

South Florida/Caribbean Network

National Park Service
Inventory and Monitoring Division



Standard Operating Procedure CR06

Measuring Rugosity on Coral Reefs—Version 2.1

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Summary

This procedure describes the steps to measure rugosity, the verticality of a reef along a sample transect. A known length of small-link, light-weight chain (e.g., dog chain) is laid along the contours of the reef beneath the defined transect. The ratio obtained between the length of chain divided by the length of transect over the bottom is the rugosity value. For example, if the bottom was perfectly flat, it would take 10 meters (32.8 feet [ft]) of chain to cover 10 meters (32.8 ft) of bottom, 10 meters/10 meters = 1.0. If the bottom has moderate structures, for example, 16.5 meters (54 ft) of chain could cover 10 meters (32.8 ft) of bottom the rugosity value would be 1.65 ($16.5 \div 10 = 1.65$). Rugosity should be measured every five years or after an episode of significant bottom disturbance (e.g., hurricane, ship grounding, or major coral die-off). This SOP is used along with the SOP CR01 *Using Videography to Monitor Coral Reefs—Version 2.1* (SFCN 2025a). A periodic review of this SOP is recommended among staff to ensure consistency.

Divers must get very close to the reef when collecting rugosity data and must exercise caution to not cause damage to the reefs being measured.

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
2007	Jeff Miller	Added rugosity monitoring on most index sites using chain method.	Healthy reefs gradually increase in rugosity. Dead reefs gradually decrease in rugosity. This method is widely used in coral monitoring to document rugosity.	1.00
2015	Jeff Miller	SOP written to meet I & M program, organization and format requirements.	Tied to I & M 2.00 version of protocol.	2.0
2020	Jeff Miller	SOP name changed from 6 to CR06. Added steps for entering data into iPad. Rugosity.	Renamed according to regional guidance. The iPad is used as our primary data entry method. Added duplicate measurements.	2.1

Equipment

- Rugosity reel, containing a multi-meter length of small link “dog” chain
- iPad in iDive with low pressure hose attached
- One clipboard with pencil attached – backup in case iPad fails
- Pre-printed data sheet on waterproof paper (see Figures 1 and 2 in SOP CR02 *Counting long-spined Sea Urchin, Diadema antillarum, on Coral Reefs—Version 2.1* [SFCN 2025b]) – backup in case iPad fails
- Rubber bands (to hold paper to clipboard)
- 1 meter (3.3 ft) length of transect tape

Procedure

1. The rugosity procedure may be accomplished by one or two divers.
2. Lay the first link of chain at the origin of the transect.
3. Proceed directly under the transect tape, unspooling the wrap of chain, and draping it over the contours of the bottom. This method aims to measure the rugosity of the hard structure of the reef, thus it is important to follow only the contour of the lithified components (Figure 1).

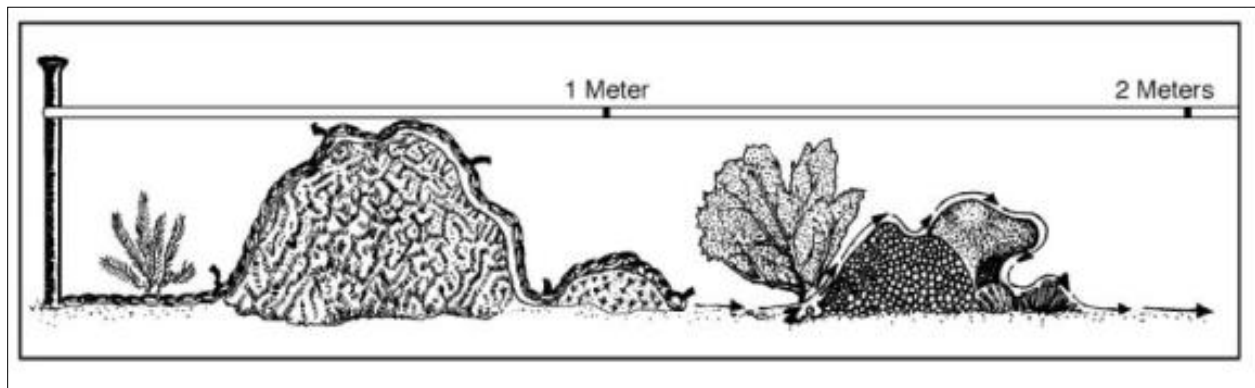


Figure 1. Positioning of the transect chain from the origin of the transect over the contours of the habitat (Figure from Rogers et al. 1994).

4. Often the transect tape will run underneath an overhang or a fire coral. The chain must still be placed over the structure, as it contributes to the relief of the reef.
5. Three errors may often occur when laying down the chain, and should be avoided:
 - a. The chain must not be allowed to “bunch up,” because this would cause an erroneously high reading.

- b. When passing over an object or structure the diver may tend to pull the chain away from the bottom. The chain will then lay at an angle and not match the contour, causing an erroneously low reading.
 - c. When laying down the chain, it is important to keep it as straight as possible with respect to the transect tape and avoid sinuosity that can cause an erroneously high reading.
6. If a gap between structures is too small for the chain to be inserted and removed without causing damage to the substrate, consider the structures as one feature, draping the chain over the small gap. In such cases the adjacent structures do not individually contribute significantly to rugosity, therefore it is most appropriate to measure them as one larger feature.
7. When the entire length of chain has been used, note the location (bottom feature and distance along the chain) at the end of the chain. Carefully reel in or gather up the chain, then begin to drape the chain where the first length of chain ended. It is important to retrieve the chain carefully to avoid causing damage to the reef. The chain often may work itself into crevices and must be removed gently.
8. Record or remember the number of times the length of chain has been deployed. This will be multiplied by the length of the chain and added to the length of chain used to reach the terminus of the transect.
9. When reaching the terminal end of the transect (usually 10 meters [32.8 ft]), stop laying the chain.
10. Measure the length of chain (to the nearest centimeter) that it took to reach the terminal end of the transect.
11. Multiply the length of the chain by the number of times it was deployed. Then add the length of chain it took to reach the terminus. Record that number in the iPad (See SOP CR24 *iPad Preparation, Data Entry, and Download—Version 1.0* [SFCN 2025c]). If the iPad fails, or is not available for data entry, record the total chain length rolled out on the data sheet (see sample data sheet in SOP CR03 *Measuring Coral Disease—Version 2.1* [SFCN 2025d]). Once back at the office, transfer the rugosity data to the iPad following SOP CR24.

Example:

A diver uses a reel with six meters (19.6 ft) of chain. The entire length of chain was deployed twice. The diver needed 3.16 meters (10.36 ft) into the third deployment of the chain to reach the terminus of the transect.

The length of chain it took to cover the bottom is $(2 \times 6 \text{ meters [6.6} \times 20 \text{ ft]}) + 3.16 \text{ meters} = 15.16 \text{ meters (49.7 ft)}$.

On each site a minimum of 10% of transects are selected for a second rugosity measurement. For a 20-transect site, in the first sample year, transects 1 and 2 are surveyed a second time by a second independent observer. In the second year, transects 3 and 4 will be measured twice. In the third year, transects 5 and 6 are measured twice, and so on. Since the method physically touches the surface tissue of living corals, we want to minimize the number of remeasurements and avoid any potential negative impact to the reef. Rugosity measurements can also be derived from photogrammetry images of the transects and this may be the future direction for the program when the network has the capacity to do so.

Literature Cited

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