Using Details of Coral-reef Fishers' Harvest, Including Taxonomic and Size-structure, to Support Ecosystem-based Fisheries Management in Montecristi National Park, Dominican Republic

El Uso de Detalles Actuales de la Cosecha de Pescadores de Arrecifes Coralinos, Incluso Detalles Taxonómicas y de los Tamaños, para Informar el Manejo de Pescarías con Enfoque al Ecosistema en el Parque Nacional de Montecristi

En Utilisant les Coordonnées Actuelles de la Récolte de la Pêche Des Récifs Coralliens, y Compris des Détails Taxonomiques et Tailles, pour Informer la Manipulation des Pescarías avec L'approche par Écosystème dans le Parc National Montecristi

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ABSTRACT

In the absence of extensive historical fisheries data and information on ecological condition, present-day "snapshots" of these factors can be compared to generalizations from similar fisheries to provide initial management guidance. Here, we present a study that examines artisanal fishers' catch, and uses details of species composition and size structure to inform ecosystem-based management. This study was conducted in the community of Buen Hombre, located within Montecristi National Park, Dominican Republic. The artisanal coral-reef fishery is accessed by approximately 30 fishermen each day. Principal fishing methods are spearfishing while either freediving or compressor diving, in addition to some fish traps and hand lines. Between June and August of 2013, we collected 60 videos of daily harvests. Videos were used to identify fish to family level and count the number of individuals harvested. Using batch weights and videos, we are able to determine or estimate the following characteristics of the catch: total biomass, total number of fish, biomass by family, number of fish per family, and the average size per individual fish. The size of harvested fish can be compared to known relationships between size ecological function, specifically grazing in herbivorous fish. In the context of EBM, these comparisons can be used to weigh the impacts of various fishing practices and fishing effort on functional overfishing – i.e. altering fish populations to where they cannot adequately perform their ecological function.

KEY WORDS: Data limited, coral-reef fisheries, artisanal fisheries, EBM, size structure, overfishing

INTRODUCTION

Fishing does not wait for scientists to have enough data to formulate a perfect management plan before proceeding to impact marine ecosystems. Here, I provide an example of how we can leverage our understanding of marine ecosystems, combined with strategic case-specific data, to make defensible management recommendations in data-limited contexts.

Montecristi National Park, located in the northwest corner of the Dominican Republic, includes marine and coastal areas. The seascape is characterized by fringing mangrove forests, extensive seagrass beds, a barrier coral reef system approximately 1.5 km from shore, and two successively deeper reef systems approximately 4 and 10 km from shore. Buen Hombre is a town within the park, and is home to approximately 600 residents. Fishing is the most important livelihood activity, and the fishery in is artisanal; fish are caught via spearfishing, gill nets, traps, and handlines. Spearfishing while freediving or compressor diving are the dominant methods.

Researchers have intermittently studied the ecological and social aspects of fisheries in Montecristi and Buen Hombre since the mid 1980s. Stoffle and colleagues (Stoffle et al. 1993, Stoffle 2001, Geraldes 1998, Garza-Perez and Ginsburg 2007) have all contributed to documenting status of the fishery and proposing recommendations for its management. Despite the efforts of national and international researchers and organizations, fisheries governance has not been effective at creating a sustainable fishing system. The most recent attempt to do so is a Caribbean Large Marine Ecosystem pilot project under the auspices of the multiple United Nations programs, branches of the Dominican government, and local and international conservation organizations (www.ambiente.gob.do). This project, completed in 2012, extensively studied the state and governance of marine resources in Montecristi National Park. This project has generated a framework from which ecosystem-based management (EBM) can proceed. The goal of our research is to support EBM of the fishery resources in this area and capitalize on the momentum generated by recent efforts.

METHODS

From June to August, 2013, we collected data on fishing fleet activity, fishermen's daily catch, and the fish community in various habitat types. Fish community surveys were concentrated near Buen Hombre with some, but less, sampling conducted at the eastern and western ends of the park.

We determined fleet effort on 12 days by observing the number of people and their fishing method while returning to the principal landing site in Buen Hombre. Boats visiting the secondary landing site were recorded, but information on their catch was not attained. With the permission of fish buyers and fishermen, 49 videos of fishermen's catch were recorded as fish buyers sorted the catch by market class. Market classes determine the price at which fish are bought and sold, and are a function of species and size. First class fish are the most desirable, and include large snapper (Lutjanidae), grouper (Serranidae), and hogfish (Labridae). Parrotfish (Scaridae), grunts (Haemulidae), and other families are judged as second or third class, with larger individuals being second class and smaller individuals third class. Videos of the sorting process were later examined to identify each fish to family level and count the number per class in each fisherman's catch. Once sorted, fish (cleaned, head-on) were batch weighed recorded. These data were used to determine the number of fish caught, the proportion of each taxon in the catch, and the mean size per individual within each class. Exact details of four fishermen's catches were attained by identifying each fish to species and measuring fork length to the nearest centimeter.

We performed 103 underwater visual censuses throughout Montecristi National Park using modified underwater visual census protocols. We attempted to representatively sample all habitat types over the entire area in order to make inferences about the fishery as a whole. We normally accompanied fishermen to their regular fishing areas, then chose specific sites to sample by swimming in the direction of the coast, within a habitat type, for an undetermined length of time, then beginning a transect. Additionally, some sampling areas were chosen specifically due to their known importance to fishing, their distance from the landing site, or their protected status (in the case of one site). We identified and estimated the length to the nearest centimeter of every fish within a 4x30 meter transect. We roughly estimated that 50% of coral reef habitats are less than 3 meters deep, and 50% greater than or equal to 3 m. Our surveys contained 30 sites in water over 3 meters, so we rarified the dataset by randomly choosing 31 shallow-water sites, and performing the analysis with these 60 sites.

We used data from the fish surveys to describe the species composition and size structure of the parrotfish (family Scaridae) community, not including bucktooth parrotfish (*Sparisoma radians*) or greenblotch parrotfish (*Sp. atomarium*), as this is the focal taxon of our analysis. The species and length of each fish observed was transformed into a grazing rate (cm^2/hour) according to the relationships described by Bruggeman et al. (1994a, 1994b, 1994c) and extended by Mumby et al. (2006). The base

$$Sparisoma\ grazing = (1088 - 17.12 * FL - Species\ offset) * (5.839 * 10^{-4} * FL^2$$

$$Scarus\ grazing = (3329 - 33.00 * FL - Species\ offset) * (4.013 * 10^{-4} * FL^2)$$

equations used to determine grazing by genera multiple bite rate by bite area, and were as follows:

FL is fork length, and the species offsets are as follows:

Sp. Viride = 56, *Sp. Chrysopterum* = 264

Sp. Rubripinnex = 86 *Sp. aurofrenatum*=260

Sc. vetula=0 *Sc. iserti*=1714, and

Sc. Taeniopterous = 1196.

No corrections were used for life phase, so our estimates will tend to overestimate grazing in the juvenile and terminal phases (i.e. for the smallest and largest individuals).

RESULTS

During summer months, there were 28 fishermen on average fishing from the beach in Buen Hombre each day (range = 20 - 40, standard deviation = 5.98). The taxonomic and size composition of fishermen's catch is presented in Figure 1. Catch composition is diverse and variable, but parrotfish are the most harvested taxon, accounting for 48% of the catch by numbers on average (sd = 26%). The

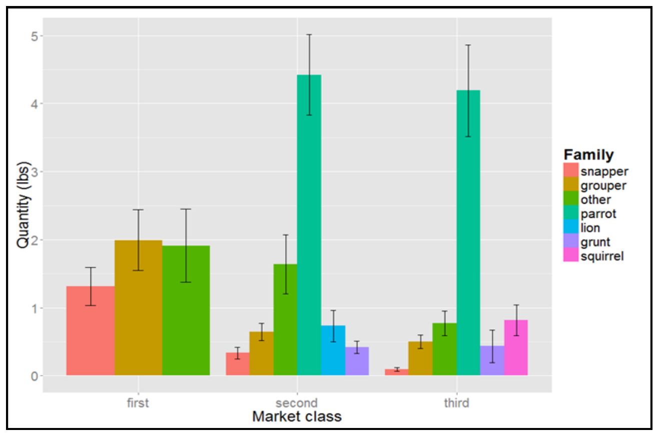

Figure 1. Average daily catch of fishermen in Buen Hombre. Weights are in pounds of cleaned, whole fish; error bars are standard error.

The parrotfish community, shown in Figure 2a, is comprised of many small individuals between 3 and 13 cm FL, with abundances tapering to around 20 cm, then remaining low above 20 cm. Striped parrotfish, *Sc. iserti*, are numerically most abundant, although redband (*Sp. aurofrenatum*) and stoplight (*Sp. viride*) parrotfish make up a large percentage of individuals in the middle size range. None of the largest scarids—blue (*Sc. coeruleus*), midnight (*Sc. coelestinus*), or rainbow (*Sc. guacamaia*)—were observed.

Larger individuals contribute proportionally more to total grazing than numerically dominant smaller individuals. Figure 2b shows how most grazing is apportioned between 8 and 20 cm, but fish above larger than 20 cm also provide disproportionately more grazing than their abundance.

Finally, the size structure of the parrotfish in four fishermen's catches is shown in figure 2c. There is a sharp lower size limit at 18 cm, below which no fish are caught. Selection for fish above this threshold is not mandated, but appears to be due to the perceptions of individual fishermen of what is acceptable for them. The bulk of harvested parrotfish fall between 19 and 24 cm.

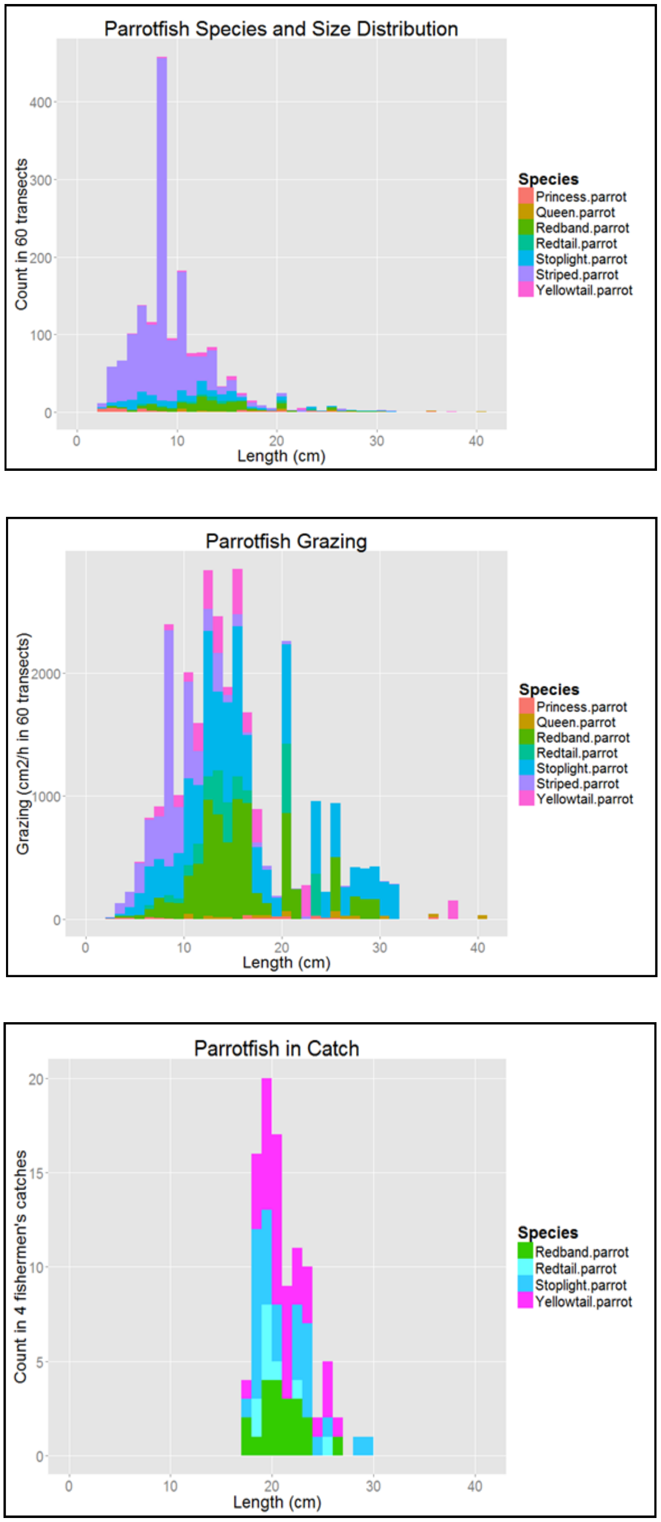

Figure 2. a) Species composition and size distribution of parrotfish in a representative sample of the Buen Hombre fishery; b) parrotfish abundance at size data used to estimate the amount of grazing performed by each species and size class; c) species and size distribution of fishermen's catch.

DISCUSSION

Maintenance and/or restoration of key ecological processes should be the top management priority in fishery ecosystems. Mean total fish biomass in our sampling was merely 21.33 g/m^2 (n = 60, sd = 19.65), compared to the Caribbean average of 65.34 g/m^2 from the years 1994 - 2007 (Marks and Lang 2007). Qualitative observations of high percent cover of macroalgae and coral mortality due to disease and competitive boring sponges further indicate poor ecological condition. The first step in assessing the possible role of fishing in degrading ecosystem health is to characterize fishing, focusing first on aspects of known importance to healthy reef functioning, together with the aspects of greatest economic importance.

We used simple technology, video recordings, and good relationships, to easily obtain a lot of information about fishers catch. We were able to determine the quantity of the catch by numbers and weight, the average size of individual fish, and taxonomic composition. These data are complemented by more detailed records of exact species and sizes of the catch. All of this data collection was possible with, and perhaps because of, virtually no disruption of fishers' and fish buyers' normal activities. Conducting research in this manner is time intensive and relies on good relationships between researchers and fishermen, but spending time together and cultivating relationships can only enhance the effectiveness of management for both parties.

In the case of the coral-reef fishery of Buen Hombre, parrotfish play a critical role in ecosystem functioning and they comprise half of the fishermen's catch. This presents a dilemma in that reducing fishing impacts would require a severe reduction in yield as it is currently harvested. However, this also presents an opportunity for fishery management to have an important impact on ecosystem condition. This stands in contrast to ecosystem impacts like climate change and water pollution that is beyond the reach of resource users' and managers' influence.

We can use information on the fish community, fishermen's catch, and generalized knowledge of coral reef to recommend that fishery interventions make restoration of grazing fish abundances and upper size structure a top priority. Low parrotfish biomass density and right-skewed size distribution, coupled with previously established relationships between size and grazing (Lokrantz et al. 2008), show that an increase in grazing could potentially be achieved by increasing the minimum size of harvested parrotfish. This should lead to an increase in the abundances of larger fish that are important contributors to grazing. One practical way to do so could be to only harvest terminal phase parrotfish. Terminal phase coloration would be a simple means of judging fish that have already experienced the majority of their growth and reproductive value. The tradeoff is that the largest fish also provide the most grazing per individual, and potentially unique forms of grazing. Still, because most species are protogynous and become males after passing through the reproductive initial phase, perhaps little reproductive output would be lost.

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