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Differential depth effects upon biomass patterns in an herbivorous coral reef fish assemblage.

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Abstract. The abundance of parrotfish and surgeonfish on fore-reef habitat was sampled on 6 reefs along an inshore-offshore gradient in La Parguera, Puerto Rico to provide for within reef (across depths) and among reef (cross-shelf) comparisons. Temporally replicated visual surveys were conducted along permanent belt transects ($100m^2$) at three depth intervals (3, 10, 15 m) to obtain data on fish species density and lengths used to calculate biomass. The herbivorous fish assemblage was dominated by small-bodied parrotfish *Scarus iseri*, *Sparisoma aurofrenatum S. viride* and *Acanthurus coerulus*. Overall the density and biomass of parrotfish and surgeonfish was higher at 3m than at 10 or 15m. However, the differences in biomass across the depth gradient were most notable at inshore reefs where the proportional decrease in biomass by depth was higher compared to the mid-shelf reefs. Depth is a well know driver of herbivorous fish abundance, but along a cross-shelf gradient additional within reef factors interact to structure biomass patterns.
Key words: Reef fish, grazing, depth gradient.

Introduction

Grazing by Parrotfish (*Scaridae*) and Surgeonfish (*Acanthuridae*) is an ecological process that structures coral reef benthic communities (Hughes 1994; Belliveau and Paul 2002). Spatial variation in the abundance of these herbivores can result in differential grazing pressure and may have implications to coral-algal interactions (Lewis and Wainwright 1985; Mumby et al. 2006). At a basic research level the patterns in fish distribution on a reef may indicate underlying processes that influence how fish use available habitats. At an applicable level understanding the processes that structure the abundance of parrotfish and surgeonfish will aid in managing for this important ecological function. Understanding the spatial patterns of parrotfish and surgeonfish on fore-reef habitats along an inshore-offshore gradient will help determine factors that structure this fish assemblage (Williams and Polunin 2001; Paddack et al. 2006; Fox and Bellwood 2007).

This study investigates spatial patterns of parrotfish and surgeonfish biomass on fore-reef habitats across the seascape asking: What area the relative abundances of the species from these two families on the fore-reefs of Southwest Puerto Rico? How are parrotfish and surgeonfish distributed spatially across the fore-reef zones in terms of density and biomass? Are the patterns in abundance consistent between the inner-shelf and mid-shelf reefs?

Material and Methods

Fish abundances were sampled on 6 reefs on inner-shelf and mid-shelf reefs to allow within reef (across depths) and among reef (cross-shelf) comparisons (Fig. 1).

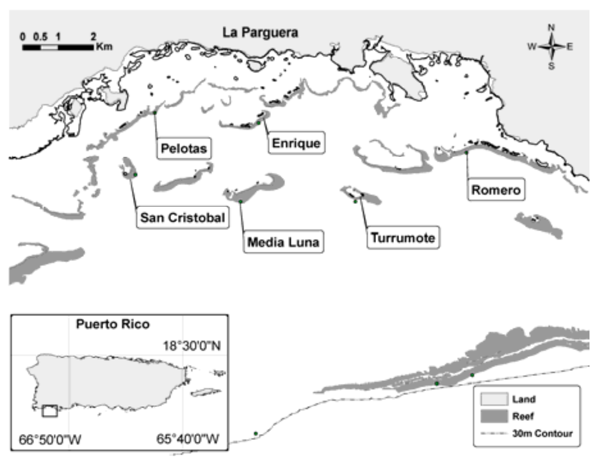

Figure 1: Map of the 6 study reefs (3 inner-shelf: Pelotas, Enrique, Romero; and 3 mid-shelf: San Cristobal, Media Luna, Turrumote).

Visual surveys were conducted along permanent belt transects (25 x 4m). Three depth intervals were selected on the fore-reef slope (3, 10, 15 m), and 3 replicates per depth were sampled 4 times per year. Fish species counts and fork lengths were recorded for each transect. Length data were used to calculate mean sizes and biomass was derived from published length-weight relationships (Ref). Data were analyzed for patterns across depths and between inner and mid-shelf strata by species and at the family level. Kruskal-Wallis (KW) non-parametric ANOVA was used to test for significant differences.

Results

The assemblage of roving herbivorous fish on the fore-reef was dominated numerically by small bodied species. The parrotfish were principally represented by 3 species: *Sparisoma aurofrenatum*, *S. viride* and *Scarus iseri* with the highest densities. Large bodied Scaridae such as *S. guacamia* and *S. vetula* were present but at very low densities and these were generally sighted on the same study reefs. Three species of surgeonfish are present and *Acanthurus coerulus* was numerically dominant.

Across all reefs the abundances of both groups were distinctly structured in relation to depth in the fore-reef habitat. Both families exhibited the highest densities and biomass in the shallowest depth interval (3 m) which sharply decreased at the 10 and 15m intervals (Fig. 2, 3). Densities across depth intervals were significantly different for parrotfish (KW, p=0.036) as well as for surgeonfish (KW, p=0.000). Biomass for parrotfish was 2.3 times higher at the 5 m depth interval than the 15 m interval, and for surgeonfish it was 4 times higher.

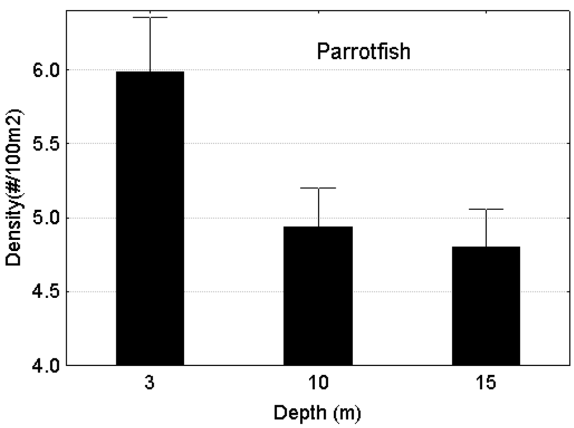

Figure 2: The overall mean density (± SE) of all parrotfish at the 3 depth intervals for the 6 study reefs.

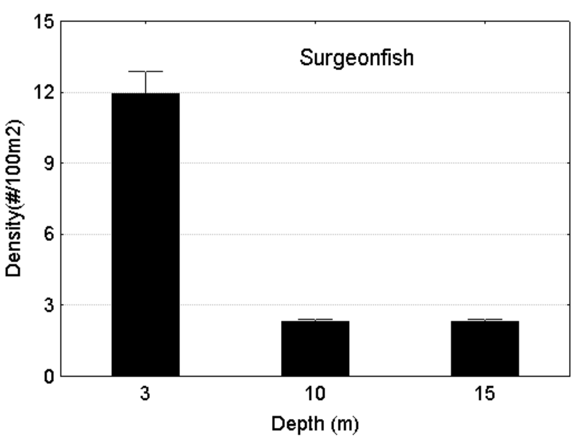

Figure 3: The overall mean density (± SE) of all surgeonfish at the 3 depth intervals for the 6 study reefs.

Comparing the biomass by depth of both families between inner-shelf and mid-shelf reefs revealed that the general trend of decreasing abundances with depth varies between the two strata. The depth-related decrease in abundance is more pronounced at inner-shelf reefs. Biomass for parrotfish on inner-shelf reefs at 3 m was 3.2 times greater than at 15 m; on mid-shelf reefs the proportional difference was 1.8 times greater (Fig. 4). However, comparing the mean biomass of parrotfish between inner and mid-shelf strata for the 3 depth intervals revealed that only the 10m depth interval was significantly different (KW, p=0.003).

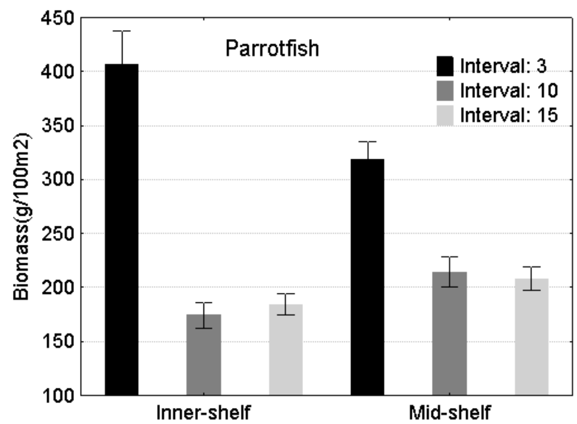

Figure 4: The mean biomass of parrotfish at the 3 depth intervals for inner and mid-shelf reefs, with 95% confidence intervals.

For surgeonfish, biomass on inner-shelf reefs at 3 m was 10.9 times greater than at 15 m; on mid-shelf reefs the proportional difference was 2.8 times greater (Fig. 5). Comparing the mean biomass of surgeonfish between inner and mid-shelf strata for the 3 depth intervals revealed that only the 15m depth intervals were significantly different (KW, p=0.000).

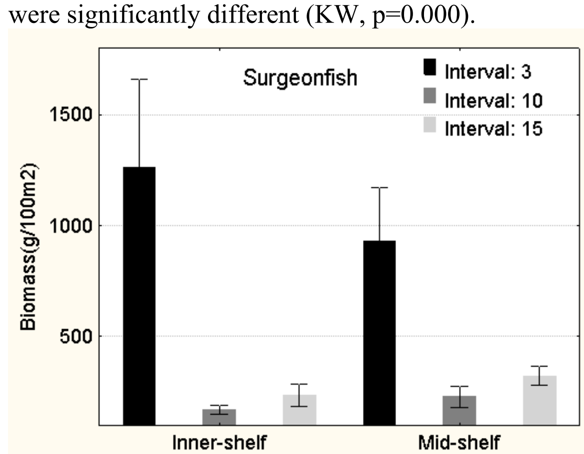

Figure 5: The mean biomass of surgeonfish at the 3 depth intervals for inner and mid-shelf reefs, with 95% confidence intervals.

Discussion

Herbivory is an ecological process that structures coral reef benthic communities and variations in the spatial distribution of herbivores may reflect differential grazing pressure (Mumby et al. 2006). Depth appears to be a major factor that structures the way that parrotfish and surgeonfish utilize fore-reef habitats as has been found in other studies on coral reefs world-wide (Lewis and Wainwright 1985; Hoey and Bellwood 2007).

In this study both the parrotfish and surgeonfish biomass decreased with depth and this was proportionally greater at inner shelf reefs. This effect can vary with reef location, possibly due to factors which are also related to distance from shore, such as water quality (Clifton 1995). Deeper fore-reef habitats seem to be less favorable to grazers which was shown by lower densities and biomass at the deeper depth intervals. This pattern was more pronounced at inshore reefs. These results are in agreement with other studies that have found a peak in herbivorous fish densities in shallow fore-reef zones (Russ 2003; Fox and Bellwood 2007). Maximum abundance at the shallow fore-reef is a result common to most studies on parrotfish and surgeonfish. This may be due to preferential food resources being available from higher productivity of algae at shallower depths (Russ 2003). However, this study documents that this pattern can vary among reefs across an inshore to offshore gradient. The fact that the use of fore-reefs by the dominant species of herbivores is site specific has implications for management strategies that aim to promote fish grazing.

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