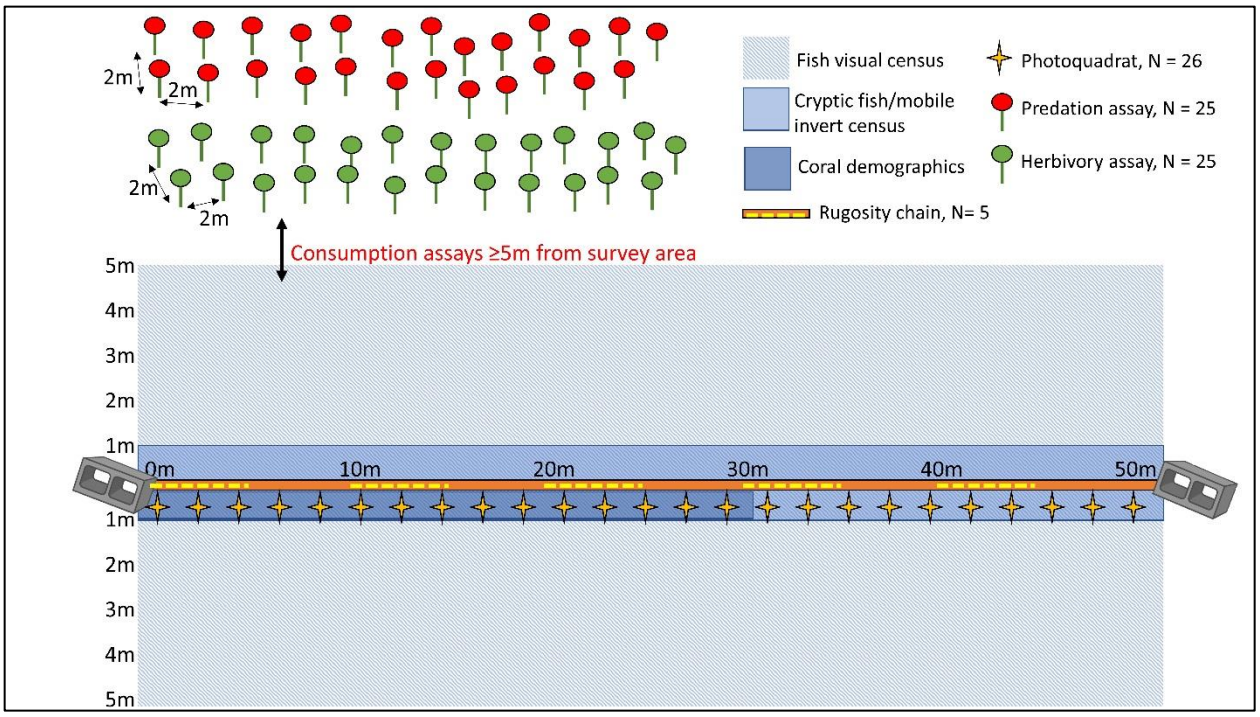

Figure 1: Experimental design for coral reef habitat protocols.

Data Submission

1. Scan the completed field data sheets and save both paper and electronic versions locally. We do not require you to submit the scanned forms.
2. Enter data into the provided data entry template. Each template is an Excel spreadsheet. Please provide as much protocol and sample metadata as possible. Use the “notes” columns to provide additional information or context if a relevant column doesn’t already exist, rather than renaming or creating columns.
3. Use our online submission portal to upload the Excel Spreadsheet: https://marinegeo.github.io/data-submission
4. Contact us if you have any questions: marinegeo-protocols@si.edu

Coral Demographics

Credit: Scott Ling, IMAS University of Tasmania

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Introduction

Coral reefs perform vital ecosystem services. In addition to creating habitat for fishes and invertebrates, reefs provide shoreline protection critical for low-lying coastal communities facing rising sea levels and intense tropical storms. Coral reef ecosystems are impacted by an array of global and local stressors. Rising ocean temperatures lead to coral bleaching events, and the spread of diseases that cause tissue loss have elevated coral mortality rates in many regions.

Monitoring the species composition of coral communities across size classes provides crucial data for understanding the shifts that occur when foundation species decline. Monitoring the health of individuals within the coral community facilitates early recognition of disease outbreak signs. Coupled with biotic and abiotic parameters measured in other MarineGEO protocols, these monitoring efforts will provide valuable insight into the dynamics of shifting coral reef communities and the diseases that afflict them.

This protocol is adapted from the IUCN Resilience Assessment of Coral Reefs Rapid Assessment Protocol and the Smithsonian CCRE Reef Assessment Monitoring Plan, with condition assessment guidelines informed by the CRTR Coral Disease Handbook.

Additional copies of this protocol, field datasheets, data entry templates, instructional videos, literature, and more can be found on the MarineGEO protocol website: https://marinegeo.github.io.

Measured Parameters:

This assay records species composition, density, diversity, and sizes of scleractinian corals in a 30 x 1 m belt transect, measured as:

- Number and identity of all scleractinian corals
- Maximum diameter of all scleractinian corals
- Number of juvenile scleractinian corals (1-4 cm in diameter)

It also records species, sizes, and condition of scleractinian corals with signs of disease in the 30 x 1 belt transect, measured as:

- Number, identity, and maximum diameter of scleractinian corals with signs of disease
- Condition description of scleractinian corals with signs of disease, as represented by a menu of condition codes (see Appendix A)

Requirements

Number of Personnel: 2 people

Estimated Total Time Per Location:
- Preparation: 1 person x 0.5 hours
- Field work: 2 people x 1.5 hours
- Post-processing: none
- Data processing: 1 person x 1 hour

Replication: At least three (6) sites per MarineGEO observatory; 1x30m transect per site

Materials:
- ☐ 1 transect tape (minimum 30m)
- ☐ GPS unit
- ☐ PVC measuring sticks marked with size bins
- ☐ Clipboard
- ☐ Demographics datasheet on waterproof paper
- ☐ Conditions datasheet on waterproof paper
- ☐ Pencil
- ☐ Camera (recommended)

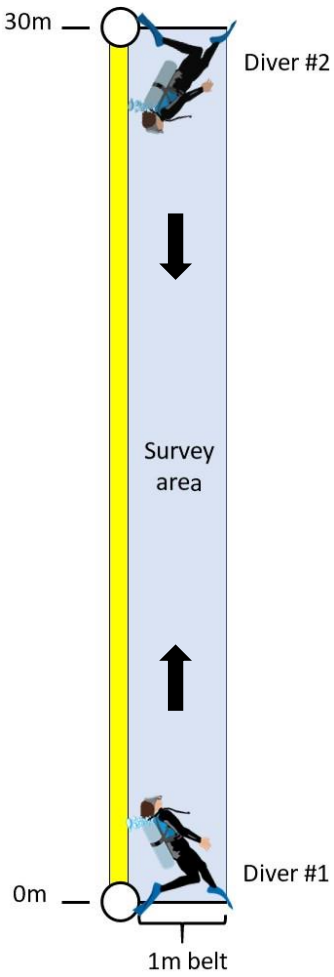
Methods

Fully review this and any additional protocols necessary for the sampling excursion. Address any questions or concerns to marinegeo-protocols@si.edu before beginning this protocol.

Preparation:
1. Print demographics datasheets and conditions datasheets
2. Prepare clipboard with a demographics datasheet on one side and conditions datasheet on the other.
3. Mark a 1m long PVC pipe at the following centimeter marks to denote size classes: **1 ; 4 ; 10 ; 20 ; 40 ; 80**

Fieldwork:

1. Coral demographics and conditions surveys should be conducted along the same permanent coral reef transects used for the Fish Visual Census protocol:
    a. Transects should be placed along a given depth contour with coral reef habitat comprising at least 90% of the underlying substrate. Start points and end points should be permanently marked for relocation.
    b. Record GPS coordinates of transect start and end point in decimal degrees to five decimal places
2. Deploy a transect tape:
    a. Coral demographics and conditions surveys are conducted along the first 30 m of the Fish Visual Census transect.
    b. Coral demographics and conditions surveys are conducted in a 1 m belt on the right hand side of the transect tape (the right side of a diver hovering at 0m and looking towards the 30m end point)
3. Conduct demographics and conditions surveys simultaneously.
    a. Divers should tally all corals within the belt on their demographics datasheet. When they encounter a coral with a condition, they should tally that coral on the demographics datasheet, then conduct the detailed survey on the conditions datasheet.
    b. If two coral divers are available, they may survey a transect together. One begins the survey at the 0m mark and the other begins the survey at the 30m mark. They should meet in the middle and communicate to ensure that corals aren't counted twice or skipped.



4. Demographic Survey:
    a. Count all scleractinian corals with live tissue that falls within the one meter belt to the right of the transect tape. (Use your meter stick to visualize 1m). Include corals with live tissue directly under the tape. Search crevices for cryptic corals, and include any corals found on overhangs that are situated above the belt.
    b. If a coral has live tissue that falls within the belt transect, measure all of that colony's live tissue with your marked PVC measuring stick, even if portions lie outside the transect. Do not include dead skeleton in the measurement. (Measuring only live tissue prevents misrepresenting colonies as large if only a small tissue isolate is remaining.)
    c. Do not include encrusting hydrozoans (ex: Millepora alcicornis) in the survey.
    d. Tally each coral by species under the appropriate size class. Size classes are (in cm): 1-4cm juvenile ; 1-4cm isolate ; 5-10 ; 11-20 ; 21-40 ; 41-80 ; >80 ; 0 (recent total mortality)

e. Identify corals to species if possible. If you are unable to identify a coral species, record the highest taxonomic resolution that you are confident about. Make a record of any unidentifiable corals and take a photograph (preferred) or detailed notes.
f. Measure coral across the longest axis of the live tissue. If an individual has several tissue isolates separated by dead skeleton, estimate the size of the total tissue area if isolates were combined (to prevent overestimating a colony's contribution of live coral tissue).

5. In coral-depauperate locations, partial mortality of large colonies is common. (For example, a 2m coral colony could only have two or three tissue isolates remaining that may be <10cm in diameter each.) When the closest distance between the two tissue isolates that are >4cm in diameter exceeds the maximum diameter of the of the larger isolate, count and measure as separate corals.
    a. Record only corals >1 cm in diameter (corals <1 cm are difficult to consistently find and identify). Distinguish between juveniles that are 1-4 cm and tissue isolates of older colonies that are 1-4 cm. Tissue isolates are remnants of tissue remaining after a colony has undergone partial mortality. While juvenile corals can settle on dead conspecific skeletons, they tend to have raised margins as they are actively growing. By contrast, isolates tend to be flush to the remaining skeleton.

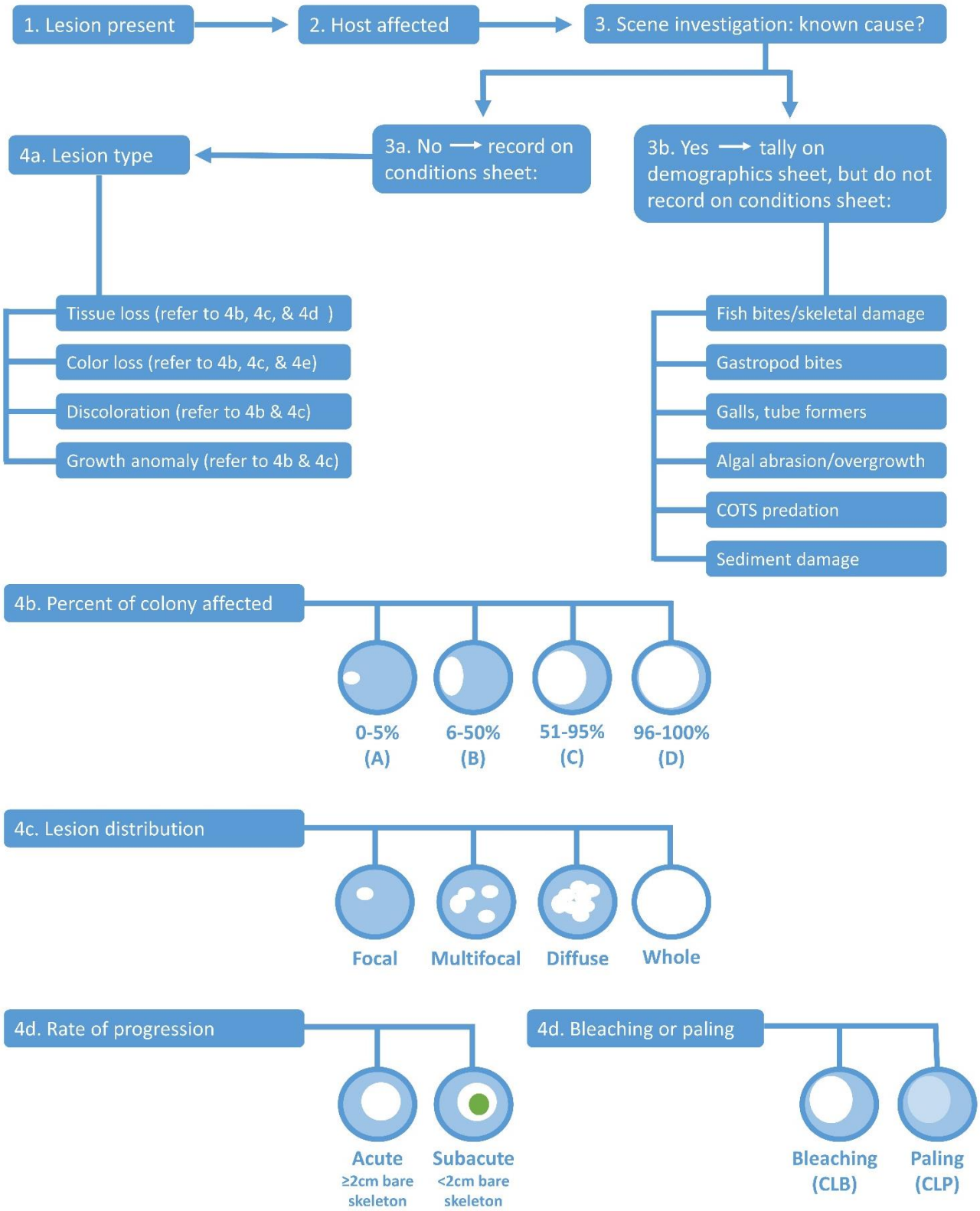
    b. Monospecific, continuous thickets can be measured as one large colony when individuals are difficult to distinguish. (e.g., in the Caribbean, this strategy may be employed with Acropora cervicornis, Porites porites, Madracis mirabilis, etc.)
    c. For surveying walls: hold the meter stick parallel to the substrate (not parallel to the water's surface) to determine which corals fall within the meter belt. This ensures that you count corals no more than one meter deeper than the tape.
    d. If you come across a colony that has no live tissue remaining, but has evidence of recent mortality (white, denuded skeleton not yet fouled by algae), record the coral in size class "0 (recent total mortality)" and complete a conditions survey to describe the size, percent mortality, and tissue loss characteristics of the coral (see below).
    e. Tally corals with ≥3 corallivory scars by coral species

6. Conditions Survey (adapted from Raymundo et al. 2008 and CREMP monitoring handbook):
    a. Does a coral have one of the following conditions?
        - Tissue loss
        - Color loss
        - Discoloration
        - Growth anomaly
    b. If so, perform an assessment:
    c. Check whether there is an obvious “incidental” cause for the condition. Examples of incidental biotic and abiotic interactions that can lead to tissue loss, color loss, etc:
        - Tissue loss or color loss caused by sedimentation (excess sediment present) or corallivory
        - Tissue loss, color loss, or discoloration clearly caused by overgrowth or boring (e.g. Cliona spp. or Millepora spp. visibly overgrowing coral)
        - Discoloration clearly caused by an interaction with Millepora, octocoral, etc.
        - Growth anomalies caused by gall crabs, damselfish predation, or overgrowth
    d. If you are confident that the condition is caused by one of the above examples, tally the coral on your demographics sheet. You do not need to score the coral on your conditions datasheet.
    e. If the tissue loss, color loss, or discoloration does not have an obvious external cause, tally the coral on the demographics datasheet, then record the following on the conditions datasheet:
        - Coral species ID
        - Maximum diameter (cm) across longest axis of the entire colony, including dead skeleton
        - Maximum height (cm) of coral measured perpendicular to substrate
        - Estimated percent mortality, including old mortality unrelated to the observed condition
        - Condition code:
            - TL : tissue loss
            - CLP : color loss – paling
            - CLB : color loss – bleaching
            - D : discoloration
            - GA : growth anomaly
            - A coral can have more than one condition. (Ex: colony has a tissue loss lesion, but remaining live tissue is bleached.) Record all conditions in the same row of your conditions datasheet. Separate conditions using a slash. Be sure to fill out the subsequent relevant columns (e.g. percent affected, distribution) for each condition you listed. Separate with slashes.
        - Estimated percent affected in percentage bins:
            - A: 0-5%
            - B: 6-50%

    - C: 51-95%
    - D: 96-100%
    - [Note: for tissue loss, percent affected refers to recent mortality]
  - Distribution of the condition on the individual: focal “F”, multifocal “MF”, diffuse “D”, or whole colony “W”
  - For tissue loss only, describe as acute “A” (clean skeleton >2cm) or subacute “SA” (clean skeleton <2cm)

f. Where possible, record the name of a suspected disease under “Notes” on your datasheet.
g. Optional: photograph diseased coral and record file number on datasheet under “Notes.”
h. Reminder: corals with conditions should still be counted in the demographic survey. All corals within the transect are tallied in the demographic survey, and a subset will also appear on the conditions datasheet.

Decision Tree for Describing Coral Lesions



Modified from Raymundo et al. 2008; Figure 2.1, page 20.

Data Submission

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3. Use our online submission portal to upload the Excel Spreadsheet: https://marinegeo.github.io/data-submission
4. Contact us if you have any questions: marinegeo-protocols@si.edu

Substrate Rugosity

Credit: https://www.livingoceansfoundation.org/great-barrier-reef-rugosity/

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Introduction

Rugosity is defined as the three-dimensional arrangement of structural features and can be used as a proxy for habitat complexity, which can be directly related to other measured parameters such as percent cover of foundation organisms and the abundance of associated species. Rugosity (**Rq**) is measured by a chain method in which a chain of known length is hung over the substrate in a straight line. A Rugosity index is calculated as **Rq** = 1-**d/l** where **d** = distance covered by chain on substrate and **l** = length of chain fully extended. A value approaching 1 indicates a nearly flat surface and decreases as the substrate becomes more structurally complex.

Measured Parameters

Substrate rugosity, measured as the ratio of fixed distance / length of chain to reach that fixed distance

Requirements

Number of Personnel: 1-2 people

Estimated Total Time Per Location:

Preparation: 1 person x 0.5 hours
Field work: 1 person x 0.25 hours
Post-processing: None
Data processing: 1 person x 0.5 hours

Replication: At least five (5) measurements per site; at least three (3) sites per habitat.

Materials:

- ☐ 1 transect tape (50m)
- ☐ 1-2 negatively buoyant 5m brass chains (link length 1cm)
- ☐ Clipboard with datasheet on waterproof paper
- ☐ Pencil

Methods

Fully review this and any additional protocols necessary for the sampling excursion. Address any questions or concerns to marinegeo-protocols@si.edu before beginning this protocol.

Preparation:

1. Review the protocol designs for selection of permanent sites.

Fieldwork:

1. Lay out 50m transect tape that approximately bisects the sampling location. Where the Visual Census protocol is used, this transect should be the same as the Visual Census transect.
2. Make sure the transect tape is pulled tight and straight (tie to start and end posts or use weights if necessary).
3. Unroll 5m of chain starting at meter 0 of the transect tape, making sure that the chain lies flat on the seafloor and runs directly under the transect tape. The chain should not be draped over soft corals, fleshy macroalgae, or sponges, and should be kept flush to hard substrate as much as possible.
4. Note the meter number on the transect tape for the point at which the chain ends.
5. Repeat steps 1-3, beginning at meter 10 on the transect tape (then meters 20, 30, and 40 for a total of 5 replicates on a 50m transect)
6. Rugosity: **Rq** = 1 – **d** / **l** where **d** = length of measured distance and **l** = total length of chain

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