Fish assemblages around patch reefs at Heron Lagoon, Australia: Who drives the algae halo patterns?

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Introduction
Coral reefs have long been known as locations of refuge for reef fishes. Hixon et al. (1993) displayed that reef fish are more abundant when there are holes in reef structure to avoid predators2. These patterns of refuge around reefs can also be observed aerially at Heron Island, Australia. In this shallow lagoon, distinct grazing halos surround patch reefs. Madin et al. (2011) found evidence supporting the hypothesis that grazing by herbivorous fish caused the halo patterns and that this foraging behavior was driven by predator-mediate effects2. The results of this study suggest that as distance from the reef edge increases, so does the risk of predation.

Based on this past research at Heron Island, I predicted that as distance from patch reef increased, fish abundance, diversity, and grazing behavior would decrease in response to higher predation risk.

Methods

Experiment design
This study was conducted at Heron Island, Australia. The study site was within swimming distance of the island and consisted of a cluster of patch reefs. We laid three transects radiating out from reef structures and set three Gopro cameras at 0, 10, and 20 meters from the reef edge. Approximately 2 hours of footage were taken by each camera. We collected data over three consecutive days (May 29, May 30, and June 1, 2017) beginning at high tide.

Video analysis
To collect data from the videos, I identified and counted fish to the lowest taxonomic level of my ability. I also calculated the proportion of fish observed foraging and average bite rate.

Data analysis
I conducted three types of analyses on the video data. To investigate the effect of distance from the reef edge on overall fish abundance, Shannon’s diversity index of fish, proportion of fish biting, and bite rate I used linear mixed effects models. The random effects in these models were reef ID and date.

To analyze the effect of distance on community structure, I conducted a multi-dimensional scaling analysis (MDS). This is a complex statistical analysis which uses the abundance of each taxa at each distance to quantify if there is difference in community structure between the distances. The further the centroid of each distance is from the other distances, the more unique the fish communities.

Results

Fig. 1 Overall fish abundance with increased distance from patch reef structure. Abundance significantly increased with increased distance from the reef (linear mixed effects model, P = 0.05).

Fig. 2 Shannon diversity index scores at each distance. The difference between 0 meters and 10 meters is marginally significant (linear mixed effects model, P = 0.05).

Fig. 3 Both (A) foraging proportion and (B) bite rate displayed no significant difference with increased distance from the patch reef (linear mixed effects model, P = 0.05).

Fig. 4 (A) This multi-dimensional (MDS) scaling model assess community structure at each distance. There is a statistically significant community difference between the three distances (P = 0.02). To determine which taxa drove the community difference, a similarity percentage analysis was conducted. The greatest difference in community structure was caused by Gerres oyeno (common silver biddy). This animal made up 42% of the differences between 6 meters and 30 meters, 35% difference between 6 meters and 20 meters, and 38% of the differences between 10 meters and 20 meters. (B) Mean abundance (± s.e.) of the five fish driving community differences were graphed to visualize the differences. These results show that Gerres oyeno prefers a greater distance from reef structure.

Gerres oyeno (common silver biddy)

Conclusion

• Contrary to my prediction, fish abundance increased with increased distance from patch reef edge.
• Fish species diversity was not influenced by distances from patch reef edge.
• There was no significant difference in foraging behavior with distance from the reef edge.
• Community structure differed with distance and differences were driven primarily by Gerres oyeno (common silver biddy).
• Gerres oyeno abundance increased with increased distance from the reef edge.
• Overall, I found that the fish community differed with increased distance from the reef, but fish foraging behavior was not affected.