Comparisons Between Abundance Estimates from Underwater Visual Census and Catch Per Unit Effort in a Patch Reef System

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ABSTRACT

Catch per unit effort (CPUE) and underwater visual census (UVC) are often used to produce indices of fish abundance, but each sampling method has inherent biases. We compared CPUE (using hook and line) and UVC abundance estimates (using the stationary cylinder method on SCUBA) in a patch reef system at Glover's Reef, Belize. UVC and CPUE data were collected at 63 randomly selected sites, and sampling was repeated at a subset of sites to assess temporal variability. The most commonly caught species, yellowtail snapper, porgy, lane snapper, white grunt, and mutton snapper, had occurrence rates of over 25% in both the CPUE and UVC data. For all 5 species, the average size observed in the UVC was significantly smaller than sizes that were caught. Correlations between CPUE and UVC abundance were significant when CPUE and UVC data were collected simultaneously (fishers fishing while divers counting fish, Mantel R = 0.34, p = 0.03), but correlations were not significant when data were collected on different days (Mantel R = 0.07, p = 0.18). These correlations were not improved when spatial effects were accounted for using partial Mantel tests. Further work will evaluate the causes of variability over time and between sampling methodologies. Both CPUE and UVC data are used to inform spatial management plans and to assess effectiveness of existing fishery management regimes. Therefore an understanding of the biases of each method will improve the ability to accurately measure management performance indicators.

KEY WORDS: CPUE, underwater visual census, spatial autocorrelation, commercial fish species, patch reef system

Comparación entre Estimados de Abundancia de Peces Obtenidos por Métodos Submarinos de Censos Visuales y el Método de Captura Por Unidad De Esfuerzo, en un Sistema Arrecifal Fragmentado

PALABRAS CLAVE: CPUE, métodos submarinos de censos visuales, peces comercial, sistema arrecifal fragmentado

Comparaison entre les Estimations d'Abondance de Poissons à Partir des Techniques Sous-Marines d'Observation Visuelle et Celles des Prises Par Unité d'Effort, Dans un Système Récifal Parcellé

MOTS CLÉS: CPUE, techniques sous-marines d'observation visuell, système récifal parcellé

INTRODUCTION

The ability to accurately estimate abundance is fundamental for the successful management of fisheries. Methods of underwater visual censuses (UVC) and catch per unit effort (CPUE) are both commonly used to estimate abundance of fish stocks. Multiple biases in CPUE have been noted, which result from hyperstability (Harley et al. 2001), spatial autocorrelation in the stock (Bordalo-Machado 2006), and variations in vessel and gear types (Ye and Dennis 2009). UVC is also subject to biases such as the diver attraction effect (Bennett et al. 2010) and species-specific differences in detectability (MacNeil et al. 2008). While these biases introduce some uncertainty into abundance estimates, in theory the two indices should produce related measures of fish abundance for a specific site at a given point in time. Understanding the biases of different abundance estimation methods is essential to management and conservation (Eros et al. 2009).

In this study, we test relationships between UVC and CPUE estimates of abundance in the spatially heterogeneous coral patch reef system of Glover's Reef Atoll, Belize. From 2008 – 2009, fish abundance was assessed at 49 patch reef sites using stationary point counts (Bohnsack and Bannerot 1986, Figure 1). Abundance at the 49 dive sites was also assessed with CPUE using traditional hook-and-line methods, and experimental fishing was repeated at each site on a different day. We test the extent of correlations over varying scales of time and space, and clarify under which circumstances CPUE and UVC are related. The goal of the study is to understand under which conditions CPUE and UVC are proportional.

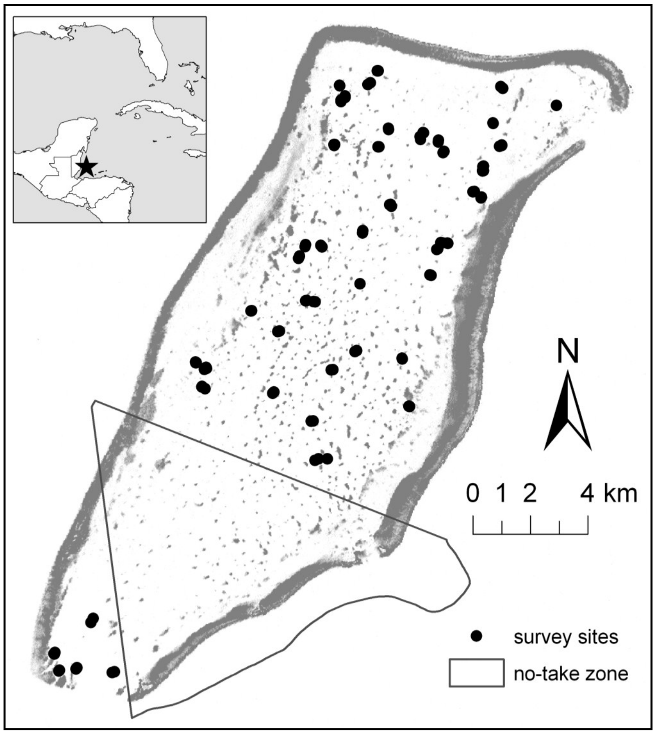

Figure 1. Survey sites at Glover's Reef Marine Reserve. Both patch reefs and shallow sand banks appear in gray.

RESULTS

The most frequently occurring fish species in the experimental fishing data were, in order of occurrence: yellowtail snapper *Ocyurus chrysurus*, saucereye porgy *Calamus calamus*, lane snapper *Lutjanus synagris*, white grunt *Haemulon plumieri*, and mutton snapper *L. analis* (Figure 2). Average length of captured fishes was greater than the average length observed in the UVC. Differences in length between individuals observed in UVC and those caught in the CPUE were significant for these top five species ($p < 0.001$ for all species except *L. analis*, $p = 0.02$).

When CPUE and UVC were collected simultaneously on the same patch (30 sites), the perMANOVA found that species composition in terms of abundance of the top five species was significantly correlated between CPUE and UVC samples ($p = 0.02$, $R^2 = 0.29$). However community structure in terms of biomass was not significantly correlated ($p = 0.19$). For the same set of sites, when CPUE and UVC were collected at different times, neither abundance ($p = 0.27$) nor biomass ($p = 0.53$) estimates were correlated.

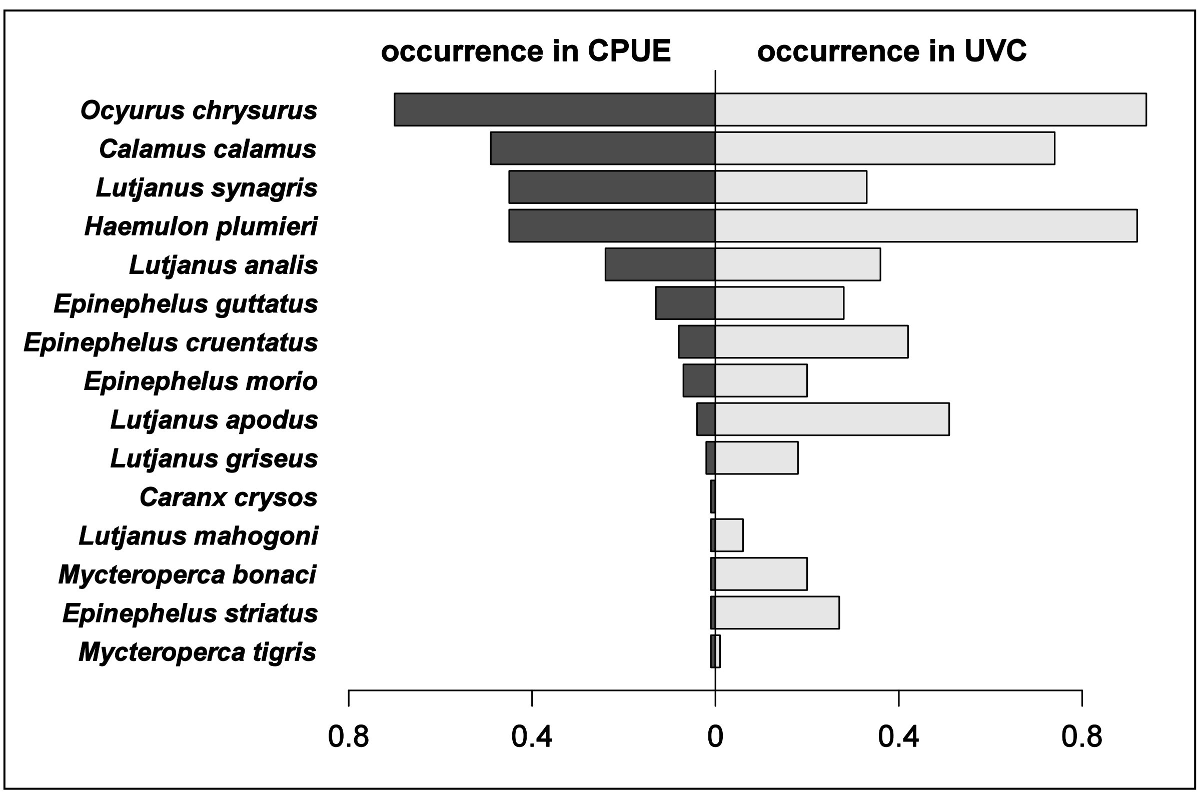

Figure 2. Barplot of occurrence rates (percent of sites where species is observed) in UVC data set and CPUE data set for the 15 species occurring most frequently in the CPUE.

When CPUE estimates of species composition in terms of abundance were compared to UVC estimates calculated from an average of five samples on different sides of the patch, the two measures were uncorrelated for abundance (per MANOVA, p = 0.39, R^2 = 0.12) and biomass (p = 0.61, R^2 = 0.10). When CPUE estimates of abundance were compared to UVC estimates only from the side of the patch where fishing took place, correlation of abundance increased (p = 0.11, R^2 = 0.16). For estimates of biomass from CPUE and UVC on the side of the patch closest to fishing, correlations were marginally significant (p = 0.05, R^2 = 0.18). Because patches are only 20 - 100 m in diameter, these results indicate that spatial autocorrelation is low and that there are differences in community composition on scales of < 100 m.

DISCUSSION

We found estimates of abundance from hook-and-line catch-per-unit-effort (CPUE) and underwater visual census (UVC) to be highly variable over small temporal and spatial scales. It is not surprising then, that we also found that estimates of abundance from CPUE and UVC were usually not correlated, unless they were collected simultaneously and at almost exactly the same location. Abundance and biomass estimates from CPUE and UVC that were collected during different periods of time were not correlated, and were only marginally correlated on spatial scales of < 100 m. Biomass estimates were generally less correlated than abundance estimates, likely a result of the fact that hook-and-line fishing targeted only larger size classes. Our results corroborate those of previous studies, which have also failed to find relationships between CPUE and UVC (Ralston et al. 1986, Connell et al. 1998), except when they are collected in the same place at the same time (Richards and Schnute 1986, Kulbicki 1988). Our study also suggests that in this complex, heterogeneous patch reef system, spatial autocorrelation is minimal. Even on very small spatial scales within patch reefs (20 m – 100 m), community composition was variable.

Given that the livelihoods of many coastal populations depend on healthy reef resources (Donner and Potere 2007), there is a need to develop efficient and cost-effective management strategies for reef fisheries. Estimating abundances of fish stocks using CPUE can be advantageous because the method is efficient, low-cost, and requires little technical knowledge or skill. However, further research should be done to elucidate the circumstances in which CPUE is proportional to fish abundance. Further work will be done to 1) elucidate the causes of variability in the various indices of abundance and 2) conduct studies to determine minimum sampling requirements necessary to detect changes.

ACKNOWLEDGEMENTS

This study was funded by the Pew Institute for Ocean Science at the University of Miami. M. Karnauskas was supported by a University of Miami Graduate Fellowship and funding from the Cooperative Institute for Marine and Atmospheric Studies while completing this work. We acknowledge the Wildlife Conservation Society for their assistance in completing the field work for this project. We also thank Randolph "Buck" Nuñez for his patience while fishing for many hours at randomly generated sites where there were no fish.

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