Pacific reef fish monitoring surveys: stationary point counts

Abstract

The NOAA Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) and partners implement multi-disciplinary coral reef ecosystem monitoring across the U.S. and U.S.-affiliated territories in the Western and Central Pacific Ocean, spanning wide gradients in both natural drivers and human impact. This includes surveys from islands and atolls in Hawaii (including the main and Northwestern Hawaiian Islands) and affiliated geopolitical regions of American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, and the Pacific Remote Islands Areas. The data provided herein include the Pacific reef fish component of the National Coral Reef Monitoring Program (NCRMP) that has been implemented since 2013, that being the entire period in which the survey design and monitoring methods have followed those specified in the NCRMP. The data collected serve four main purposes: 1) to fulfill NCRMP mandates to assess the status and trends of reef fish assemblages across coral reefs of the U.S.; 2) to provide data in support of coral reef fisheries stocks; 3) to support federal and jurisdictional management by providing a broad spatial context to status and trends apparent from spatially smaller-scale surveys conducted by those agencies; and 4) to generate a consistent and large-scale dataset as a resource for the scientific community. This standardized dataset is a powerful resource that can be used to understand how human, environmental and oceanographic conditions influence coral reef fish community structure and function, providing a basis for research to support effective management outcomes.

Sampling methods

The target sampling domain is hard-bottom habitat in water shallower than 30 m. All islands/atolls within regions are stratified by reef zone (backreef, forereef, lagoon, protected slope) and depth zone: shallow (>0–6 m[1]), mid (>6–18 m), and deep (>18–30 m). Larger islands are further stratified into sectors per island, with sector boundaries designed to reflect broad differences in oceanographic exposure, reef structure, and local human population density. Some of the smaller, more closely spaced islands are always pooled into single reporting and sampling units (i.e., Ni`ihau and Lehua). The density of sites that are sampled per stratum is determined by proportionally allocating effort (e.g., the number of sites to be surveyed) based on a weighting factor calculated from the area per stratum and the variance of the target output metrics (e.g., consumer group biomass and total fish biomass).

The stationary point count (SPC) protocol (Ault et al., 2006) consists of a pair of divers conducting simultaneous counts in adjacent, visually estimated 15-m-diameter cylindrical plots extending from the substrate to the limits of vertical visibility. Each count consists of two components. The first of these is a 5-minute species enumeration period in which the diver

records the taxa of all species observed within their cylinder. At the end of the 5-minute period, divers begin the tallying portion of the count, in which they systematically work through their species list and record the number and estimated size (total length, TL, to the nearest cm) of each individual fish. The tallying portion is conducted as a series of rapid visual sweeps of the plot, with one species-grouping counted per sweep. See Ayotte et al. (2015) for more details.

Calculating response metrics

Using the fish count and size data collected per observer in each replicate survey, the body weight of individual fish is calculated using length-to-weight (LW) conversion parameters, and, where necessary, length-length (LL) parameters (for example, to convert TL to fork length [FL] for species with LW parameters based on FL). LW and LL conversion parameters were taken from FishBase (Froese and Pauly, 2010; Kulbicki et al., 2005). Biomass per fish is calculated using the standard length-weight equation. Herein, the term "biomass" refers to the aggregate body weight of a group of fishes per unit area ($g\ m^{-2}$). Total counts per fish species are used to calculate fish density (count m^{-2}), and further turned into presence-absence per species (1 or 0, respectively) to calculate occurrence per species. Response metrics are calculated for individual species, consumer group, and all fishes combined. Consumer groups consist of primary consumers (herbivores and detritivores), secondary consumers (omnivores and benthic invertivores), planktivores, and piscivores; these classifications are based on diet information taken largely from FishBase (Froese and Pauly, 2010).

Pooling estimates from the stratified survey design

Site is the base sample unit, and the response metric per site (biomass, density, or occurrence) is calculated by taking the mean value from the paired SPC surveys, and in cases where more than one SPC paired survey is conducted, data from matched members of each pair are first averaged before pair-specific results are averaged to create site estimates. Summary statistics (e.g., mean and variance) of each response metric are calculated by averaging values across the sampled sites within each stratum. These values are then pooled to larger reporting scales (sector, subjurisdiction, and jurisdiction) using a weighted average approach via formulas below due to the variance in size among survey strata, whereby

(1) pooled mean biomass (*X*) across S strata: $X = \sum_1^S (X_i * w_i)$ and;

(2) pooled variance of mean biomass (*VAR*) across S strata: $VAR = \sum_1^S (VAR_i * w_i^2)$

where X_i is the estimate of mean biomass within stratum i, VAR_i is the estimated variance of X_i, and w_i is the stratum-weighting factor. Strata weighting factors are based on the size of strata, i.e., if a stratum is 50% of the total habitat area surveyed at an island, its weighting factor will be 0.5, and total of all weighting factors in an island sums to 1 (Smith et al. 2011).

Strata that contain a minimum of two sites surveyed in a given year are included in pooled summaries of response metrics as indicators of the status of fish communities in each individual survey year. For trends in response metrics, only the strata that meet the sampling requirements across all years surveyed are included to maintain consistency through time in the strata being pooled and thus pooled metrics represent the same sampled areas across all years.

Additional methods references

Ayotte, P., K. McCoy, A. Heenan, I. D., Ivor D. Williams, and J. P. Zamzow. 2015. Coral reef ecosystem program standard operating procedures: data collection for rapid ecological assessment fish surveys. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96818-5007. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-15-07, 33 p. doi: https://doi.org/10.7289/v5sn06zt

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