Comparing Management Actions and Assessing Trends in Populations of Reef Fish that Form Spawning Aggregations in the Caribbean

Comparación de las Acciones de Manejo y Evaluación de Tendencias en Poblaciones de Peces de Arrecife que Forman Agregados de Desove en el Caribe

Comparer les Actions de Gestion et Évaluer les Tendances dans les Populations de Poissons de Récif qui Forment des Agrégations de Frai dans les Caraïbes

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EXTENDED ABSTRACT

Introduction

Species that form fish spawning aggregations to reproduce often do so at predictable locations and times, making these species easy targets for exploitation. Caribbean species from the genera *Mycteroperca* and *Epinephelus* are often targeted during their spawning seasons, with multiple members of these genera listed as Near-Threatened, Threatened, or Endangered under the International Union of the Conservation of Nature Red List (Cornish and Eklund 2003). Nassau grouper, along with many other grouper species, form large reproductive aggregations at highly predictable times and locations throughout their range (Colin 1992). Once aggregations of the species are discovered, they are typically fished intensively each winter; many such aggregations have ultimately been fished to the point where fish apparently cease to aggregate (e.g., Sadovy and Colin 2012). Additionally, grouper stocks face threats from climate change, habitat alterations, and invasive species. In order to protect these valuable species many countries have implements a variety of management actions, including: spatial closures, seasonal closures, slot limits, and gear restrictions. In places where management actions have taken place or are proposed, to assess the adequacy and effectiveness of these protections, managers require accurate estimates of regional population abundance through time.

The Reef Environmental Education Foundation (REEF) started in 1990 and has collected over 150,000 citizen science fish surveys in the Tropical Western Atlantic (REEF.org). Since 1993, volunteers with REEF have conducted reef fish surveys (species-specific presence/absence and relative abundance), using either SCUBA or snorkeling, at sites throughout the Caribbean. The fish surveys use the roving diver technique (Schmitt et al. 2002) and record abundance for species observed on using categories based on the log-scale abundance, where: single is one individual; few is two to ten individuals; many is eleven to one hundred individuals; and abundance is greater than one hundred and one. The utility of REEF data for assessing species abundance through time has been established in previous studies (Gruss et al. 2013, Lotterhos et al. 2014, Thorson et al. 2014). Using these data, we examined trends in the presence and abundance of marine fishes from the genera *Mycteroperca* and *Epinephelus*. In particular, we compared trends between locations with management protections in place for aggregating species, such as the Nassau Grouper, versus those without such protections. Our goal is to identify locations with evidence of rebuilding aggregations, and explore causal mechanisms in socio-political and resource management frameworks.

Methods

We estimated an index of abundance through time for each species in a given location using a Bayesian state space model. The REEF data was aggregated by year, species, island, and location within the island. The mean REEF abundance sighting value was assumed to approximate the index of abundance through time. A total of eight models were explored. Four models had the species linked through a hierarchical growth rate and four of the models allowed each species to have its own growth rate. Two other variables were modified in order to examine the effect of marine protected areas (or other forms of closures). The population growth rate was either kept the same across areas or allowed to differ between areas and the observation error was either kept the same across areas or allowed to differ between areas. If the best fitting model indicates that the population growth rate is different between areas, this indicates that the spatial closures is influencing the population through time. If the best fitting model is one in which the observation error is different by region, this indicates that the behavior of the fish (or the divers) is different within regions, this could be a result of fish becoming habituated to the divers.

Results and Conclusions

The model was successfully run for eight islands in the Tropical Western Atlantic: Bahamas, Belize, Cayman Islands, Dominican Republic, Jamaica, Puerto Rico, Turks and Caicos Islands, and the US Virgin Islands. In these eight islands six species of grouper species were recorded by the REEF surveys: black grouper, goliath grouper, Nassau grouper, red hind,

tiger grouper, and yellowfin grouper.

When the data was aggregated by year only three islands indicated that a spatial difference existed: Turks and Caicos Islands, Jamaica, and Little Cayman Island. Future studies will evaluate finer resolution data, first investigating the data when aggregated by season and then month, and finally, evaluating a model which uses the individual observations (following the methods of Thorson et al. 2014).

KEYWORDS: Grouper, spawning aggregations, population estimation, management strategy evaluation

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