Mesophotic Coral Ecosystems (MCEs) Act as Deep Reef Refuges for Fish Populations in Cozumel, Mexico

Los Ecosistemas Mesophoticos Arrecifales Actúan como Zonas Profundas de Refugio para Poblaciones de Peces en Cozumel, Mexico

Les Ecosystemes Coralliens Mésophotiques Représentent des Récifs Profonds Refuges pour les Poissons à Cozumel, Mexico

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ABSTRACT

Mesophotic Coral Ecosystems (MCEs; 30 – 150 m deep reefs) may provide natural refuges for fisheries targeted species by virtue of their depth. We surveyed shallow reefs and MCEs around Cozumel, Mexico including sites inside and outside a protected area. Our results suggest fish communities shifts across the depth gradient are affected by protection levels. Greater overall fish biomass, with larger body lengths of commercially valuable fish, were found in the shallows within the marine park than in areas with no protection. On MCEs however, fish biomass and commercially valuable fish body lengths were similar regardless of protection; implying deep reef areas act as natural refuges. These findings highlight the need to integrate fish populations on MCEs into current reef fisheries management plans.

KEYWORDS: Mesophotic coral ecosystems, deep reef refuges, Cozumel, Mexico, fish

INTRODUCTION

Mesophotic coral ecosystems (MCEs), reefs from 30 - 150 m depth, are found globally in tropical and sub-tropical locations (Hinderstein et al. 2010). Globally, MCEs are understudied (Menza et al. 2008), threatened (Andradi-Brown et al. 2016a) and have received little conservation attention because of difficulties in accessing them (Pyle 1998). Yet MCEs are likely to play a crucial role in supporting the resilience of adjacent shallow coral reefs as well as potentially providing refuges for threatened shallow reef species (Bridge et al. 2013). While it is not clear how many economically important reef fish species can be found at these depths, several studies have suggested that fishing intensity on coral reefs declines with increased depth (Stevenson et al. 2011; Lindfield et al. 2014), suggesting MCEs could act as fish biomass refuges. We conducted the first characterization of MCEs around Cozumel, Mexico identifying benthic cover and fish diversity, abundance and biomass on shallow reefs and MCEs inside the Cozumel National Marine Park and at sites outside the protected area.

METHODOLOGIES

Eight sites were surveyed around Cozumel by diver operated stereo-video system (SVS; for system overview see: Andradi-Brown et al. 2016b) for fish communities and black corals size, and by photo quadrat for benthic community composition. Five sites were surveyed in the National Marine Park, and three sites were surveyed in areas without any protection. Four 30 m transects were conducted at 15 m and 55 m at all sites. Photo quadrats were taken at 5 m intervals along the transects, and each transect was separated by a 10 m interval. Videos were analyzed in EventMeasure software (SeaGIS, Melbourne, Australia). Total biomass of each fish was calculated using fish length-weight relationship data from the online database fishbase (Froese and Pauly 2016). Benthic photo quadrat analysis was conducted with Coral Point Count (CPCe) software (Kohler and Gill 2006) using 10 randomly placed points for each image. The frequency of each benthic coverage types was averaged across all photo quadrats on a transect to give overall cover for the transect. We tested changes in fish and benthic community structure between depth, protection and sites using Permutational Multivariate Analysis of Variance (PERMANOVA) based on Bray-Curtis fourth-root transformed fish species or benthic category data. Analysis was conducted using the vegan package in R (R Core Team 2013; Oksanen et al. 2013). Fish length distributions were compared using kernel density estimation methods following Langlois et al.(2012). Here we present preliminary results based on benthic quadrats from all sites, and SVS surveys from two sites inside and two sites outside the protected area.

RESULTS

We recorded higher hard coral coverage on shallow reefs inside the protected area than outside (PERMANOVA, $p<0.05$), yet no difference in hard coral cover on MCEs based on protection. Sponges dominated MCEs regardless of protection status, covering >30% of the benthos. Fish species richness appeared similar within depth bands when comparing sites inside and outside the park (Figure 1A). Shallow reef fish biomass was lower outside the protected area than inside, but there was no difference in reef fish biomass based on protection on MCEs (Figure 1B). These findings were strengthened by comparisons of fish length distributions inside and outside the protected area for commercially valuable fish species, with significantly larger fish found on protected shallow reefs compared to unprotected shallow reefs, but no effect of protection status on fish length distributions for MCEs (Figure 2).

CONCUSION

This study represents the first detailed characterisation of MCEs around Cozumel. Our results suggest that MCEs around Cozumel act as natural depth refuge for fish biomass, with local fisheries likely to have less impact on deeper reefs than shallow reefs including for commercially valuable fish. However, regardless of protection and depth, large fish (> 500 mm) were highly scarce, suggesting widespread impacts of fisheries. Our result will support and encourage local managers to integrate MCEs into management plans.

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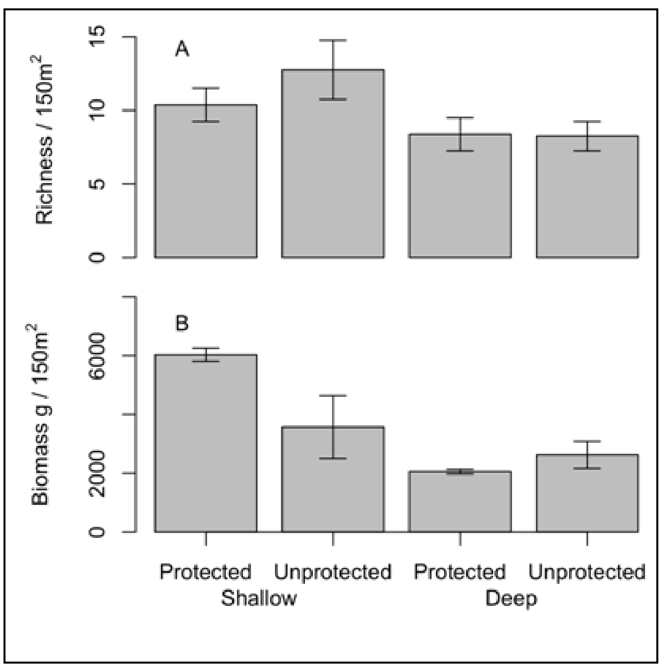

Figure 1. Comparisons of fish (A) species richness, and (B) biomass at shallow (15 m) and deep (MCEs - 55 m) depths inside and outside the protected area. Error bars indicate 1 standard error.

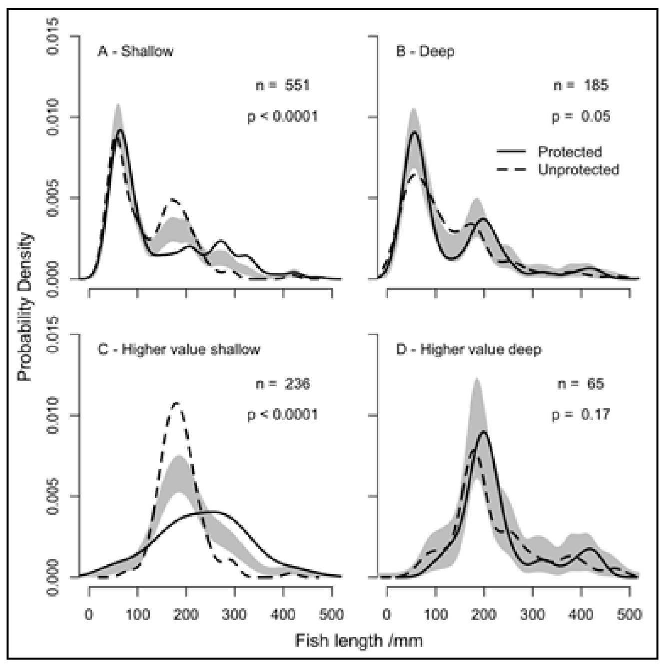

Figure 2. Fish length distributions comparing inside and outside the protected area for all fish species in the (A) shallows, (B) deep, and higher commercial value fish species in the (C) shallows and (D) deep. Grey shaded regions represent one standard error either side of the null model, n = number of individual fish measured, p indicates whether the length distributions are significantly different based on permutation tests.