Mangrove Removal in the Belize Cays Adversely Impacts Mangrove Fish Assemblages

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ABSTRACT

We investigated the effects of mangrove cutting on fish assemblages in Twin Cays, Belize in two habitat types. We conducted visual censuses at two sites in adjoining undisturbed/disturbed (30-70% of shoreline fringe removed) sub-tidal fringing *Rhizophora mangle*. Observers recorded significantly more species and individuals in undisturbed sites, especially among smaller, schooling species (e.g. atherinids, clupeids), where densities were up to 200 times greater in undisturbed habitat. Multivariate analyses showed distinct species assemblages between habitats at both sites. In addition, extensive trapping with wire minnow traps within the intertidal zone in both undisturbed and disturbed fringing and transition (landward) mangrove forests was completed. Catch rates were low - 638 individuals from 24 species in 563 trap nights. Trap data, however, indicated that mangrove disturbance had minimal effect on species composition in either forest type (fringe/transition). Different results from the two methods (and habitat types) may be explained by two factors: 1) a larger species pool in the subtidal habitat, and visual 'access' to all species, and 2) the selective nature of trapping. Our data indicate that even partial clearing of shoreline and more landward mangroves can have a significant impact on local fish assemblages.

KEY WORDS: *Rhizophora mangle*, mangrove destruction, visual census, traps

Retiro de Mangles en los Cayos de Belice Impactan Negativamente a las Agrupaciones de Peces

Investigamos los efectos del corte de mangles sobre las agrupaciones de peces en en dos habitáculos en Twin Cays, Belice. Conducimos censos visuales en dos sitios adjuntos a manglares de borde submareal de *Rhizophora mangle* impactados y no impactados por el corte (30-70% del borde litoral removido). Observadores anotaron significativamente más especies e individuos en los sitios no impactados, especialmente entre las especies de peces más pequeñas que forman cardúmenes (e.j., atherinidos y clupéidos), en las cuales las densidades fueron hasta 200 veces mayores en los habitáculos no impactados. Análices multivariados demostraron distintas agrupaciones de especies entre los habitáculos en ambos sitios. Además, hicimos extenso uso de trampas de alambre para chipas en la zona submareal en bosques de borde y de transición (hacia tierra) impactados y no impactados. Las tasas de atrape fueron bajas – 638 individuos de 24 especies en 563 noches/trampas. Los diferentes resultados obtenidos por los dos métodos (y tipos de habitáculos) se pueden explicar por dos factores: 1) una fuente de especies más grande en el habitáculo submareal y "acceso" visual a todas las especies, y 2) la naturaleza selectiva de las trampas. Nuestros datos indican que aún corte parcial de mangles de litoral y de tierra adentro pueden tener impactos significativos en las agrupaciones de peces locales.

PALABRAS CLAVES: *Rhizophora mangle*, destrucción de mangles, censo visual, trampas

INTRODUCTION

Mangroves are now well-documented as one of the most biologically diverse and productive tropical marine habitats, and the complex linkages between the mangal and adjacent marine systems are slowly being unraveled. The value of the mangal as nursery habitat for juvenile coral reef fishes is currently of great interest among researchers, and an abundant literature reviews various aspects of this habitat value (Nagelkerken *et al.* 2000). This nursery habitat value is a direct result of the structural complexity, offering safety from predators and shelter from physical disturbance, as well as habitat enhancement for invertebrates, which serve as a food supply (Cocheret de la Morinière 2004, Manson *et al.* 2005).

Researchers have directly measured the enhancement effect that mangroves have on coral reef fisheries. Mumby *et al.* (2004) have provided estimates of reef fish biomass at three Caribbean atolls with mangrove-scarce reef systems (minimal or no mangrove habitat nearby) and compared these data with mangove-rich reef sites, where mangroves were abundant nearby. Biomass of fishes was notably greater (up to 25 X) at reef sites with abundant mangrove cover nearby. These data raise alarm at the documented rate of mangrove destruction worldwide, now estimated at 35% (Valiela *et al.* 2001) .

One avenue to slow the rate of mangrove destruction might be to provide data on the direct effects of mangrove removal on fishes inhabiting therein. We describe below the impacts of mangrove removal on fishes inhabiting the intertidal and subtidal mangroves in the Belize cays.

METHODS

Study Location

The study site was located on Twin Cays on the Belize barrier reef. Twin Cays is a complex of mangrove islands, about 12 km offshore from Dangriga, Belize (16° 50´ N, 88° 06´ W), located only 1.5 km west of the crest of the

Belize barrier reef. The vegetation has been extensively studied (summarized in Feller *et al.* 2002), and shorelines are dominated by what is termed the 'fringe', consisting of *Rhizophora mangle* in a stand 5 - 20 m wide and 4 - 6 m tall. Landward of this is the 'transition' zone, where tree height is less, and *Avicennia germinans* and *Laguncularia racemosa* are dominant, although R. mangle is also found. This zone varies from 5 - 30 m wide, and the substrate elevations are the highest along a gradient across the island.

On Twin Cays, and elsewhere in the Belize cays (Woodroffe 1995), clearing of mangroves is becoming more common, in attempts by local property owners to allow construction of buildings on the cays. The general pattern is to cut a significant portion of the shoreline *R. mangle* fringe and then clear-cut the transition zone, except for a few larger *A. germinans* (D.S.Taylor Pers. obs.)

To study the effect of this cutting on resident fishes, we chose two sites, one each on the two larger cays of the Twin Cays complex. At both sites, a 200 m portion of the shoreline fringe had been cleared, accompanied by total clearing of the landward transition zone. Each cleared site (hereafter termed 'disturbed') directly adjoins an uncut ('undisturbed') area of otherwise identical habitat. Water depth at the outside of the *R. mangle* fringe at all sites varied from 1 - 2 m. We assessed fish assemblages at the four sites using the following techniques:

Visual surveys — We conducted visual censuses of fishes along adjacent portions of disturbed and undisturbed fringe shoreline on both cays. Four observers equipped with snorkeling gear started about 50 m apart along the shoreline. Each observer marked a beginning point in the fringe and swam a 5-minute transect, counting and identifying fishes observed within the prop roots and beneath the canopy extending beyond the prop root zone. No fishes outside of this area were included. Fishes were identified to species in most cases. The numbers of smaller schooling species (e.g. engraulids, clupeids), were estimated and identified only to family, with some designated as 'unknown schoolers'. After completing the 5-minute interval, another marker was placed and another 5-minute transect begun, for a total of four transects per observer. After all four transects were complete, swimmers would immediately move to the adjacent undisturbed/disturbed site, and the process was repeated. After both disturbed and undisturbed sites were complete, the length of each marked transect was measured, following the contours of the shoreline. We completed five total sets of these surveys over two week periods within two different years (Oct.-Nov. 2003 n = 2 surveys; Sept. 2004 n = 3 surveys), for a total of 80 individual transects.

Fish trapping — We placed Gee™wire minnow traps within disturbed/undisturbed intertidal fringe and transition areas on one cay over five-day periods during three different years (2003, 2004, 2005). Traps were baited with pieces of cut fish and deployed for 24 hours. All fishes taken were identified to species and released, except for specimens needed for stable isotope analysis and voucher specimens for laboratory identification. Overall, 563 traps were deployed over the 3-year period.

Data analysis — Species assemblages between undisturbed and disturbed mangrove habitats and between years for each cay were analyzed with non-metric multi-dimensional scaling (MDS). Visual census and minnow trap data were analyzed separately. A sample similarity matrix was created using the Bray-Curtis similarity coefficient (Bray and Curtis 1957). MDS ordinations were followed by a two-way (visual data) or one-way (trap data) crossed analysis of similarities (ANOSIM) test to more formally test for community differences between habitat types and years. Finally, a similarity percentages (SIMPER) routine was performed on the visual data to determine which species contributed most to observed differences (Clarke 1993).

RESULTS

Visual Census / Minnow Traps

With the visual surveys, we documented a total of 62 species within both treatments at both sites. At one cay, forty-seven species were recorded at the undisturbed site, with 39 at the corresponding disturbed site. At the other cay, the disturbed site was more depauperate, and there were 49 and 34 species, respectively. However, differences in density (fish/linear m) were much more pronounced, especially with schooling species. Densities for non-schooling species were 2.4 and 4.4 times greater at the two undisturbed sites and 7.5 and 192.5 times greater for schooling species. The multivariate techniques indicated differences in fish assemblages at both cays over both years, and ANOSIM indicated significant differences in both habitat and year. The SIMPER analysis showed that grunts and snappers *(Haemulon flavolineatum, H. sciurus,* and *Lutjanus apodus*) and various schooling species contributed most to the observed difference by habitat and year. Schooling species were especially significant in differentiation at one of the sites.

Analysis of the minnow trap data was inconclusive. Trap catch-rates were low (638 individuals, 24 species in 563 trap-nights). The primary intent of the trapping was to establish if any differences exist in the transition, where visual observations are not possible, but this technique did not capture any differences in community structure, if they exist.

DISCUSSION

While it is intuitive that removal of mangroves will affect fish assemblages, we note few studies documenting this effect. Our data seem to indicate that even partial removal of fringing *R. mangle* and other mangroves found to landward will adversely affect both fish species diversity and density. Although species diversity was reduced by disturbance, the effect on density was more striking, especially in schooling species. At one site, schooling densities were nearly 200 times less at the disturbed site. Among the 62 species documented, almost all were more abundant in undisturbed than in the corresponding disturbed sites.

The minnow trap data failed to indicate any effect of mangrove cutting on assemblages within the intertidal fringe and transition. The differing results from the two methods (visual vs. minnow traps) may be explained by the presence of a larger species pool in the sub-tidal fringe and the more comprehensive nature of visual census, as opposed to the selective nature of trapping.

Our data seem to clearly show the value of intact mangroves to fishes within oceanic mangrove cays on the Belize barrier reef. Woodroffe (1995) indicates that many of the mangrove ranges on the Belize barrier reef are undergoing recession, possibly due to the effects of sea-level rise. If this is the case, any additional losses of mangrove habitat due to human activity may aggravate a compounding problem for fisheries management.

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