Are demersal zooplankton populations affected by a phase shift on the coral reef at Discovery Bay, Jamaica?

Erik R. Schoen and Erica B. Close

Abstract: The decrease of urchin grazing in Discovery Bay, Jamaica, following the *Diadema* die-off in 1983, has resulted in decreased coral cover on the reef and increased macroalgal cover. The effects of this phase shift on lower trophic organisms, like demersal zooplankton that depend on substrate for protection from diurnal predators, are unknown. We compared zooplankton populations over two substrates affected by decreased *Diadema* grazing, coral and macroalgae, in the back-reef of Discovery Bay. Copepods and polychaete larvae tended to be more abundant over macroalgae than coral while decapod larvae, medusae and zooplankton over 2 mm in length had similar abundance over each substrate type. If macroalgae provide better daytime habitat for copepods, the most abundant zooplankton on the reef, total zooplankton populations could be positively affected by increased macroalgal growth. These changes may cascade up to higher trophic levels and influence reef recovery.

Key Words: cnidarians, copepods, decapods, Diadema antillarum, *diel migration, emergence trap, macroalgae, polychaetes,* Porites porites, Siderastrea sideratrus

Introduction

Jamaican coral reefs have undergone a massive change in community structure since the early 1980s. The combined effects of overfishing, hurricanes and a die-off of the important sea urchin herbivore *Diadema antillarum* have led to a dramatic decrease in coral cover and an increase in macroalgal cover (Hughes 1994, Aronson and Precht 2000). Although *Diadema* has begun to recover and reduce macroalgae abundance, corals have recovered only slightly (Edmunds and Carpenter 2001). The effects of this phase shift have been documented for several species, including parrotfish (Carpenter 1990) and surgeonfish (Robertson 1991). However, the impact of these changes on zooplankton is largely unknown.

Demersal zooplankton migrate vertically to feed in the water column at night and associate with coral reef substratum during the day. If food abundance is high, we theorized that their populations may be limited by shelter (i.e. the amount of substrate available for refuge). Previous studies have shown a higher abundance of many zooplankton taxa emerging over complex substrate, like coral or grass, compared to mud or coral rubble (Jacoby and Greenwood 1989), and over highly branching corals compared to smaller corals (Jacoby and Greenwood 1977, Porter and Porter 1977). Different zooplankton taxa collected have had varying abundances over different substrates (Alldregde and King 1977). A broad change in substrate cover in Discovery Bay could affect the total demersal zooplankton population of the reef and the relative abundance of different taxa.

To examine the possible effects of the coral reef phase shift on demersal zooplankton populations, we sampled zooplankton over live coral and macroalgae in the back-reef of Discovery Bay. If zooplankton associate most frequently with live coral, the high macroalgal growth after the 1983 *Diadema* die-off may have caused a decrease in zooplankton populations. However, if macroalgae provide an equally or more protective substrate than coral for zooplankton, the high percent cover of these algae could increase demersal zooplankton abundances. Since demersal zooplankton are the most important zooplankton group for sessile reef planktivores (Porter 1974, in Ohlhorst 1982) and play an important role in determining planktivorous

reef fish abudance (Forrester 1990, in Noda et al. 1992), zooplankton population changes could affect higher trophic levels (Fig. 1).

Methods

This study was conducted from 3 – 9 March 2002 at Discovery Bay, Jamaica. We collected zooplankton over patches of live coral and macroalgae to compare zooplankton abundance between the two substrates. Zooplankton were caught in multiple emergence traps (0.25 m^2 area of substrate) approximately 50 m from the reef crest of the west fore-reef. Live coral treatments consisted of mounds of *Siderastrea siderea* and/or heads of *Porites porites* that covered at least 70 percent of the area under a trap. Macroalgae treatments consisted of occasional growths of *Dictyota* spp., *Halimeda* spp., *Wrightiella blodgettii*, *Laurencia* spp., *Acanthopora spicifera*, and large amounts of *Amphiroa* spp., *Jania* spp. and *Hyphea* spp. on dead coral mounds or heads. Occasionally a small amount of turtlegrass (*Thalassia testudinum*) or sand was also included within the sampled area of both treatments.

Emergence traps, constructed after Ohlhorst (1982), consisted of cone-shaped tents of polyvinyl plastic ~0.6 m tall, attached to a square frame of PVC pipe. Traps were anchored with cinder blocks and loose rocks over the treatment substrate during daylight hours on 6 - 7 March. Collection bottles (0.25 L) were placed at the apex of the traps at 16:30 on each day and collected at 22:30 the same evening, ~3.5 hrs after sunset, when most demersal zooplankton in Discovery Bay emerge from the benthos (Olhorst 1982). Three samples were taken from both substrate types on the first night and 4 on the second for 7 replicate samples on both coral and macroalgae.

We preserved zooplankton in formalin immediately after sampling and counted the number of zooplankton in seven taxonomic categories: copepods, decopods, polychaetes, cnidarians, amphipods, isopods, fish and arrow worms. All zooplankton were divided into <2 mm and >2 mm size classes. Unidentified zooplankton were excluded from analyses.

Mean numbers of zooplankton in each category were compared between treatments

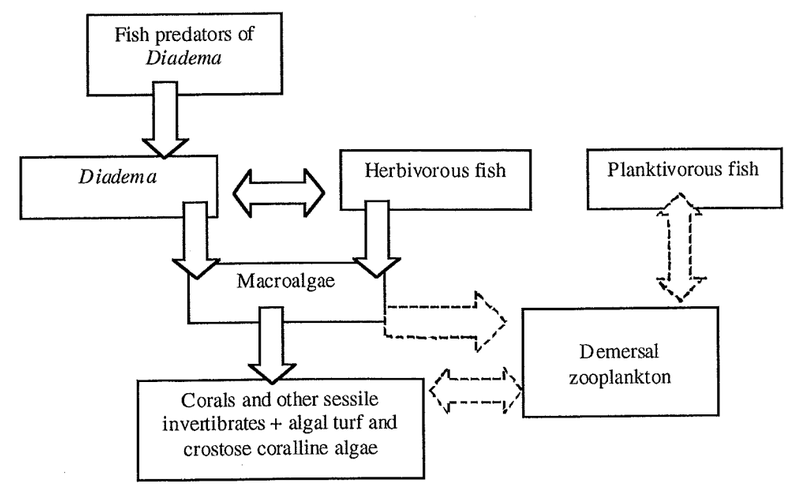

FIG. 1. Trophic relationships between coral reef organisms affected by *Diadema antillarum*. Dashed arrows indicate possible relationships addressed in this study.

with student's t-tests after square root transformation. Mean zooplankton abundances in <2 mm and >2 mm size classes were also compared using a student's t-test. Zooplankton abundance was normalized to a per square meter basis for comparisons with other studies.

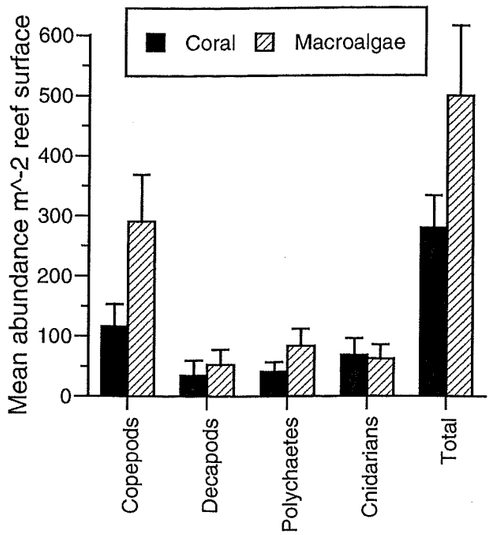

FIG. 2. Mean (± SE) abundance of zooplankton of each taxonomic group collected over coral and macroalgae in emergence traps. Total also includes isopods, amphipods, fish larvae, arrow worms and unidentified zooplankton (n = 7).

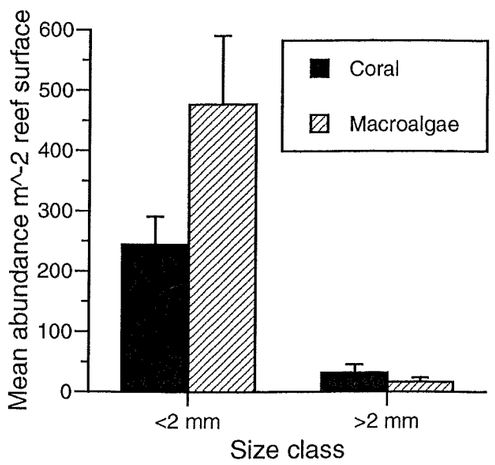

FIG. 3. Mean number (± SE) of zooplankton in two size classes collected over live coral and macroalgae (n = 7).

Results

Copepods were the most abundant zooplankton, comprising 52% of the total zooplankton over all samples. Decapod larvae, polychaete larvae and medusae were also common, each occurring in at least 12 of the 14 samples. Amphipods, isopods, fish larvae and arrow worms were less common, occurring in low abundances in few samples. Most zooplankton were <2 mm in length; zooplankton >2 mm in length consisted of few large decapods and polychaetes and the less numerous taxa: amphipods, isopods, fish larvae and arrow worms.

Total zooplankton abundance tended to be higher over macroalgae than coral substrate ($t = 1.72$, $df = 12$, $P = 0.11$). Copepods were marginally significantly more abundant over macroalgae than over coral ($t = 2.10$, $df = 12$, $P = 0.06$; Fig. 2). Polychaetes tended to be more abundant over macroalgae ($t = 1.39$, $df = 12$, $P = 0.19$), while decapod and medusae abundance did not differ between substrates ($t = 1.01$, $df = 12$, $P = 0.33$; $t = 0.19$, $df = 12$, $P = 0.85$).

Zooplankton <2 mm in length tended to be more abundant over macroalgae than coral substrate ($t = 1.89$, $df = 12$, $P = 0.08$; Fig. 3). Larger zooplankton >2 mm in length had a higher mean abundance over coral than over macroalgae (mean ± SE = 8.0 ± 3.4, 4.1 ± 1.8), but this result was not significant ($t = 0.99$, $df = 12$, $P = 0.34$). Fish larvae were surprisingly unevenly distributed; 25 occurred in one coral sample while only four were found amongst all other samples.

Discussion

Abundance of demersal copepods and polychaetes tended to be greater over macroalgae than living coral. This trend may be explained by the relatively high, small-scale structural complexity of the macroalgae common in the Discovery Bay back-reef. Although smooth *Siderastrea siderea* mounds provide the large-scale structure required by *Diadema* and many refuge-seeking fishes, macroalgae may be a better source of refuge on the scale of millimeters.

Like other studies, we saw differences between zooplankton taxa in their distribution between substrates. The differential abundance of various zooplankton taxa between the two substrates suggests that factors determining suitable substrate for zooplankton may differ between taxa. These differences in distribution may reflect differential survival or active selection of substrate type.

Copepods, which comprise between 47 and 95% of the night-active zooplankton in the west back-reef at Discovery Bay (Ohlhorst 1982, Chiavelli et al. 1998, Fagan et al. 2002), are major components of the total zooplankton population of other reefs as well (Alldredge and King 1977, Jacoby and Greenwood 1989). Therefore, the substrate associations of demersal copepods may be the most important in determining how substrate phase shifts could affect total zooplankton abundance. Alldredge and King (1977) found that copepods made up the greatest proportion of zooplankton caught in emergence traps over live coral. The distribution of copepods explained the 8-fold increase in demersal zooplankton abundance over live coral compared to sand, rubble or rock in the Great Barrier Reef. If macroalgae is a better substrate for copepods than live coral as our results suggest, copepod populations, and consequently total zooplankton populations, could be positively affected by large-scale macroalgal growth.

Demersal zooplankton distribution should be investigated on the fore-reef before conclusions can be drawn about the effect of the phase shift on zooplankton. Although fore-reef sampling is logistically difficult at night, the higher abundance and diversity of corals would allow a better comparison between coral and algae than is possible in the algae and sea grass dominated back-reef. Fore-reef comparisons are especially important because studies have shown over 4-fold increases of emergent zooplankton on the fore-reef compared to the back-reef in Discovery Bay and the Great Barrier Reef (Alldredge and King 1977, Ohlhorst 1981, Jacoby and Greenwood 1988).

Our results suggest that zooplankton abundances differ between substrates, so a change in substrate type like the phase shift on Jamaican reefs may affect demersal zooplankton abundances; this in turn may cause cascading effects in higher trophic levels. For example, more abundant demersal zooplankton associated with high macroalgal cover could increase food resources for zooplanktivorous nocturnal fish and cnidarians. Thus, while replacement of coral with macroalgae may reduce refuge habitat for some fish it may benefit some planktivores.

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