Detailed Methods for Characterization and Monitoring of Coral Reef Ecosystems and Associated Biological Communities at Flower Garden Banks

There are two complementary components to our field methodology. The first is a 25m long belt transect used to quantify fish species' size and abundance. This component is particularly effective for sampling multiple habitat types such as reefs, where it enables the diver to see what is on the distal side of structures. Fish data collected from this component can then be related back to large-scale habitat information to identify spatial patterns in community structure. The second component involves taking detailed habitat measurements along the belt transect. This component is particularly effective in enabling the diver to see what is on the distal side of structures. Data collected can then be related back to the fish data in order to gain insight into small-scale fish-habitat relationships.

I. Belt Transect Fish Census

Once in the field, the boat captain navigates to previously selected sites using a handheld GPS unit. On-site, divers are deployed and maintain visual contact with each other throughout the entire census. One diver is responsible for collecting data on the fish communities utilizing the belt-transect visual census technique over an area of 100 m^2 (25 m length x 4 m width). The belt-transect diver obtains a random compass heading for the transect prior to entering the water and records the compass bearing (0-360°) on the data sheet. Visibility at each site must be sufficient to allow for identification of fish at a minimum of 2 m away. Once reasonable visibility is ascertained, the diver attaches a tape measure to the substrate and allows it to roll out for 25 m while they are collecting data.

Although the habitat should not be altered in any manner by lifting or moving structure, the observer should record fish seen in holes, under ledges and in the water column. To identify, enumerate or locate new individuals, divers may move off the centerline of the transect as long as they stay within the 4 m transect width and do not look back along area already covered. The diver is allowed to look forward toward the end of the transect for the distance remaining (i.e., if the diver is at meter 15, he can look 10 m distant, but if he is at meter 23, he can only look 2 m ahead).

On-site, no attempt to avoid structural features within a habitat such as a sand patch or an anchor should be made as these features affect fish communities and are "real" features of the habitats. The only instance where the transect should deviate from the designated path is to stay above 33.5 m (110 ft). The transect should take 15 minutes regardless of habitat type or number of animals present. This allows more mobile animals the opportunity to swim through the transect, thus standardizing the samples collected to allow for comparisons.

Data are collected on the following:

1. Identification - as the tape roles out at a relatively constant speed, the diver records all fish species to the lowest taxonomic level possible that come within 2 m of either side of the transect and towards the end of the transect. To decrease the total time spent writing, four letter codes are used that consist of the first two letters of the genus name followed by the first two letters of the species name. In

the rare case that two species have the same four-letter code, letters are added to the species name until a difference occurs. If the fish can only be identified to the family or genus level then this is all that is recorded. If the fish cannot be identified to the family level then no entry is necessary. Individuals too difficult to identify or unique in some manner may be photographed for later clarification.

2. Abundance and size - the number of individuals per species is tallied in 5 cm size class increments up to 35 cm using visual estimation of fork length. If an individual is greater than 35 cm, then an estimate of the actual fork length is recorded.
3. Logistic information - diver name, dive buddy, date, time of survey, site code, transect bearing.

A PDF version of the datasheet used to collect the above fish data is linked on the same project page as this document.

II. Habitat Composition Census

Once in the field, the boat captain navigates to previously selected sites using a handheld GPS unit. On-site, divers are deployed and maintain visual contact with each other throughout the entire census. One diver is responsible for collecting data on benthic composition. This diver follows the belt-transect diver and records data on small-scale benthic habitat composition and structure within a 1 m^2 quadrat divided into 100 (10 x 10 cm squares) at four separate positions along the transect. Each position is randomly chosen before entering the water such that there is one random point within every 6 m interval along the transect. Percent cover is obtained as if looking at the quadrat in a two dimensional plane (i.e., a photograph) versus three dimensions where percent cover could add up to greater than 100%. To estimate percent cover, the diver first positions the quadrat at the chosen meter mark along a randomly chosen side of the transect tape. The remaining quadrats are placed on alternating sides of the transect at the subsequent three locations.

Data are collected on the following:

1. Logistic information - diver name, dive buddy, date, time of survey, site code and meter numbers at which the quadrat is placed.
2. Habitat structure - to characterize the benthic habitats of the dive site, the habitat diver first categorizes the habitat structure of the site (high or low relief). This is done by quantification to the nearest 5% of the dominant coral forms within a 25 m radius of the transect starting point. High relief habitat is characterized by the dominance of coral colonies in the genus *Montastraea* and *Diploria* while the low relief habitat is characterized by the dominance of *Madracis mirabilis*. The habitat category to which a site is assigned should be made independently of the map so that *in situ* data can be used for map validation.

3. Transect depth profile - the depth at each quadrat position. Depth is measured with a digital depth gauge to the nearest 0.3 m (1 ft).
4. Abiotic footprint - defined as the percent cover (to the nearest 1%) of hard bottom, sand, rubble and fine sediments within a 1 m^2 quadrat. Rubble refers to rocks and coral fragments that are moveable; immovable rocks are considered hard bottom. The percent cover given as a part of the abiotic footprint should total 100%. In a hard coral area for example, despite the fact that hard corals may provide 50% cover the underlying substrate is 100% hard substrate so this is what is recorded. The diver then estimates the height (in centimeters) of the hardbottom within each quadrat from the substrate.
5. Biotic footprint - defined as the percent cover (to the nearest 0.1%) of live corals, algae, sponges, gorgonians and other biota (tunicates, anemones, zooanthids and hydroids) within a 1 m^2 quadrat. The remaining cover is recorded as bare substrate to bring the total to 100%. Again, the diver must use a planar view to estimate percent cover of the biota. Species covering less than 0.1% of the area are not recorded. Taxa are identified to the following levels: stony coral to species, algae to morphological group (macro, turf, crustose), and sponge to morphological group (barrel/tube/vase or encrusting). Macroalgae is defined as algae equal to or greater than 1 cm in height whereas turf is identified as a mix of short algae less than 1 cm high. For stony corals, the approximate area covered by living coral tissue is recorded. Coral skeleton (without living tissue) is usually categorized as turf algae or uncolonized substrate. Data on the condition of coral colonies are also recorded. When coral is noticeably bleached, the entire colony is considered affected and is recorded as bleached to the nearest 0.1%. Diseased/dead coral refers to coral skeleton that has recently lost living tissue because of disease or damage, and has not yet been colonized by turf algae.
6. Maximum canopy height - for each soft biota type (e.g., gorgonians, sponges-except encrusting form, algae) the maximum height is recorded to the nearest 1 cm.
7. Abundance and maturity of queen conchs (*Strombus gigas*) - conch encountered within the 25 x 4 m belt transect are enumerated. The maturity of each conch is determined by the presence or absence of a flared lip and labeled mature or immature respectively.

8. Abundance of spiny lobsters (*Panulirus argus*) - a count of the total number of lobsters encountered within the 25 x 4 m belt transect.
9. Abundance of long-spined urchin (*Diadema antillarium*) - a count of the total number of urchins encountered within the 25 x 4 m belt transect.
10. Photos - Two photos are taken in opposite directions at each location to document the surrounding habitat. Additional photos may be taken to document disease, bleaching or other events of note.
11. Marine debris - type of marine debris within the 25 x 4 m belt transect is noted. The size of the marine debris and area of habitat that it is affecting is also recorded along with a note identifying any flora or fauna that has colonized it.

A PDF version of the datasheet used to collect the above habitat data is linked on the same project page as this document.

NOTE: If rugosity, conch, lobster, or urchin data are collected by a fish diver, data must be transferred to the habitat data sheet. The habitat diver is responsible for transferring the data to their data sheet; however, the fish diver should assist the habitat diver with this task by reporting the data once the dive concludes.