TECHNIQUES AND ASSESSMENTS OF BASELINE CONDITIONS FOR IDENTIFYING CHANGES ASSOCIATED WITH THE MARINE FISHERY RESERVE IN LA PARGUERA, PUERTO RICO

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ABSTRACT

In anticipation of the establishment of the Marine Fishery Reserve at La Parguera on the southwestern coast of Puerto Rico, a two year feasibility study was initiated to allow detection of community level changes in the surrounding reef areas. The project approach was designed to generate support from the local fishing community by highlighting the socio-economic benefits and by allowing local input into the decisions on site selection and enforcement. Assessment methods were required that would develop a database pertinent to local interests. Commercially important fishery species on the three potential reserve sites were targeted for underwater visual census using a time-based 'Active Search Census' (ASEC) method. The ASEC technique shows effectiveness in assessing the structure of a designated community and maximizing available data on key commercial species. To date a total of 57 commercially important species from 22 families have been included in the censuses. Preliminary data show significant differences in the dominant family groups and in the most abundant species between the three reef study sites. Initial analyses also show a relatively high abundance of juvenile snappers, goatfishes, bar jacks, and parrotfishes with a low abundance of adults. This work is coupled with transect surveys intended to assess changes in benthic habitat.

INTRODUCTION

As with many other tropical islands the fishery resources of Puerto Rico currently reflect the stress of overfishing. In 1931, 1403 fishermen using 711 vessels landed 3,080,100 lbs (Jarvis 1932). In 1989, 1822 fishermen (30% increase) with 1107 vessels (56% increase) landed 2,305,004 lbs, 75% of the 1931 catch (Appeldoorn et al. 1992, Matos and Sandovy 1990). Fisheries landings for the island peaked in 1979 at 5.36 million lbs. and declined to a low of 1.67 million lbs. in 1988 (Appeldoorn et al. 1992). Slight increases were seen

from 1989 until the present but they have been minor compared to the earlier peak (Fig. 1).

These declines have been accompanied by shifts in the basic structure of the catch (Fig. 2), particularly within the demersal finfish fishery (Appeldoorn and Meyers 1993). Shifts in composition of the snapper component of the catch from shallow water reef associated species to deep water species illustrate the effects of intense inshore fishing pressure. Shifts to smaller mean sizes for much of the catch [e.g., Haemulon flavolineatum (French grunt), Ocyurus chrysurus (Yellowtail snapper), Mullidae spp. (goatfish), Sparids (porgies), and Balistids (triggerfish)] are indicative of growth overfishing (Appeldoorn et al. 1992). Obviously, management alternatives are needed that can halt or reverse these trends.

Small-scale artisanal fisheries tend to dominate within the tropical Caribbean. By their nature they present a challenge to management organizations in terms of data collection as well as dissemination of information, management of stocks and enforcement of regulations. Marine Fishery Reserves (MFRs) offer a likely alternative to other methods more commonly used in temperate regions (Roberts and Polunin 1991). They are, in theory, simple to develop and enforce; and the effectiveness of management, as evidenced by changes in population or community structures, can be monitored non-destructively using an appropriate permutation of the various visual census methods available.

Visual census techniques as fishery management tools have been in development since Brock (1954) introduced the concept of transect surveys into the world of reef ecology. Since then a variety of methods have been used to analyze the temporal and spatial distributions of various shallow shelf communities. Numerous improvements and adaptations have been proposed urging the use of stationary point census (Bohnsack and Bannerot 1986); random swim time-species analyses, as RVT (Jones and Thompson 1978, Thompson and Schmidt 1977) or VFC (Kimmel 1985); or variations in the transect method itself (Smith 1989). Each of the methods has its advocates and each has certain strengths. In spite of the criticisms of the various methods (Bortone et al. 1986, Brock 1982, Demartini and Roberts 1982, Thresher and Gunn 1986), these visual census techniques, if carefully selected or adapted to particular research, offer the best currently available means to enumerate and analyze the complex structures of coral reef communities.

Our particular research at La Parguera was initiated with a specific set of goals; the grassroots nature of the effort to establish an MFR dictated the priorities of the project (Garcia 1994).

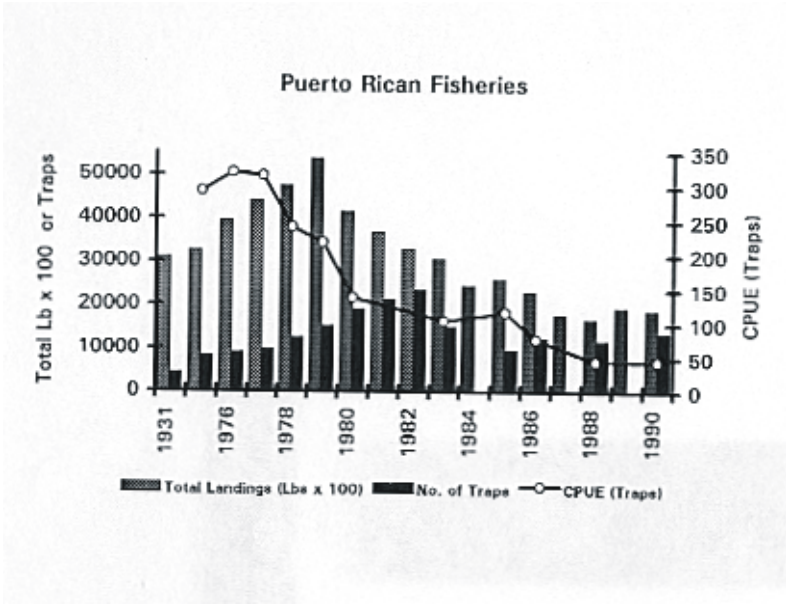

Figure 1. Fisheries landings for Puerto Rico from 1970-1990 for total pounds caught and number of traps used.

OBJECTIVES

The principal objectives of the feasibility study during the first (two) year(s) were the following:

1. Consolidate local fishermen (and local community) support for a Marine Fishery Reserve (MFR) in La Parguera
2. Select a site for the establishment of the MFR in La Parguera
3. Develop a scientific (data) baseline for evaluation of the MFR as a coral reef associated fisheries management option
4. Convey the concept of MFR as a focus of scientific research in Puerto Rico.

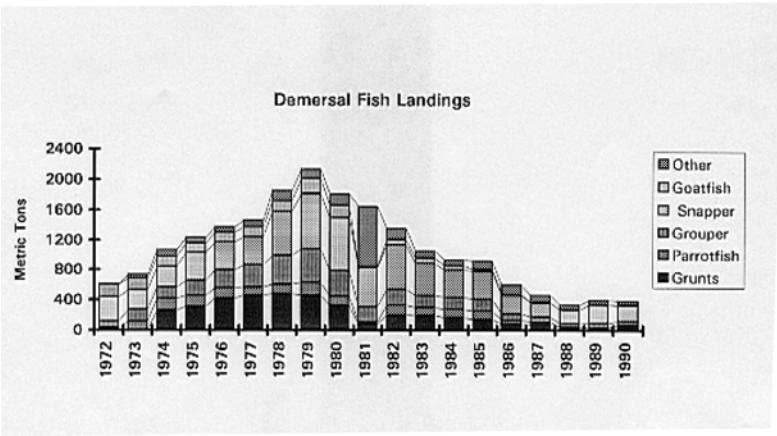

Figure 2. Change in composition of major reef species throughout Puerto Rico. Source Appeldoorn and Meyers 1993.

In order to accomplish these objectives a broad focus is needed. This project not only has a scientific basis, the investigation of the effects of reef closure; it also has a socio-economic component of equal or greater importance. It is necessary to demonstrate to the local fishing community that closure of a valued fishing area is going to be done in a scientific way with their interests in mind. The MFR concept needs to offer future benefits with as little negative impact as possible, in the present. Therefore, a combination of techniques was the logical choice to assess the impact of the establishment of the MFR (Garcia 1994).

For assessing the fish community at a level that would be both useful ecologically and pertinent to the major support group for the reserve, a method was needed that would target the species of commercial interest. Although these species can be detected using any of the established visual census techniques, the numbers of species or individuals from each sample can be, routinely, too small to allow statistical evaluation of variations in specific populations. A new method was therefore developed that would target only those species that are of importance in the local fisheries catch. This method is the Active Search Census (ASEC).

For assessing more general community changes a plot/transect variation was devised to correlate differences in fish populations with substrate variables. The linear transect method quantifies structural relief and rugosity, coverage and composition of sessile and benthic organisms. A sequentially performed transect-based census quantifies the associated ichthyofauna. The combination of these two methods enables us to document baseline conditions to the degree necessary for detecting anticipated changes in community structure after the advent of the Marine Fishery Reserve in La Parguera, Puerto Rico.

METHODS

The study site is on the west end of the south coast of Puerto Rico. La Parguera is protected by a series of three coral reef platforms. Sharing the same middle platform are the three reefs that were considered as candidates for the Marine Fishery Reserve. Turrumote is an emergent reef that runs longitudinally east-west about 3.5 km offshore. It has a total reef surface area of approximately 1.3 km2 although adjoining, submerged reef platforms more than double this potential area. Turrumote is the farthest east, making it the farthest up-current in the prevailing westerly current. Nearest to Turrumote, about 2 km to the west but separated by a deep channel, is another emergent, elongated reef, Media Luna. Media Luna is oriented southeast- northwest with a longitudinal extension of 2.3 km. Total surface area of the reef is about 1.7 km2. San Cristobal reef is the farthest west. It lies only about 1.5 km offshore. Its orientation is east-west with a length of about 0.8 km. Its area is small compared to the other two sites but it offers similar underwater topography.

At each of the reef sites three physiographic zones can be distinguished according to the substrate characteristics and the associated fish communities. These were identified as the fore- reef crest (FRC) at depths of about 0-5.5 m, the fore-reef slope (FRS) from 5.5-13 m and the deep fore-reef (DFR) at the reef base about 20 m deep.

Selection of methods for the assessment of the anticipated Marine Fishery Reserve were based on the criteria of detecting changes in community structure at multiple levels. The support that was garnered through the approach to the local fishing community was based on the expectation that they would be able to see changes in both the age (or size) structure and the abundance of the species of commercial importance in the area. Evaluation led to the development of a list of species considered most desirable by the fishing community. These species were targeted for census with ASEC. The ASEC method was conceived during the initial stages of the assessment process. It requires SCUBA equipment, a waterproof timer (preferably with an alarm) and an underwater

writing slate. To conduct the survey a semi-random spot is chosen to begin the sweep. Because the lengths of fore-reefs at the study sites are greater than can be covered during the course of one survey, the starting points of subsequent dives are changed so that over time the entire length of the reef will have been covered. However, the actual starting point is not marked and each survey is randomly begun.

Upon entering the water the diver swims to the reef base, DFR, and begins timing. He then swims parallel to the reef face generally uni-directionally but with the freedom to search any available crevice, ledge, cave or overhang. These are the havens for many of the target species during the day. When target species are encountered, they are identified to genus and species, counted, and estimated for size. Numbers and sizes are recorded on the slate according to a four letter species code to minimize writing time. Slate edges are marked off in centimeters for visual comparisons. Frequent calibration against background substrates is used as an aid to accurate estimates. Frequent reassessment of mental calibrations increases the accuracy of census data (Rooker and Recksiek 1988). The search census is continued in this manner until the end of the time period (30 minutes). This marks the end of the survey.

For our project, at the end of the first survey, the observer swims immediately up to the intermediate depth, the FRS. The timer is again started and the active search is conducted in the opposite direction maintaining depth between 5.5 - 13 m. At the end of 30 min. the diver swims to the FRC (0 - 5 m) and conducts another search, swimming in the original direction taken during the ASEC of the deep fore-reef. At the conclusion of the dive any questionable identifications are confirmed from notes on key characteristics and results are tallied and archived. Continued use of ASEC during the monitoring of the three sites has built confidence in its ability to maximize enumeration of the targeted populations.

Although this method met the needs for building local support, an alternative method was desired to assess the subtle changes in species that are ecologically important but of little direct interest to the fishermen. A transect/plot method was used to characterize territorial species and the sessile-benthic community. This was a modification of the classic line transect method previously described by Brock (1954) and others. Transect/plots 10 x 3 m were laid out. The purpose in establishing 'plot-like' transects was to allow correlations between fish abundance, taxonomic composition and diversity and substrate variables using the linear (10 m) transect approach (Loya 1976, Porter 1972). Replicated plot transects were established in the three physiographic zones (fore-reef crest, fore-reef slope, and deep fore-reef) at each of the three

reefs studied during the first year. More complete information on the method and results are available in the annual project report (Garcia 1994).

RESULTS

Preliminary results from both techniques were presented in the annual report to the funding agency (Garcia 1994). Here we present the ASEC method and the results derived. The initial results were presented to the fishing community of La Parguera to allow them to make an informed decision regarding their MFR.

Initial Assessments

Turrumote was the site agreed upon by the local fishermen as the preferred site for the MFR. Initial surveys found a mean of 57.8 individuals/transect. The most abundant species, in order, were *Ocyurus chrysurus* (Yellowtail snapper) 19.0%; *Lutjanus apodus* (Schoolmaster snapper) 16.0%; *Haemulon flavolineatum* (French grunt) 12.3%; *Haemulon plumieri* (White grunt) 9.5%; *Caranx ruber* (Bar jack) 4.5%; and *Mulloides martinicus* (Yellow goatfish) 4.0%. Size frequency distributions suggested that adult individuals of many species were still present.

San Cristobal is the farthest to the west and is the smallest of the three sites. It is designated as a control site and will be monitored for natural fluctuations in fish and benthic populations. It had a mean number of 73.4 individuals/transect. The most abundant species found were *O. chrysurus* (Yellowtail snapper) 22.8%; C. ruber (Bar jack) 17.2%; *M. martinicus* (Yellow goatfish) 15.5%; *Scarus viride* (Stoplight parrotfish) 10.4%; *Scarus vetula* (Queen parrotfish) 6.8%; *L. apodus* (Schoolmaster snapper) 6.3%.

Media Luna is nearest to the (expected) reserve site and because of its proximity and similar size, it should serve as a representative control site, reflecting natural temporal variation. In the long term we expect that Media Luna is the most logical location to observe export of biomass from the MFR. In the initial analysis it contained the highest mean number of individuals 91.9 individuals/transect. The most abundant species were *M. martinicus* (Yellow goatfish) 17.8%; *O. chrysurus* (Yellowtail snapper) 14.1%; *L. apodus* (Schoolmaster snapper) 12.1%; *C. ruber* (Bar jack) 11.5%; *Lutjanus synagris* (Lane snapper) 8.2%; *Haemulon plumieri* (White grunt) 7.0%.

Monthly Monitoring Program

Following presentation of the preliminary information a monthly monitoring program was set up to visit each reef site on a regular basis and build

the database of baseline conditions. The most recent results show a slightly different pattern than that originally seen.

Turrumote has shown a mean number of 101 individuals per transect: 43 species in 17 families. The dominant families are Scaridae (31.5%), Haemulidae (22.2%), Lutjanidae (17.4%), Carangidae (11.5%), and Mullidae (7.4%). The most abundance species are *S. viride* (16.7%), C. ruber (11.5%), Scarid species (unidentified) (10.9%), and *O. chrysurus*, (9.3%).

San Cristobal was represented by 107 individuals per transect; 34 species and 17 families. The most abundant families were Scaridae (41.6%), Lutjanidae (18.6%), Mullidae (13.3%), Carangidae (8.4%) and Haemulidae (7.4%). The most abundant species were S. viride (27.6%), O. chrysurus (13.3%), M. martinicus (13.3%) and unidentified Scarid species (10.1%).

Media Luna had a mean of 96 individuals per transect; 45 species and 17 families. The dominant families ranked by abundance were Carangidae (21.8%), Lutjanidae (20.8%), Scaridae (18.6%), Mullidae (14.5%), and Haemulidae (11.7%). The most abundant species were *C. ruber* (21.5%), *M. martinicus* (14.4%), Scarid species (10.5%), *O. chrysurus* (8.8%), and *L. apodus* (7.3%).

An index for Percent Similarity was calculated (Sale and Douglas 1981) to look at the degree of similarity between the sites. A maximum score of 1.0 would indicate complete overlap of species and identical abundances. The minimum score of 0.0 means there is complete difference in the abundances.

Based on the taxonomic level of family the scores are fairly similar indicating 70-80% overlap based on numerical abundances:

Turrumote to Media Luna..... 0.737
Turrumote to San Cristobal..... 0.806
Media Luna to San Cristobal 0.743

More differences are evident when the proportion of species present are compared between any two sites; the similarity indices show more dissimilarity:

Turrumote to Media Luna..... 0.656
Turrumote to San Cristobal..... 0.728
Media Luna to San Cristobal 0.649

Additional data were examined on the size-frequency distributions of four of the most commercially desirable species. Yellowtail snapper (*O. chrysurus*) is ranked as a 'first class' fish in the fisheries of Puerto Rico. Individuals from most size classes of its reported range were represented at Turrumote and Media Luna, but large adults were rare. A very large proportion

of the individuals were recently settled juveniles less than 10 cm. Similar trends were evidenced by the size-frequency distributions of the Bar jack (*C. ruber*), Schoolmaster snapper (*L. apodus*) and the Spanish grunt (*Haemulon macrostomum*).

DISCUSSION

ASEC is a time-based method for judging the relative abundance of selected target species that have common characteristics in their diurnal behavior patterns while on the reef. Almost all of these species are secretive and elusive, preferring to hide within the crevices of the reef. Although this presents a problem for the investigator trying to determine their abundance in an area, they still form the basis of the multi-species commercial fishery on the south coast of Puerto Rico. ASEC allows the diver to behave almost as a spear- fisherman, seeking prey in the most likely places. ASEC is a simple method requiring only SCUBA gear and underwater writing capabilities (plasticized paper or slate). The method provides a means to compare the species on each reef and at each physiographic zone along the fore-reef. It allows collection of data on the size and numbers of individuals, length frequencies of key species (Bell et al. 1985), and seasonal variations due to migrations or recruitment.

Future research will include strengthening the calibration between researchers, and comparisons with some other established visual census techniques by way of validation. Time-species comparisons are now underway to examine the possibility of shortening the time duration in order to cut down the fatigue factor that can reduce the effectiveness of the observer in the latter time periods of a transect.

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