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Traditional Fisheries of Antongil Bay, Madagascar

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Abstract— Madagascar's marine fisheries provide revenue and sustenance for the island nation. Antongil Bay, the largest shallow-water bay along Madagascar's eastern coast, harbors significant marine resources and is heavily utilized by traditional, artisanal (shark-fin) and industrial fisheries. Mean hourly catch rates are just under 1 kg/hour/fisher and mean daily catch rates are 4.4 kg/day/fisher. Beach seines, tamis (fine mesh seines), and combined use of gillnet and line were the most efficient gear types in terms of hourly and daily catch rates while gillnet and line were the most common gear types employed. Catch composition included 140 fish species from 69 families. Overall catch was dominated by species from Scombridae and Carangidae (*Atule mate*, *Decapterus russelli*, *Megalaspis cordyla, Rastrilliger kanagurta*). The Bay appears to be an important breeding habitat for scalloped hammerhead (*Sphyrna lewini)* and other species in the family Carcharhinidae. Given the multi-species and multi-sector nature of this fishery, ecosystem-based management, wherein sensitive habitats are protected and limits are placed on destructive gear, is recommended, along with a zoning program to control resource-use overlap and encourage ownership.

INTRODUCTION

A threatened biodiversity hotspot, Madagascar has attracted conservation attention for decades (Myers 1988; Green & Sussman 1990; Brooks *et al*. 2002; Benstead *et al*. 2003). As knowledge of Madagascar's marine biodiversity increases, so does the need for conservation, with the number of marine protected areas on the rise (McKenna & Allen 2003; Cooke 2003).

Marine fisheries provide vital income and sustenance, valued at over US $160 million annually (World Bank 2003). Export-driven, often foreign-owned tuna and shrimp fisheries account for most of the value, with the latter comprising 73% of total worth (World Bank 2003). Yet 70% of overall production comes from small-scale fisheries, providing an important national protein source (World Bank 2003). Marine fisheries in Madagascar are not well-managed, with stocks considered fully exploited (FAO 1999, 2005). Given the global fisheries crisis, importance of fisheries to food security, and connection between availability of fish and terrestrial biodiversity conservation, greater attention to fisheries management in Madagascar and the developing world is needed (Brashares *et al*. 2004).

Antongil Bay is a large, productive shallow-water area on the eastern coast of Madagascar, providing seasonal habitat for humpback whales

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(*Megaptera novaeangliae*) and harboring marine protected areas (Rosenbaum *et al.*1997; Kremen *et al*. 1999; Francis *et al*. 2002; Ersts & Rosenbaum 2003). Herein we characterize the traditional fishery of the Bay.

MATERIALS AND METHODS

Sheltered from the Indian Ocean by the Masoala peninsula, Antongil Bay is a 2,800 km^2 semi-enclosed bay with maximum depths of 70 m (Figure 1). Nine major rivers and many small tributaries enter the Bay. Estuaries, seagrass beds, mangroves, and reefs can be found, with the latter occurring within marine protected areas (Figure 1). The watershed includes protected forests of Masoala National Park (PNM) and Makira and agricultural/ degraded areas (Figure 1**).** Air temperatures range from 26° C to 21° C and rainfall from 300-500 mm/month (December – August) to 75-150 mm/ month (dry season), with annual values exceeding 2,000 mm/year.

Seven large and many smaller villages occur around the Bay, with fewer settlements on the eastern side due to the presence of the PNM and the absence of roads. Maroantsetra, the largest and wealthiest town, has the most diverse economy while smaller villages rely mostly on fishing and agriculture (rice, vanilla, cloves and coffee). Fishing complements agriculture, and while it does not provide a sole-source of income, fish is the primary source of protein. Transport and ecotourism are also economically important. Fishing includes a traditional fishery, conducted on-foot or from dug-out canoes (pirogues), an artisanal fishery, comprised of about six motorized vessels (25-50 hp motorized vessels <30 m length) targeting sharks for fin export, and a seasonal

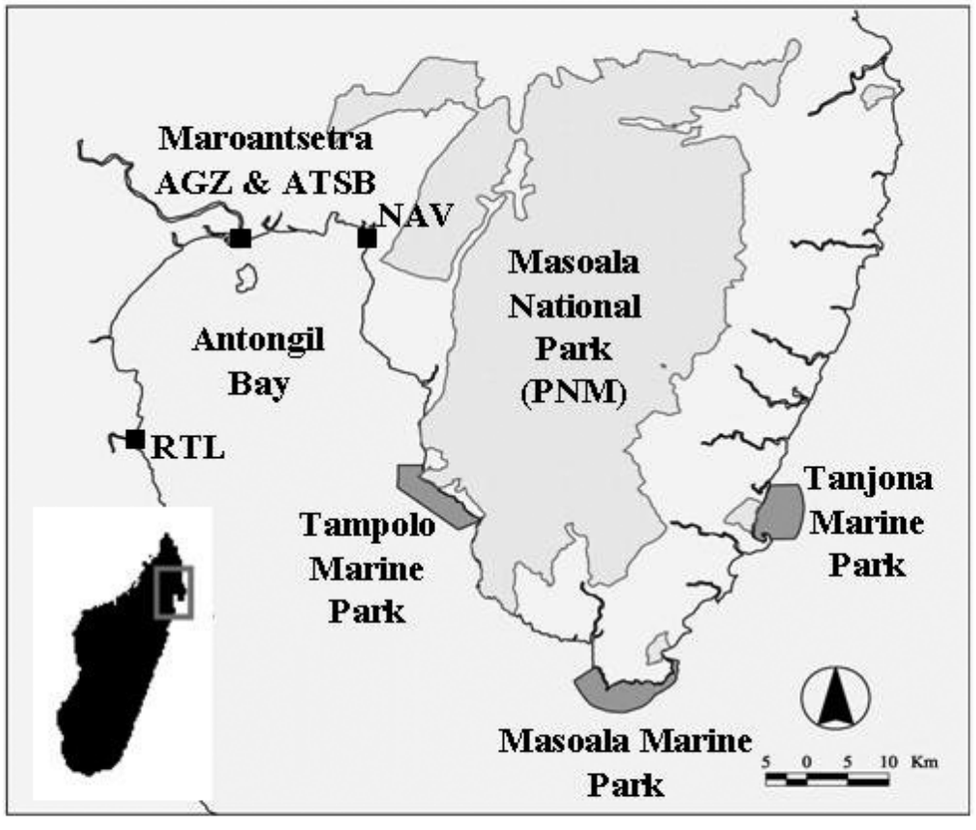

Fig. 1. Map of Madagascar and Antongil Bay illustrating Masoala National Park. Note: abbreviations denote landing site names as follows: Navana (NAV), Rantohely (RTL) and Maroantsetra (Andranonangozy (AGZ), Antsiranamborondolo (ATSB))

industrial fishery, performed by a maximum of five large trawling vessels targeting shrimp for export and finfish bycatch for export and national sale.

Informal community interviews and observations were conducted in 14 villages in 2000. Fisheries monitoring programs were then established in Navana (NAV), Rantohely (RTL) and Maroantsetra (landing sites Andranonangozy (AGZ), Antsiranamborondolo (ATSB)) between 2001 and 2003 (Figure 1). Villagers were trained in data recording and to examine and record the catch of 8-10 fishermen per day, 16 days per month. Total catch weight, weight by Malagasy name, fishing site, effort, gear, and total daily effort (number pirogues fishing) were recorded. Local Malagasy fish names were documented to family and/or species, with voucher specimens deposited at the American Museum of Natural History (AMNH; New York, USA). Hourly and daily CPUE comparisons between gear types were performed using nonparametric multiple comparisons in SPSS 15.0 for Windows.

RESULTS

Antongil Bay's traditional fishery is non-specific and non-target, with all non-poisonous, non-taboo species consumed. Gillnets, line, beach seines, tamis (small mesh seines of mosquito net or thin cloth), wooden seines and tidal traps ("vitry"), and spearguns (not reported here) are used. No destructive fishing (poisons, dynamite) occurs. Fishing is conducted generally near the villages where fish are consumed, although markets in large towns (Maroantsetra, Rantohely, Masoala) are supplied by fishers from within and outside of the Bay. Fish not consumed immediately are dried, smoked and/or salted. Men and women of all ages fish, with women and small children using seine nets and traps on foot; men and older boys conduct pirogue-based fishing, and groups of men, women and children are involved in beach seining. Fishmongers are generally women and wives of fishermen.

Gillnets are the commonest gear used (of mean length 150 m, range of 50-400 m, 1 m height and 2.5-5 cm mesh) followed by hook and line fishing. Average daily fishing effort was five hours (Table 1). Fishers using line and gillnet combined spent the most time fishing (Table 1). Mean catch rates for all sites and gears combined was just under 1 kg/hour/ fisher and 4.4 kg/day/fisher (Table 1). Significant differences (≤0.05) were found among gear types for hourly and daily rates (Table 2). On average, 20 pirogues were active per day.

Catches included over 140 fish species from 69 families with over 225 local names (Table 3). Specimens of 81 species were preserved at the AMNH. Catches were dominated by species of Scombridae (47%) and Carangidae (16%). *Rastrelliger kanagurta* represented 38% of the total catch, *Megalaspis cordyla*, 7%, and other small Carangids (*Atule mate*, *Decapterus russelli*), 9%. Sharks, shrimp and marine mammals occur in the traditional catch. Small sharks are not directly targeted or valued ($0.15-0.50 /individual). Catch

Table 1. Results of fisheries monitoring program in Antongil Bay, Madagascar. G: gillnet; L: line; V: Vitry (fence like structures made of wood or reeds); T: tamis (fine-mesh seine); G/L: gillnet and line combined; BS: beach seine

Gear	CPUE (kg/fisher/hour)			CPUE (kg/fisher/day)			Time (minutes)		
	Mean (Range)	SE	N	Mean (Range)	SE	N	Mean (Range)	SE	N
G	0.83	0.018	3351	4.50	0.103	3404	306	2	3364
L	0.66	0.025	1245	3.45	0.166	1245	293	3	1215
V	0.81	0.057	77	3.80	0.401	78	270	12	77
T	2.41	0.418	38	7.10	0.983	38	204	12	38
G/L	1.53	0.296	62	10.91	2.203	64	416	13	63
BS	4.62	0.500	87	9.27	0.296	92	133	10	86
All	0.88	0.019	4865	4.43	0.094	4964	300	2	4843

Table 2. Results of non-parametric multiple comparisons between CPUE for gear types and hours and daily catches (see Table 1 for abbreviations). Hourly rate comparisons above diagonal, daily rate comparisons below, with significant differences (0.05) indicated (*)

	G	L	BS	V	G/L	T
G		*	*	-	-	*
L	*		*	-	-	*
BS	*	*		*	*	*
V	-	-	*		-	*
G/L	*	*	-	*		-
T	-	*	-	*	-	

Table 3. Families of fish harvested in the Antongil Bay, Madagascar, traditional fishery listed in decreasing order of abundance (by weight). Multiple family names are indicated when species within all families had been observed and the accuracy of monitor identification was uncertain. Species specific information available from the author upon request

Scombridae
Carangidae
Engraulidae
Anguillidae, Muraenesocidae, Muraenidae
Sciaenidae
Mullidae
Sphyraenidae
Atherinidae, Elopidae, Clupeidae
Gobiidae, Platycephalidae, Synodontidae
Ariidae
Serranidae
Carcharhinidae, Rhinobatidae Sphyrnidae
Menidae, Leiognathidae
Gerreidae, Sparidae
Trichiuridae
Haemulidae
Belonidae , Hemiramphidae
Bothidae, Cynglossidae, Soleidae, Psettodidae
Siganidae
Terapontidae
Lutjanidae
Scaridae
Psettodidae
Polynemidae
Sillaginidae
Nemipteridae,Holocentridae
Plotosidae
Pempheridae, Apogonidae
Chirocentridae
Ambassidae
Echeneidae
Mugilidae
Pomacentridae
Lethrinidae
Acanthuridae
Labridae
Balistidae, Diodontidae, Ostraciidae, Tetraodontidae
Scatophagidae
Rachycentridae
Caesionidae
Monodactylidae
Dactylopteridae
Muraenidae
Scorpaenidae
Zanclidae
Fistulariidae
Kyphosidae
Aulostomidae
Liparidae

records contained 273 individual sharks (NAV N=62 in 29 months; RTL N=211 in 13 months) of small size (mean TL 52.0 cm ± 14.9 SD, range 13.5-97.0 cm). Sharks identified by local name (N=203) consisted of species of non-hammerhead (N=111; mean TL 52 cm ± 14.9 SD 17.0 cm, range 13.5-97.0 cm) and hammerhead species identified as *Sphyrna lewini* (N=92; mean TL 52 cm ± 12.4 SD 17.0 cm, range 28.0-90.0 cm). All non-hammerhead sharks were species of Carcharhinidae. Three specimens of *Rhizoprionodon acutus* were deposited in the AMNH collection (40.0 cm TL). Hammerhead sharks were not captured at any site between July and September, while non-hammerhead sharks were captured only from June –December at RTL. Guitarfishes (Rhinobatos sp. *Rhynchobatus djiddensis*) also occur in the traditional catch. These fishes are not consumed due to local taboo. Interviews revealed that dugong (*Dugong dugong*), dolphins, and sea turtles are caught, the latter in catch reports at NAV. Shrimp occur in catches using beach seines and other gear.

Discussion and Conclusion

This study provides baseline catch data for the traditional fishery in Antongil Bay. The CPUE values observed are lower than those in reef fisheries elsewhere in Madagascar and in surrounding island fisheries (see Laroche & Ramananarivo 1995) with hourly CPUE similar to that in São Tomé and Príncipe (d'Almeida *et al*. 1995). Using CPUE to gauge fishery health is difficult given the lack of comparative and baseline data, but the data will be useful for bio-economic modeling of the importance of fisheries to local populations (as protein, and for livelihoods), and for gauging future changes in fisheries health and the impacts of management. Comparisons of catch rates among gear types confirmed fisher's assumptions that beach seines yield higher catch rates than other gears. Expanded use of beach seines and other efficient gear (tamis) could significantly impact the fishery and ecosystem.

Antongil Bay appears to be a productive system, with high biodiversity and important essential habitat for marine resources. The main species occurring in the traditional fishery, *Rastrelliger kanagurta* and *Decapterus russelli* are small, planktivorous species common in coastal bays and plankton-rich waters, indicating the Bay is rich in primary productivity. Fisheries dependent and independent observation of estuarine seine fisheries in the northern part of the Bay indicate these areas act as juvenile habitat for species occurring in the traditional fishery as adults (Ramahery 2004). The Bay further provides important habitat for sharks (e.g. *Rhizoprionodon acutus* and *Sphyrna lewini*) and guitarfish (Rhinobatos sp. *Rhynchobatus djiddensis*), with juveniles occurring in the traditional fishery on a seasonal basis, and adults, sometimes gravid (e.g. *Sphyrna lewini*), harvested in the artisanal fishery (Doukakis, unpublished). Sharks are increasingly threatened by the shark-fin fishery in the Bay and elsewhere in Madagascar (McVean *et al*. 2006). The Bay also harbors biodiversity beyond that described here as evidenced by catch in other fisheries sectors, including additional species and size classes of Lutjanidae and Scombridae, elasmobranchs (Family Carcharhinidae, Dasyatidae, Hemigaleidae, Myliobatidae, Rhinobatidae, Torpedinidae) (Doukakis, unpublished), coral reef fishes (Odendaal *et al*. 1995; in Cooke 2003), and a recently discovered new species of ponyfish (*Photoplagios* sp.; Sparks 2006).

The health of Antongil Bay's fisheries may be in decline, in part due to poor management. Fishers reported the need to travel farther, for longer, to acquire sufficient catch, decreased size of fish, and species composition changes. Fishers attributed the observed changes to the use of destructive gear (beach seines, small mesh seines), increased overall effort, and/or industrial fishing. The management of Antongil Bay fisheries is weak, with laws pertaining to fishery regulation (e.g. mesh size, marine mammal and turtle harvest prohibition) not enforced outside of marine protected areas and fisheries officials having limited capacity. Traditional fishers report abandoning practices such as throwing back undersized fish and joint net ownership because of decreasing catch, increased availability of inexpensive gear, and sharing of the fishery with other, unregulated actors.

Spatial and temporal overlap and interaction among fisheries sectors is a major management issue in Antongil Bay and Madagascar overall. A limited continental shelf causes industrial fishers to operate close to shore, with more than two-thirds of industrial shrimp trawler catch in Madagascar occurring within two miles of the coast (Gorez 2000). Although the industrial fishery targets shrimp, finfish by-catch is substantial (by-catch: shrimp ratio estimated at 7:1 to 17:1; Randrianarisoa *et al*. 2005). Low quality by-catch is sold to or collected by traditional fishers, with fishers forced into this practice by their own poor catch rates. Juvenile and adult shrimp harvest by traditional fishers produces conflict, potentially decreasing the productivity of industrial fisheries for shrimp, in turn leading to increased industrial exploitation of finfish as shrimp catch declines. The ecological impacts of trawling are likely to be considerable (e.g. FAO 2001) and traditional fishing gear is often destroyed by industrial trawling. Efforts made during this study to engage the industrial sector were unsuccessful but local NGO activity is currently focused on these issues. The 18 fisher organizations formed during our work provide an important social organization for addressing these issues.

Fisheries management in Antongil Bay should embrace a holistic ecosystem-based approach, incorporating zoning to reduce overlap among sectors, protect essential, heavily exploited habitats and top predators, and reduce destructive gear and industrial trawler by-catch (Pikitch *et al*. 2004). The socio-economic impact of fisheries restrictions should be studied before management action is undertaken, particularly with respect to gender and age. Local populations wish to establish protected areas and restore mangroves degraded for charcoal production. Management must be

sensitive to terrestrial and marine resource health connections and the potential for resource-use shift between these environments. Bay communities use both marine and terrestrial resources, sometimes simultaneously, so marine resource decline could threaten PNM, while reduction in agricultural land availability and productivity could increase the pressure on marine resources.

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