A first assessment of elasmobranch catch in Mauritian artisanal fisheries using interview surveys

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Abstract: Elasmobranchs face severe overexploitation worldwide and data to support effective fisheries management are lacking, particularly for artisanal fisheries. There is a dearth of information on Mauritian fisheries and nothing is known about elasmobranch catches in the artisanal sector. Artisanal fishers (n=92) were interviewed across Mauritius island, to assess the basic characteristics and magnitude of the elasmobranch fishery. Elasmobranchs were targeted using lines and were caught incidentally in nets, but whatever the intent of the catch, sharks and rays were almost always retained to eat or sell. Eleven elasmobranch species were recorded including Sphyrnidae, Carcharidae, Lamnidae, Rhinobatidae (*Rhynchobatus djiddensis*) and Myliobatidae (*Manta* spp*)*. It appears that Mauritian industrial fisheries were responsible for significant shark mortality from the late 1990s until the early 2000s, resulting in severe declines. Currently, elasmobranchs are rarely caught by artisanal fishers and there is no major market for shark fins in Mauritius.

Keywords: bycatch, Chondrichthyes, Mauritius, rays, sharks, small-scale fisheries

Introduction

Over recent decades, the shark fin trade has transformed elasmobranch fisheries from low-value to extremely high-value and c. 63 - 273 million sharks were fished annually between 2000 and 2010 (Worm *et al.* 2013; Eriksson & Clarke 2015). Elasmobranchs are generally long-lived, slow-growing and late-maturing with low fecundity and their fisheries must therefore be managed conservatively (Hoenig & Gruber 1990; Musick *et al.* 2000; Baum & Myers 2004; Barker & Schluessel 2005) However, elasmobranch fisheries are typically data-poor and shark populations are widely reported to be in serious decline (Castro *et al.* 1999; Baum *et al.* 2003; Ward & Myers 2005; Dulvy *et al.* 2014). Many elasmobranch species, especially sharks, are apex predators, and changes in their abundance may adversely affect species in lower trophic levels (Heupel *et al.* 2014; Hussey *et al.* 2015).

At the global level, most elasmobranch catch is taken by industrial fisheries, but the impact of artisanal fisheries is also likely to be extensive, particularly in developing countries (Bonfil 1994; Jacquet & Pauly 2008; Oliver *et al.* 2015). Artisanal fishers

generally focus on nearshore waters, which are important for a number of shark and ray life-history stages (Knip *et al.* 2010). Even when elasmobranchs are not directly targeted by artisanal fisheries, they are often still a valuable component of the catch; in reality, sharks and rays are often more accurately considered as secondary targets rather than waste (Kroese *et al.* 1995; Dulvy *et al.* 2008). The informal nature, geographical inaccessibly, diverse gears and wide range of species that are caught in artisanal fisheries make them particularly difficult to monitor and regulate (Pilling *et al.* 2008). However, fishers' knowledge can provide a useful tool to rapidly collect information on a fishery to advise management efforts (Moore *et al.* 2010; Daw *et al.* 2011).

Mauritius is a small island nation located in the western Indian Ocean, c. 800 km to the east of Madagascar (Figure 1). Although the fisheries sector is not a major contributor to Gross Domestic Product or national employment, artisanal fisheries are important at the local level, both culturally and for coastal livelihoods (Paul 1987; Hollup 2000; Vogt 2001; Sobhee 2004). The country's Exclusive Economic Zone is extensive, spanning Mauritius, Rodrigues, St Brandon (Cargados Carajos Shoals) and Agalega, covering an area of 1.9 million km^2. Mauritian fisheries include industrial (national and foreign fleets), semi-industrial, small-scale commercial, artisanal fleets and recreational fishers (Everett & van der Elst 2010). Mauritian artisanal fishers employ gillnets, large nets, basket traps, lines and harpoons from small fiberglass motor boats in the lagoon on fringing reefs and other nearshore areas around Mauritius and Rodrigues (Ministry of Agro Industry, Food Production and Security 2008). The main groups targeted include Serranidae , Siganidae, Lethrinidae, Lutjanidae, Scaridae, Mullidae, Mugilidae, Acanthuridae, octopus and lobsters (Paul 1987).

Artisanal elasmobranch fisheries are widespread in the western Indian Ocean region but reliable data on the scale of these fisheries are limited (Marshall & Barnett 1997; Smale 2008). Preliminary assessments of shark and ray fisheries have been conducted for the island groups of Chagos (Graham *et al.* 2010), Madagascar (McVean *et al.* 2006; Doukakis *et al.* 2011; Robinson & Sauer 2013) and Reunion (Poisson 2011). The Republic of Seychelles has developed a national plan of action for shark conservation (Nevill *et al.* 2007) and the Indian Ocean Tuna Commission collects basic data on the magnitude of shark bycatch in industrial, semi-industrial and more recently, artisanal fisheries (Indian Ocean Tuna Commission 2015). However, there is a paucity of data relating to marine fisheries in Mauritius (van der Elst *et al.* 2005; Everett & van der Elst 2010). This study aimed to provide a first assessment of the basic characteristics and magnitude of artisanal elasmobranch fisheries in Mauritius.

Materials and Methods

Elasmobranch catch in Mauritian artisanal fisheries was evaluated using structured interviews of fishers and evaluation of existing fishery data. A total of 11 out of the 61 official landing sites on Mauritius island were sampled (Figure 1). Sites were selected to achieve a geographically representative sample using stratified sampling with strata based on the number of fishers registered at each site (Ministry of Agro Industry, Food Production and Security 2008). Fishers were questioned about

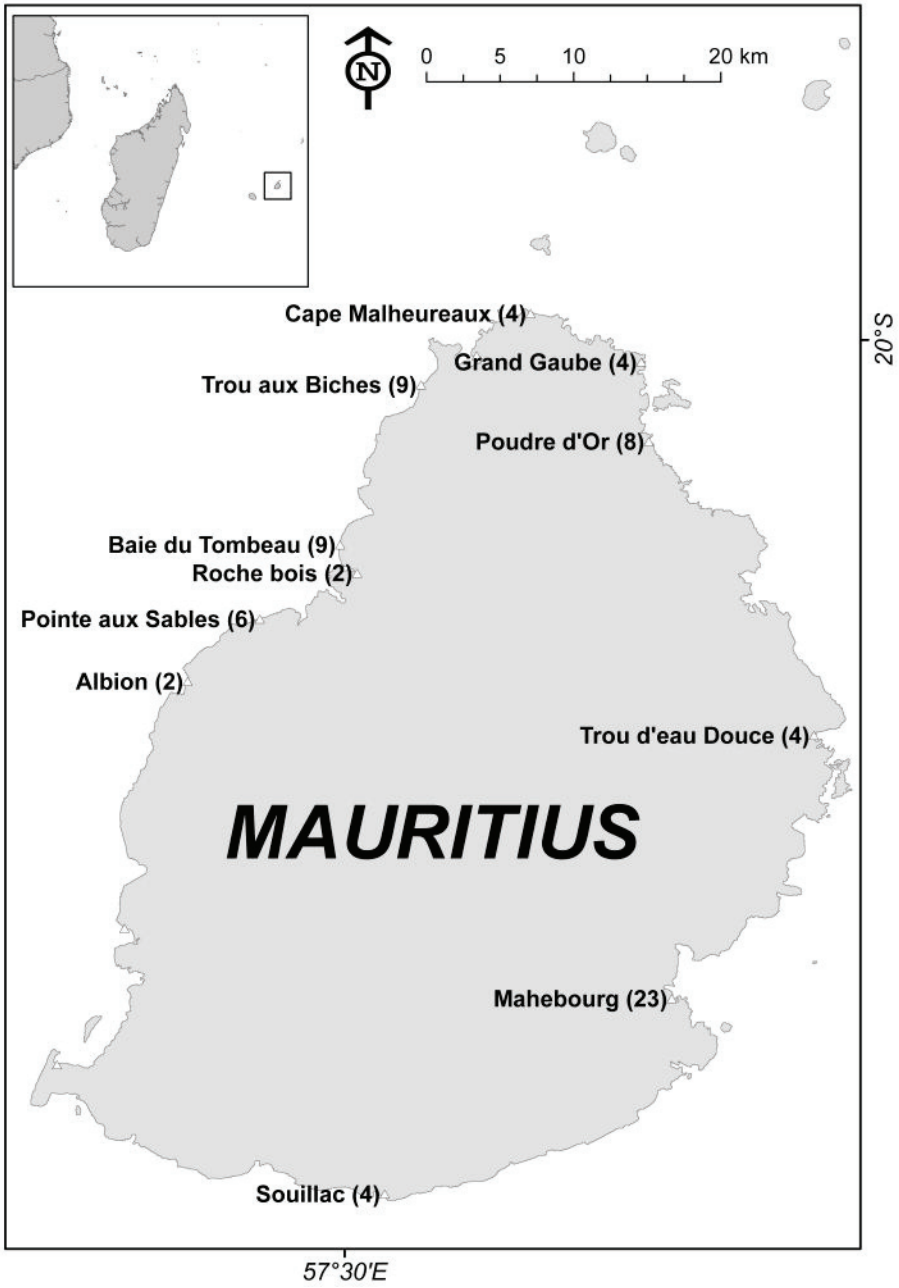

Figure 1. Mauritius, showing fisher interview sites. Inset shows location in the Indian Ocean. Bracketed numbers indicate number of fishers interviewed at each site.

their boat and gear characteristics, relative frequency of catch for each species, whether elasmobranchs were targeted or caught incidentally, spatial and temporal characteristics of fishing sites, market preferences, uses and trade and local attitudes (approach based on Moore *et al.* 2010). Fishers were selected at random and interviewed individually in Mauritian Creole by a team of students from the University of Mauritius. All fishers interviewed gave their prior and informed consent before interview and were given the option to remain anonymous. Images of elasmobranch species were used to clarify identification discrepancies. A total of 92 interviews were conducted out of the estimated 2,078 artisanal fishers (4.4 %) and 1,570 boats (5.9 %) registered on the island (Ministry of Agro Industry, Food Production and Security 2008).

Results and Discussion

Fishing experience of respondents ranged from 5–70 years (mean = 29.0 years), all fishers interviewed worked at least 2-4 days per week and most went to sea everyday (68 respondents, n = 92, 73.9 %). Fishers used boats from 4 m to 12 m (mean = 7.4 m) in length, almost all were motorized (6–100 HP, mean = 17.0 HP). Three main fishing gears were recorded among artisanal fishers: lines, nets and traps; seven fishers also used harpoons as a supplementary gear (Table 1). Lines with 1-20 hooks were the most common gear reported (75 respondents, n=92, 81.5 %) and were used in a wide range of habitats, from 0.1 to 45 km (mean = 10.3 km) offshore. Nets were utilized by 16 respondents (n=92, 17.4 %), 6–500 m (mean = 330 m) long and with a mesh size of 5–15 cm, deployed 0.3-20 km (mean = 5.8 km) offshore. Traps were used by 54 fishers (58.7 %), n=92 and measured 0.7-9 m across, deployed to depths of up to 100 m. Frequency of elasmobranch catch depended on the gear being used, and whether the fisher was actually targeting elasmobranchs or if they were caught incidentally (Table 1). Lines were the preferred gear to target elasmobranchs, and nets were the gear most likely to catch sharks incidentally, with 62.5% of net fishers catching sharks and rays even though they were not actually targeting them (Table 1).

Table 1. Gear distribution for the targeted shark fishery, incidental shark catch and the Mauritian artisanal fishery as a whole (bold text indicates most prevalent gear for each catch category)

	Number of fishers using gear	**Number of fishers using each gear who reported**	
	(N)	Targeted elasmobranch catch	Incidental elasmobranch catch
Longline	75	39 **(52.0%)**	24 (32.0%)
Trap	54	1 (1.9%)	2 (3.7%)
Net	16	1 (6.3%)	10 **(62.5%)**
Harpoon	7	-	-

Most of the fishers interviewed (77 respondents, n=92, 83%) had caught sharks and rays, and out of these, elasmobranchs were targeted (41 respondents, n=77, 53.2 %) and caught incidentally (36 respondents, n=77, 46.8 %) in almost equal proportions. Elasmobranchs caught incidentally were nearly always retained, only one fisher stated that they would release them and one preferred to use them as bait; all others sold or ate any shark catch. Shark and ray meat was sold for between 0.18–2.90 (mean 1.35) US$ kg^{-1}, making it far less valuable than other finfish which retail at 3-9 US$ kg^{-1} (Ministry of Agro Industry, Food Production and Security 2008).

Elasmobranch catches were rare: shark fishers stated that they had caught between 0–30 animals (mean = 3.6) during the last year. Catches were widely considered to be most frequent during the austral summer (December – February). Fishers mainly caught sharks and rays in the open ocean (53 respondents, n=77, 69%). Shark fins were only mentioned by one fisher, who noted the value of dorsal fins, indicating that there was no major local market for them in Mauritius at the time. In general, fishers had highly negative feelings towards sharks, and thought of them as dangerous, destructive, man-eaters.

A total of eleven elasmobranch species were reported by shark fishers around Mauritius and there were no obvious differences between species distribution for targeted or incidental catch (Table 2). *Sphyrna* spp. were most widely caught, although they may have just been most commonly reported because of their recognizable features. Elasmobranch catches included a wide variety of Carcharidae, two Lamnidae, the guitar shark *Rhynchobatus djiddensis* and one mention of *Manta* spp. (Table 2). In terms of conservation status, *Sphyrna lewini* and *S. mokarran* are Endangered and catches also included the Vulnerable *Carcharodon carcharias, R. djiddensis, Isurus oxyrinchus* and *Manta* spp. (IUCN 2015; Table 2).

Table 2. Shark species caught by Mauritian artisanal fishers ordered by frequency of reports and showing conservation status of each species

Species	Number of fishers reporting catches	% shark fishers (n=77) reporting catches	IUCN Red List status[1]
Sphyrna spp.	38	49.4	LC - EN
Galeocerdo cuvier	30	39.0	NT
Carcharhinus limbatus	13	16.9	NT
Triaenodon obesus	10	13.0	NT
Carcharhinus amblyrhynchos	7	9.1	NT
Carcharodon carcharias	6	7.8	VU
Rhynchobatus djiddensis	6	7.8	VU
Isurus oxyrinchus	5	6.5	VU
Loxodon macrorhinus	4	5.2	LC
Carcharhinus leucas	3	3.9	NT
Manta spp.	1	1.3	VU

[1] IUCN, 2015

Inadequate and misleading reporting of shark catches, particularly in artisanal fisheries is widespread (Bonfil 1994; Clarke *et al.* 2006; Jacquet *et al.* 2008; Boistol *et al.* 2011). Mauritius has submitted elasmobranch catches to the Food and Agriculture Organization of the United Nations (FAO) from 1977-2013, ranging from 0-500 tonnes y^{-1}, with a peak of 309 tonnes in 2003 and only 1 tonne reported in 2013 (Food and Agriculture Organization of the United Nations 2014). The Indian Ocean Tuna Commission (IOTC) also holds shark catch records in Mauritian industrial longlines from 2001-2008, ranging from 0-309 tonnes y^{-1}; and in artisanal hand lines from 2011–2013, amounting to 1–3 tonnes y^{-1} (Indian Ocean Tuna Commission 2015). By crudely extrapolating the figures obtained during this study, it is likely that the artisanal fishery in Mauritius is responsible for an elasmobranch mortality of the order of 6,000 sharks per year. Between 1996 and 2011, Hong Kong imported 899,359 shark fins from Mauritius, with a peak of 135,155 fins in 2003 (Clarke 2014); these figures show little correlation with the catch reported to the FAO and IOTC, except for generally increased shark catch and exports in the late 1990s and early 2000s with a peak in 2003.

All shark catches reported by Mauritius to the IOTC were recorded as bycatch (Indian Ocean Tuna Commission 2015) although it is clear from this study that artisanal fishers also directly target elasmobranchs, and almost always retain any shark bycatch. In the current study, net fisheries were found to be the most prevalent gear for incidental captures of sharks, as has been found for several other taxa (Reeves *et al.* 2013; Wallace *et al.* 2013). Shark products are rarely sold locally in Mauritius, except to Chinese restaurants, where shark fin soup is openly available; jaws sell for 20 US$ each (Clarke & Dent 2014) and fins are also traditionally used by the Mauritian-Chinese community as a treatment for renal illnesses (Mahomoodally & Muthoorah 2014; Mootoosamy & Fawzi Mahomoodally 2014).

Mauritius has attempted to reduce fishing pressure within the lagoon by deploying Fish Aggregation devices (FADs) for utilization by artisanal fishers. Sharks are often a significant component of FAD–associated communities (Taquet *et al.* 2007) and so it is likely that much of the shark catch reported here was caught at FADs although no fishers mentioned FADs during interviews.

A total of 61 elasmobranchs including 43 shark species and 18 rays are known to exist in Mauritian waters (Kiszka *et al.* 2009). This study confirmed that at least 11 species are caught by artisanal fishers, including the guitar shark *Rhynchobatus djiddensis* and *Manta* spp. The species recorded corresponded closely with those caught by artisanal fishers in the neighbouring Seychelles (Nevill *et al.* 2007), but contrasted with Mauritian commercial longliners, which primarily land *Prionace glauca* and *Isurus* spp. as bycatch (Mamode 2011; Beeharry *et al.* 2013). It was surprising that *Carcharhinus longimanus* was not reported, because this species is regarded as abundant in the area (Smale 2008). The threatened status of many of the species reported is also cause for concern.

Mauritius' economy depends heavily on international tourism and pristine marine biodiversity, and the presence of sharks increases the desirability of the destination, particularly for divers (Topelko & Dearden 2005; Sobhee 2006). There are dive sites in Mauritius that historically have a reputation for aggregations of sharks,

including the 'Shark Pit' at Flat Island, off Cape Malheureux and 'Passe St Jacques' near Le Morne. The frequency of shark sightings at both sites has fallen significantly in recent years, and local divers commonly blame overfishing (Kiszka *et al.* 2009). Declines of sharks at these sites correspond closely with the peak of shark exploitation in Mauritius mentioned previously.

This study suggests that following heavy exploitation of elasmobranch fisheries in Mauritian waters from the late 1990s until the early 2000s, targeted and incidental catches in artisanal fisheries are now a rare occurrence. The low catches and visible disappearance of sharks from dive sites indicates that elasmobranch populations have significantly declined as a result of overfishing. It is now unlikely that any proliferation in elasmobranch fisheries will occur in the near future because sharks are now so rare that a major targeted fishery is unlikely to arise in the artisanal sector, even if demand for shark products increases.

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