# Field Methodology of the P.R. Coral Reef Monitoring Program

The following descriptions of the PRCMP field methodologies are extracted from the most recent PRCRMP reports available at http://drna.pr.gov/programas-y-proyectos/arrecifes-monitoreo/. Additional descriptions of changes in methodologies are provided.

## Site Selection

The PRCRMP follows a depth, distance from shore and geographical (east-west; north-south) sampling design that includes some of the main oceanographic gradients that appear to drive the ecological health and community structure of neritic coral reefs in Puerto Rico. Neritic coral reef systems included in this monitoring program are all shallower than 40m, and thus lie within the Caribbean Surface Mixed Layer water mass with pycnocline at depths that vary seasonally between 45 – 70 m. Due to the permanent stratification forces acting on this water mass, oceanic waters around Puerto Rico remain highly oligotrophic, and the coastal estuarine influence of river discharge, watershed runoff and resuspension/remineralization processes from the insular shelf produce marked inshore-offshore gradients of water turbidity associated with both organic (phytoplankton) and inorganic (sediments) sources. Coral reefs located to the east of the mainland, such as those in the Cordillera de Fajardo (Palomino, Palominito, Diablo), and the islands of Vieques (Canjilones, Boya Esperanza and El Seco) and Culebra (Dakity, Carlos Rosario, Luis Pena) are at the head of the current and receive minor estuarine influence from landmasses. Likewise, reefs located in the oceanic Isla Desecheo are also far from estuarine influences. Shelf-edge reefs associated with the mainland are intermediate across this inshore-offshore gradient and their estuarine influence is geographically variable, being higher in the west and north coasts, and lower in the south coast due to the presence/absence of major rivers.

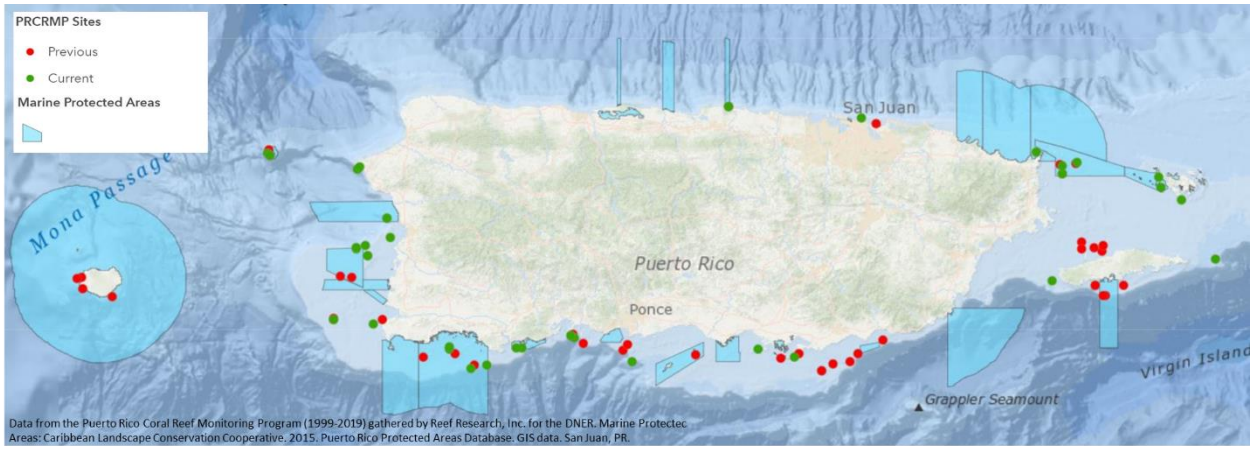


**Figure 1**. Distribution of PRCRMP monitoring stations (sites) around the Puerto Rican archipelago.

The natural exponential decline of light penetration with increasing depth creates another relevant gradient for coral reef ecology that needs to be addressed in the understanding of potential causes of reef degradation and management options. Thus, the coral monitoring program includes reefs located across inshore-offshore gradients, vertically (depth) stratified sampling stations on several Puerto Rico reef sites, and at similar depths on the east, west and south coasts to enable comparative analyses between depths and across natural turbidity gradients associated with riverine influences and island mass effects.

Site characteristics for each monitoring station are provided in the PRCRMP Site Classification Database file, including site coordinates (Figure 1). For more information on the site selection criteria and the number of sites across different spatial scales, see the Analysis of PRCRMP Design and Data section of this report.

## Sessile-benthic Reef Communities

At each reef station, a set of five 10 m long transects is surveyed. Transects are positioned non- randomly (fixed) in areas visually considered to be of optimal coral growth within similar depths (± 3 m) and reef physiographic zones. This allows for better detection of coral cover changes through time. Transect mean depths are determined from the five depth measurements taken at the start rebar marker, but depths vary along transect paths. All transects are permanently marked with steel rebars set on naturally occurring crevices or holes in abiotic sections of the reef substrate at both ends. A tag with the transect number has not been installed in all transects. Plastic zip-ties are attached to the beginning of the transect to identify the transect number and are replaced when lost due to heavy fouling or material oxidation/degradation. Wherever possible, the starting point of the transect was marked with rebar on a reef structure of high topographic relief to facilitate visual recognition during future surveys. Kitchen twine is used as a reference line to delimit the two end-markers to identify the transect paths during reef monitoring activities and then removed upon survey completion (Figure 2).

Determinations of percent substrate cover by sessile-benthic categories at mesophotic depths (≥ 30m) are obtained from Coral Point Count (CPC) analyses of digital photographic images due to the reduced bottom-times associated with SCUBA diving at mesophotic depths (≥ 25 m). A total of 10 non-overlapping photos of the reef substrate are photographed over the permanent transect reference line. A set of 25 random points is overlaid on each photo frame and sessile-benthic categories under each point are classified following the same criteria used with the chain-link method. The total number of points over each substrate category is divided by the total number of points applied to the images analyzed for each transect to obtain the data on percent cover by each substrate category.

Octocorals, except for encrusting forms (e.g. *Erythropodium caribaeorum*, *Briareum asbestinum*) are counted as the number of colonies intercepted per transect, whenever any of their branches crossed the transect reference line. Hard live coral colonies under the transect line are counted and examined visually for the prevalence of apparent infectious diseases. Colonies of

similar coral species growing close together and sharing attachment surfaces are counted as individual colonies if separated by a distance of 15 cm or more. Diseased colonies on each transect are identified and counted. Preliminary field identifications of potential diseases were made whenever possible following the photographic guidelines by Raymundo et al. (2008) Coral Disease Handbook. The percent coral disease prevalence is calculated based on the total number of diseased colonies divided by the total number of colonies intercepted by the five transect array at each reef station.

Sessile-benthic reef communities are characterized by the continuous intercept chain-link method (as modified from Porter, 1972), following the CARICOMP (1994) protocol. This method provides information on the percent linear cover by sessile-benthic biota and other substrate categories along transects. It allows the construction of reef community profiles by assignment of metric units to each substrate transition, which serves as a high precision baseline for monitoring. The chain has links of 1.42 cm long, marked every 10 links for the facilitation of counting underwater. The exact position of the chain was guided by a series of steel nails set into available hard (abiotic) substrates along transects. Individual measurements of substrate categories, as recorded from the number of chain links are sorted, added and divided by the total distance (in chain links) on each transect to calculate the cumulative percent linear cover by each substrate species and category.

**Figure 2**. Sessile-benthic transect layout at Cayo Caribe monitoring site (2016). Both ends of the transect are marked with rebar on a high relief substrate. The transect numerical identity is provided by one zip tie in the start rebar, identifying transect #1 in this case. The kitchen twine delimits the chain path and the length of the transect (10 meters) between the two rebars.

Substrate cover percentage by sessile-benthic categories at El Seco Reef at 30 meters depth in Isla de Vieques was estimated using Coral Point Count (CPC) random point count analyses of digital photographic images due to the reduced bottom-times associated with SCUBA diving at mesophotic depths (>30 m). A total of 10 non-overlapping photos of the reef substrate were photographed over the permanent transect reference line. A set of 25 random points was overlaid on each photo frame and sessile-benthic categories under each point classified following the same criteria used with chain-link method. The total number of points over each substrate category was divided by the total number of points applied to the images analyzed for each transect to obtain the data on percent cover by each substrate category.

During conditions of extreme wave and surge action, such as those occurring during hurricanes and/or exceptionally high North Atlantic swells, rebar transect markers may become detached from the reef structure. In such cases, the protocol is to re-install the marker in the same substrate position that it was before without any alteration of the transect path. In cases where the reef structure supporting the rebar was physically displaced, overturned, or collapsed, then the transect path was identified using the remaining marker and the sequence of existing nails and continued until a 10 m linear path was reached. A new rebar marker was installed at the transect endpoint whenever the original rebar was lost in the sand or could not be found.

## Reef Fishes and Motile Megabenthic Invertebrates

Demersal diurnal non-cryptic reef fish populations and motile megabenthic invertebrates are surveyed by sets of five 10 m long by 3 m wide (30 $m^2$) belt-transects centered along the reference line of transects used for sessile-benthic characterizations at each reef station. Transect width was marked with flagging tape stretched and tied to weights on each side of the transect. Each transect is surveyed for 12 - 15 minutes depending on the complexity of the fish community on each transect. The initial one or two minutes are dedicated to the detection of elusive and/or transitory species that swim away from the "belt-transect" area as soon as they detect a diver (e.g. snappers, jacks, mackerels, groupers, hogfish, large parrotfishes, etc.). During the next three to four minutes, the diver swam over both sides of the transect area counting fishes that form schooling aggregations over the reef (e.g. *Chromis* spp., *Clepticus* spp., etc.) and other transitory species as they enter the survey area, including the wrasses (e.g. *Thalassoma*, *Halichoeres* spp.) which tend to be attracted to divers and thereby, may increase in density during the survey. A second run over both sides of transects was performed during the next four to six minutes in order to count demersal and territorial fishes (e.g. *Stegastes* spp., *Gramma loreto*, squirrelfishes, etc.) that remain within the transect area. The last two or three minutes are dedicated to counting the

small gobies, echinoderms, mollusks, and crustaceans associated with coral heads and crevices on both sides of transects.

Since 2015, upon completion of the 10 meter belt-transect survey the diver swims along the same depth and physiographic reef zone for an extra 10 meters to identify fishes and megabenthic invertebrates of commercial value (snappers, groupers, hogfishes, barracuda, mackerels, sharks, lobsters and queen conch) and/or fish species that are considered important reef herbivores (parrotfishes, doctorfishes). This provides a total of 60 $m^2$ where a visual total length (TL) estimate (in cm) was recorded for each individual. The cephalothorax length (measurement from the tip of the rostrum to end of the thorax), also known as carapace length (CL) in cm was used to report the size of lobsters (*Panulirus* spp., *Scyllarides* spp.) within belt-transects. Queen Conch (*Strombus gigas*) length was reported as the total (diagonal) shell length in cm. The precision of length estimates allowed discrimination between new recruits, small juveniles, juveniles, adult and large adult size classes.

From 2004-2013, the size-frequency observations were surveyed using an Active Search Census (ASEC) technique. This is a non-random, fixed-time method designed to optimize information on the numbers of fish individuals present at each of the main reef habitats, providing simultaneous information on size-frequency distributions. At each reef station, the total number of individuals of each species observed within a fixed time frame of 30 minutes was registered. Individuals were actively searched for in the water column and within crevices, ledges and potentially important hiding places. For each individual sighted, a length estimate was recorded. One ASEC survey was performed at each reef station. The change in methodology from ASEC to 60 $m^2$ band transects in 2015 was done to align the DNER PRCRMP with the NOAA National Coral Reef Monitoring Program (NCRMP) methodology.

## References:


Department of Natural and Environmental Resources (DNER). 2001, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2017, 2018. Puerto Rico Coral Reef Monitoring Program Reports (prepared by Garcia-Sais et al.). San Juan, Puerto Rico. Available at: http://drna.pr.gov/coralpr/

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