EFFECTS OF HIGH WINDS ON A CORAL REEF FISH COMMUNITY ON LITTLE CAYMAN ISLAND

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Abstract: Even relatively protected, shallow-water back reefs experience frequent disturbance from periods of high wind that increase turbulence and turbidity in the water column. We studied fish communities along the back reef on the north side of Little Cayman Island, and compared the abundance, taxonomic composition, and vertical distribution of fish between calm and windy days. We found higher abundances and taxonomic diversity of fish in the water column in calm periods, as the danger of displacement and injury diminished. We also predicted fish would move lower in the water column during high winds to avoid surface turbulence, but this did not occur.

Keywords: wind disturbance, shallow reef

INTRODUCTION

Tropical coral reefs and their marine inhabitants are subject to weather disturbances of various frequencies and intensities. High intensity disturbances like cyclones bring extreme winds, rainfall, wave-action, and sedimentation. These can cause long-term changes in reef structure, substrate, and coral mortality, and alter behavior, species composition, and distribution of fish (Kim et al. 1997, Halford et al. 2004).

There is apparently little information on how less intense wind events affect reef fish behavior, taxonomic composition, and local distribution. High winds change shallow-water habitat conditions by increasing turbidity, water movement, and sedimentation (Sousa 1984, Kim et al. 1997, Genevase & Witman 2004). These changes may negatively affect fishes' feeding efficiency, and increase their risk of injury on the reef.

We hypothesized that fish behavior would change during high winds to minimize energy expenditure and the threat of injury, resulting in changes in fish abundance, taxonomic diversity, and vertical distribution. We predicted that fish would either escape to deeper water (e.g. on the ocean side of the reef crest) to avoid surface turbulence, or take refuge deep in the back reef. We predicted that fish not hiding in the reef would swim near the bottom to avoid surface turbulence and wave action.

Alternatively, wave action and turbulence could stir food up from the sea floor, particularly benthic invertebrates, providing fish

with a feeding opportunity. Under this alternative hypothesis, we would predict that proportionally more fish would feed during high winds, resulting in greater abundance of visible fish.

We also predicted that we would observe more juveniles than adults along the reef edge in high winds, because stronger adults would out-compete juveniles for the best hiding places, or escape to deeper waters.

METHODS

We studied fish communities along the back reef near the Little Cayman Research Center on the north side of Little Cayman Island. We measured the abundance and behavior of all fish encountered in plots, on two occasions: during the high winds of Feb 29 2008 (winds ca. 22 knots, visibility ca. 3.5 m) and during the relative calm of Mar 2 2008 (winds ca. 12 knots, visibility ca. 15.5 m). We used twelve 3x2 m plots, with adjacent plots separated by 10 m, along a 146 m transect placed parallel to and near the edge of the back reef, in water ca. 1.8 m deep. We observed each plot for 6 minutes after allowing 1 minute for fish to habituate to our presence. We carefully checked crevices on the reef surface for hiding fish for 1 minute plot^{-1}. We attempted to identify each species of fish, but because many were unidentifiable, we used higher taxonomic groups for analysis (Appendix 1; Table A). We noted each fish's life stage (juvenile or adult), its location relative to the reef edge (in or out of the reef, where "in" = within 30 cm of the reef), its vertical position in the water column (high, middle or low, dividing the water column into thirds), and its behavior most represented during the observation period (feeding, hiding or swimming).

We paired our data in time, using the same plots for calm and windy conditions, and performed paired t-tests. We used a chi-squared test to test for how windy conditions affected fish behavior, vertical distribution, and juvenile and adult abundance.

RESULTS

More fish were visible on the back reef during calm conditions than in high winds (paired t-test, $t = -8.91$, $df = 11$, $P < 0.0001$; Fig. 1). We explored non-metric multidimensional scaling to search for patterns between taxonomic group abundances, by plot and weather. No single taxonomic group clearly drove the greater abundance during calm conditions, but damselfish, parrotfish and wrasses all increased in abundance (Fig. 2).

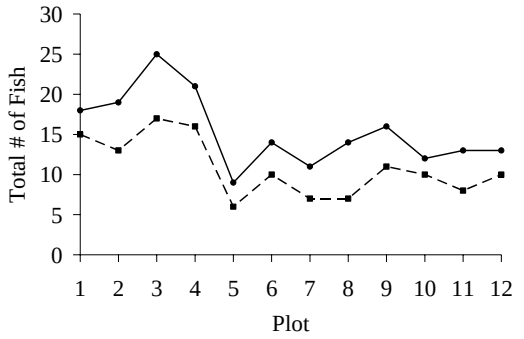

Figure 1. Total fish abundance per plot during windy (dashed line) and calm conditions (solid line), along the back reef near the Little Cayman Research Center on the north side of Little Cayman Island. Data from 12 plots, each 2 x 3 m, 10 m apart.

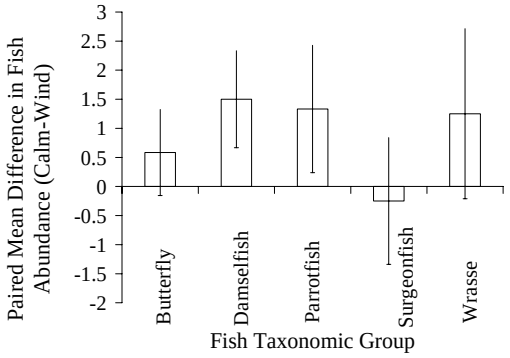

Figure 2. Paired mean differences (means and 95% confidence intervals) in fish abundance between calm and windy conditions, for the 5 major taxonomic groups, along the back reef near the Little Cayman Research Center, on the north side of Little Cayman Island. Data from 12 plots, each 2 x 3 m, 10 m apart.

There were also significantly more taxonomic groups visible under calm conditions (paired t-test, t = -2.69, df = 11, P = 0.021; Fig. 3). Greater group richness was driven by several groups that were rare in our samples, and present only in calm conditions (angelfish, trunkfish, and blennies).

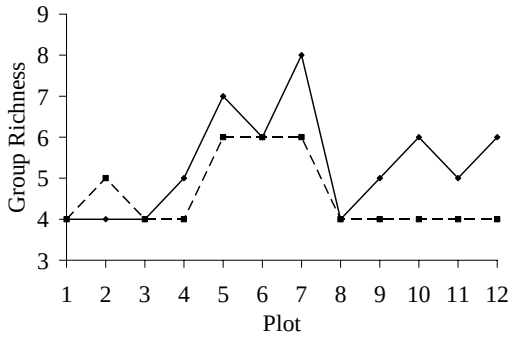

Figure 3. Number of taxonomic groups in each of 12 plots during windy (dashed line) and calm conditions (solid line), along the back reef off the northern side of Little Cayman Island. Data from 12 plots, each 2 x 3 m, 10 m apart.

The proportion of fish in low, middle or high strata of the water column did not change with weather (χ^2 = 2.99, df = 2, P = 0.224). In both windy and calm conditions, the highest proportions of fish were close to the bottom, and the least near the surface. There was a marginally significant trend toward a higher proportion of fish in the reef structure during the windy day sample (χ^2 = 3.08, df = 1, P = 0.079).

The distribution of behaviors differed significantly between weather conditions (χ^2 = 13.2, df = 2, P = 0.0014). There was a tendency for more feeding in calm conditions, and more swimming during high winds. The proportion of fish hiding remained similar, irrespective of wind conditions (Fig. 4).

We found no difference in adult to juvenile abundance ratios with weather (χ^2 = 0.117, df = 1, P = 0.732).

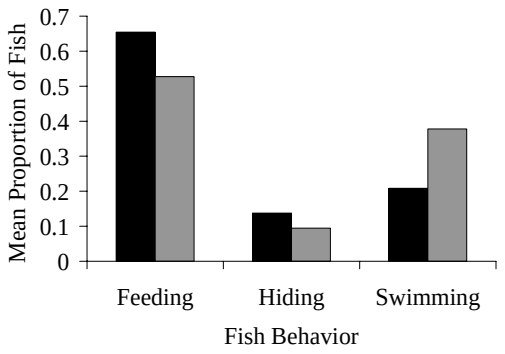

Figure 4. Proportional behavior in fish during calm weather (black) and high winds (gray) along the back reef near the Little Cayman Research Center. Pair-wise differences for each behavior by weather do not differ statically.

DISCUSSION

Abundance and richness of observed fish decreased significantly during windy conditions. This was likely due to conditions of high turbulence and decreased visibility, forcing the fish to escape to deeper waters, or hide deeper in the back reef. The overall decline in abundance with windy conditions probably drove the decline in group richness. Alternatively, some groups may be better able to handle rough conditions than others. This could explain why certain groups of fish were absent from all plots during high winds.

There was no change in the ratio of adult to juvenile abundance between winds and calm, implying that adults and juveniles responded similarly. Many of the fish groups absent during high winds were moderately large species, such as snapper and grunts. Larger fish may be more likely to move to deeper waters than smaller fish, to avoid high turbulence in shallow waters. It may be physically difficult for smaller fish to cross the reef crest, or the deeper waters may present a higher predation risk.

Surprisingly, fish preferred to stay near the bottom in both wind and calm conditions. Perhaps fish hide near the bottom to avoid detection by pelagic predators. Also, vertical position in the water column may be dictated by local food sources, particularly benthic invertebrates, that some fish search for regardless of weather conditions.

As predicted, windy conditions affected fish behavior, forcing fish to expend more time swimming and less time feeding, which might affect their growth rates. However, windy conditions are frequent around Caribbean islands, and our results show that fish associated with the back reef are capable of dealing with the rough conditions and re-establishing their local distribution and abundance quite rapidly.

LITERATURE CITED

Genovese, S. J., and J.D. Witman. 2004. Wind-mediated diel variation in flow speed in a Jamaican back reef environment: Effects on ecological processes. Bulletin of Marine Science 75.2:281-293.

Halford, A, A.J. Cheal, D. Ryan, D.M. Williams. 2004. Resilience to large-scale disturbance in coral and fish assemblages on the Great Barrier Reef. Ecology 85:1892-1905.

Kim S.C., L.D. Wright, B.O. Kim. 1997. The combined effects of synoptic-scale and local-scale meteorological events on bed stress and sediment transport on the inner shelf of the Middle Atlantic Bight. Continental Shelf Research 17:407-433.

Sousa, W.P. 1984. The role of disturbance in natural communities. Annual Review of Ecology and Systematics 15:353-391

APPENDIX 1.

TABLE A. Fish species abundance by life stage in calm and windy conditions along the back reef near the Little Cayman Research Center. Data from 12 plots, each 2 x 3 m, 10 m apart.

Species	Life Stage	Calm	Wind
Banded Butterflyfish	Adult	9	2
Bar Jack	Adult	1	1
Barred Butterflyfish	Adult	1	0
Barred Jack	Adult	1	0
Beaugregory	Adult	9	8
Beaugregory	Juvenile	7	2
Blenny	Adult	1	0
Bluehead Wrasse	Juvenile	21	20
Blue Tang	Adult	4	8
Blue Tang	Juvenile	6	5
Cocoa Damselfish	Adult	3	0
Cocoa Damselfish	Juvenile	4	1
Damselfish	Adult	0	1
Dusky Damselfish	Adult	1	1
Dusky Damselfish	Juvenile	1	0
French Grunt	Adult	4	1
Gray Angel	Juvenile	1	0
Hairy Blenny	Adult	1	0
Horse Eye Jack	Adult	0	1
Longjaw Squirrelfish	Adult	6	4
Mahogany Snapper	Adult	1	2
Mutton Snapper	Adult	1	0
Princess Parrotfish	Juvenile	0	1
Redtail Parrotfish	Adult	1	0

Redtail Parrotfish	Juvenile	2	0
Schoolmaster	Adult	0	1
Sergeant Major	Adult	2	0
Sergeant Major	Juvenile	0	3
Slippery Dick	Adult	0	2
Slippery Dick	Juvenile	14	8
Spotted Damselfish	Adult	1	0
Spotted Goatfish	Adult	0	1
Spotted Goatfish	Juvenile	2	2
Spotted Trunkfish	Adult	1	0
Stoplight Parrotfish	Adult	2	3
Stoplight Parrotfish	Juvenile	6	0
Unidentified	Adult	25	20
Unidentified	Juvenile	40	27
Unidentified	Unidentified	0	1
Yellow Tail parrotfish	Adult	3	0
Yellowtail Damselfish	Adult	3	4