Seagrass Community Responses to the Decline in Queen conch (*Strombus gigas*) Populations

Respuestas de las Comunidades de Pastos Marinos a la Reducción de Poblaciones de Caracol (*Strombus gigas*)

Réponses des Communautés D'herbiers Marins à la Réduction des Populations de Lambi (*Strombus gigas*)

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ABSTRACT

The crisis in the world's fisheries is well documented with many stocks being fully or overexploited. The consequences of these activities include a number of cascading effects such as alteration of trophic dynamics and simplification of complex communities. We examined seagrass communities, both macrophyte resources and mega-invertebrate abundance, across the central Bahamas in order to investigate the potential negative impacts the loss of Queen conch may have on ecosystems and broader services. All sites were classified as shallow, dense seagrass beds with *Thalassia testudium* and associated detritus the dominate resources. Shannon-Weiner mega-invertebrate diversity across a gradient of queen conch and total Strombid (*S. gigas* + *S. costatus*) densities revealed significant quadratic relationships with peaks of diversity at intermediate densities. Multivariate analyses indicated significant differences in mega-invertebrate functional groups between communities with low, moderate, and high conch densities. Conch densities may serve as useful indicators of relative diversity, complexity, health, and function of seagrass communities over a broad scale.

KEY WORDS: Trophic; dynamics; cascades

INTRODUCTION

The crisis in the world's fisheries is well documented with many stocks being fully or overexploited (FAO 2012, Froese et al. 2012). The consequences of these activities go well beyond a simple decline in target species but include a number of cascading effects – loss of predators, release of prey species, alteration of trophic dynamics, and simplification of complex habitats and communities (McClanahan and Muthiga 1988, Sala et al. 1998, Jackson et al. 2001, Steneck et al. 2004, Worm et al. 2006). Queen conch (*Strombus gigas*) has been traditionally harvested throughout the Caribbean region for centuries and represents a major economic activity supplying the demands of local people, tourism and export markets (Brownell 1981, Theile 2001). The drastic reductions of Queen conch, a relatively abundant component of undisturbed seagrass and associated shallow-water ecosystems, over the last several decades have given rise to concerns over the future of these fisheries and associated livelihoods. However, what have not been sufficiently explored are the potential negative impacts the loss of Queen conch may have on ecosystems and broader services where they are naturally abundant.

MATERIAL & METHODS

We examined seagrass communities at 15 sites across the central Bahamas (Andros, Bimini, Berry Islands and the Exuma Cays) during a 10 day cruise aboard Shedd Aquariums' research vessel Coral Reef II in April 2013. All sampling was done on SCUBA. The living macrophyte components, various species of seagrass and macroalage, were sampled using a 10 cm diameter core to a depth of 15 cm at three randomly selected points along 60 meter transects. Surface detritus was collected at those same random points using a 0.0625 m^2 PVC quadrat. These materials were separated by species, above and below ground components, and dried at 70^o C for 24 hours or until achieving constant mass. All macrophyte abundance was expressed as grams dry mass per meter squared (gDM/m^2). All mega-invertebrates were counted within two meters of either side of a 60 meter transect (total area = 240 m^2) and measured (vainer calipers +/- 1 mm) across the longest body axis. In addition, the lip thickness of all stromdid conchs was also measured when present. Mega-invertebrate taxa were assigned to specific consumer functional groups (specialists, generalists, sub-surface and surface deposit feeders, suspension feeders and predator/scavengers) and ultimately expressed as proportional abundances at each site. Statistical analyses were conducted using routines in Sigmaplot ver. 19 and PRIMER-E ver. 6.1.6 (Clarke and Warwick 2001).

RESULTS

All sites were classified as shallow (4.1 m +/- 0.3), dense seagrass beds. Above ground *Thalassia testudium* (467+/-101 $gDMm^2$) and associated detritus (136+/-43 gDM/m^2) dominated macrophyte biomass at all sites. Total Queen conch densities ranged widely (0 – 1617 indiv./ha) with sub-adults/adults (lip thickness > 4 mm) being present at only three sites (Figure 1). Mean Queen conch densities across all sites were: adults - 58 indiv./ha (s.e. = 33); juveniles - 156 indiv./ha (s.e. = 86). Shannon-Weiner mega-invertebrate diversity across a gradient of Queen conch and total Strombid (*S. gigas* + *S. costatus*) densities revealed significant quadratic relationships ($p < 0.02$) with peaks of diversity at intermediate densities

(Figure 2). Further analyses were conducted on the distribution of mega-invertebrate consumer functional group proportions across significantly different low (< 11 indv./ha), medium (11 - 100 indv./ha) and high (> 100 indv./ha) conch densities ($F = 22.3$, $p < 0.001$, Tukey - all pairs significantly different, $p < 0.026$). Multivariate analyses in PRIMER-E revealed significant differences between communities across density categories: nMDS plot (stress = 0.11), analysis of similarity: Global $R = 0.622$, $p = 0.001$, All pairs $p < 0.017$.

DISCUSSION

The highest conch density sites were dominated by unfished *S. gigas* congeneric specialists, *Strombus costatus* (64%), and may indicate a "functional replacement" as Queen conch are selectively removed through fishing (Loreau 2004). Low conch density sites were dominated by non-selective generalist grazers (e.g. *Lytechinus variegatus*) (52%), which have the potential to destructively overgraze living seagrasses as well as reduce recruitment and diversity of competitive functional groups (Sala et al.

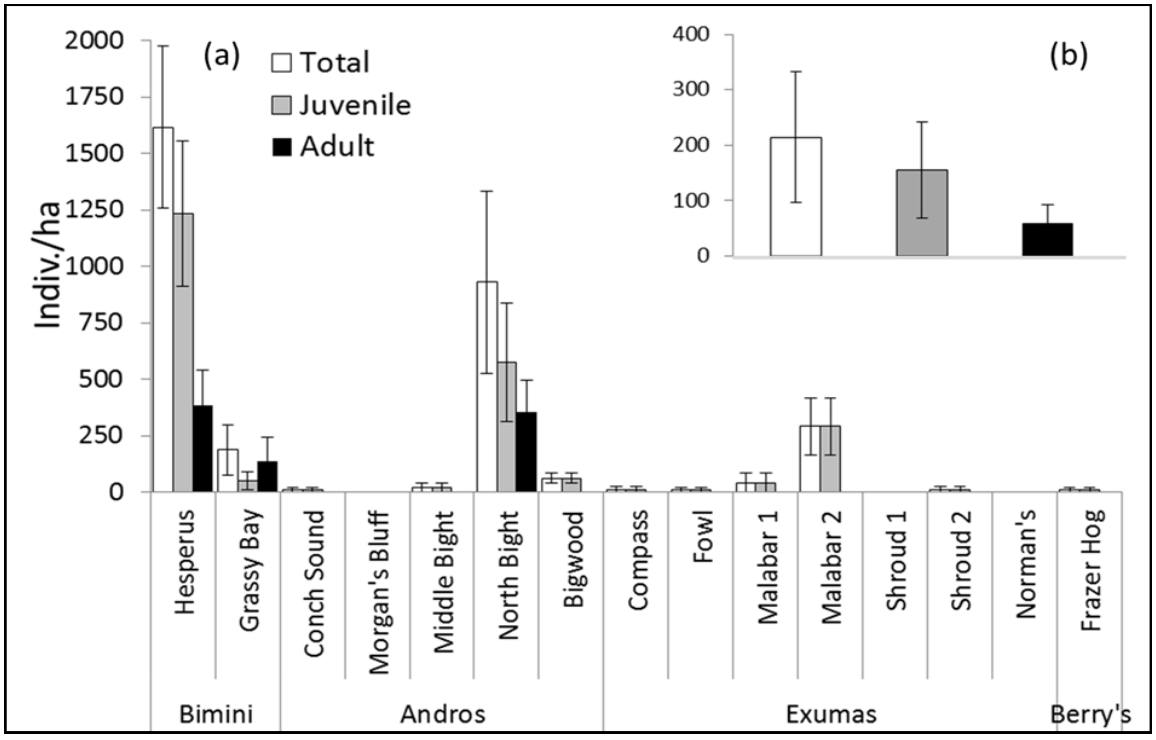

Figure 1. Total, juvenile and sub-adult/adult (> 4 mm lip thickness) queen conch (*Strombus gigas*) densities observed during April 2013 across (a) 15 seagrass sites and (b) overall in the central Bahamas. Error bars are standard error of the mean.

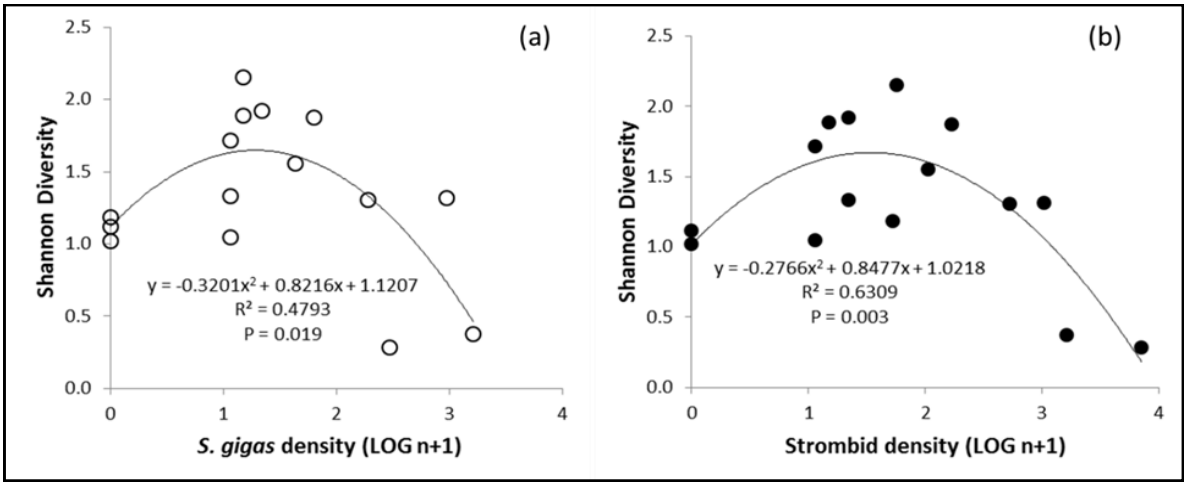

Figure 2. Quadratic relationships of Shannon-Weiner mega-invertebrate diversity across gradients of (a) Queen conch (*S. gigas*) and (b) total Strombid (*S. gigas* + *S. costatus*) densities observed during April 2013 across 15 seagrass sites in the central Bahamas.

1998, Jackson et al. 2001, Eklof et al. 2008). Communities at moderate conch densities had the highest diversity and most even distribution of consumer groups including sub-surface deposit feeders (29%), suspension feeders (25%) and surface deposit feeders (20%). The selective grazing activities of conch at intermediate densities likely facilitate consumer diversity by maintaining the integrity of the living seagrass canopy as physical structure and as a source of detritus (Duggins et al. 1989, Stoner et al. 1995, Moore et al. 2004, Tewfik et al. 2007). Conch densities may serve as useful indicators of relative diversity, complexity, health & function of seagrass communities over a broad scale.

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