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Assessing the small-scale shark fishery of Madagascar through community-based monitoring and knowledge

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ABSTRACT

Over 90% of those employed in commercial capture fisheries work in the small-scale fisheries (SSF) sector and an estimated 97% of small scale fishers are found in least developed countries. However, the capacity for monitoring SSF globally is low and there is a paucity of data, in particular for remote areas within developing nations. The methods presented here demonstrate a low cost participatory approach for gathering data on small-scale fisheries, in particular for those that take place across remote areas. Community-based data collectors were trained to record biological and socioeconomic data on the traditional (non-motorised) shark fishery in the Toliara region of Madagascar over a six year period (2007–2012). An estimated 20 species of shark were recorded, of which 31% (n = 3505) were *Sphyrna lewini* (scalloped hammerhead), a species listed by the IUCN as Endangered (IUCN, 2016). Although the number of sharks landed annually has not decreased during our survey period, there was a significant decrease in the average size of sharks caught. Despite multiple anecdotal reports of shark population declines, interviews and focus groups highlight the possibility that shark landings appear to have been maintained through changes in gear and increases in effort (eg. number of fishers, time spent fishing), which may mask a decline in shark populations. The numbers of sharks taken by the traditional fishery in our study region was estimated to be between 65,000 and 104,000 year^{-1}, whilst estimates using national export and import of dried shark fin from Madagascar, and shark length data in this study, put total landings between 78,000 and 471,851 year^{-1}. Reliable data on the total volume of sharks landed in Madagascar's waters is scarce, in particular from foreign industrial boats both directly targeting shark species and as bycatch in fisheries targeting other species. There is currently no legislation in place to protect sharks from overexploitation in Madagascar and an urgent need to address the lack of shark fishery management across the traditional, artisanal and industrial fisheries.

1. Introduction

There is a paucity of information on take and bycatch from small-scale, traditional and artisanal fisheries often due to their remoteness, seasonality, and the numerous landing sites and vessels used (Salas et al., 2007). This is despite the fact that over 90% of 120 million employed in commercial capture fisheries work in this sector (Béné et al., 2007; World Bank/FAO/WorldFish Center, 2010). Worldwide, more than one billion people rely on fish as an important source of protein, and it can account for 50% of protein intake in the least developed countries in Africa and Asia (Béné, 2006), where 97% of coastal fishing populations are found (World Bank/FAO/WorldFish Center, 2010). Studies have shown that small-scale fisheries generate a significant proportion of household income. For example, it accounts for 82% of household income in some regions of Madagascar (Barnes-Mauthe et al., 2013), highlighting the importance of sustainable management strategies.

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The recorded global catch of chondrichthyans (sharks, rays and chimaeras) grew rapidly in the latter half of the 20th century, increasing from approximately 270,000 metric tonnes in 1950 to a peak over 900,000 metric tonnes in 2003 (FAO, 2013), largely in response to the increase in the fin market in Asia (Field et al., 2009). However, recent estimates using shark fin market data (Clarke et al., 2006) suggest that FAO figures underestimate the size of the fishery by up to four times; whilst Worm et al. (2013) have estimated that annual shark mortality (including reported landings, dead discards and illegal, unregulated and unreported take) has ranged between 1.41 and 1.44 million metric tonnes from 2000 to 2010 and equates to annual shark mortality of 63–273 million sharks. Sharks are landed both in small-scale and industrial fisheries. Although relative numbers on the volume of sharks landed in specific fisheries are scarce, many countries report significant landings figures from small-scale vessels (Blaber et al., 2009; Cartamil et al., 2011).

Accurate assessments of shark mortality across all fisheries are confounded by the fact that many sharks are finned at sea and discarded or discarded whole, as well as subject to Illegal, Unreported and Unregulated (IUU) fishing (Biery et al., 2011; Worm et al., 2013). These factors have led to a severe underreporting at all scales of fishing activity, from direct take to bycatch (Varkey et al., 2010; Le Manach et al., 2012). This underreporting and lack of official data means that managing shark fisheries presents a significant challenge, whilst threatening the long-term sustainability of these fisheries, and those that rely on them for their livelihoods and food (Shehe and Jiddawi, 2002; Vieira and Tull, 2008; Cartamil et al., 2011).

Sharks and other chondrichthyans are particularly vulnerable to overexploitation through direct take and bycatch due to their relatively slow growth and reproduction rates (Camhi et al., 1998). Coupled with the degradation of marine habitats, this has led to the decline in chondricthyan population numbers worldwide (Baum et al., 2003; Baum and Myers, 2004; Cortés et al., 2006; Ferretti et al., 2008; Hayes et al., 2009). As a result, there has been an increase in the number of shark species listed on the IUCN Red List, with a quarter of species estimated to be threatened with extinction, primarily due to overfishing (Dulvy et al., 2014; IUCN, 2016).

The status of shark fisheries in the Western Indian Ocean is poorly known (Kroese and Sauer, 1998; Le Manach et al., 2012). The rise in shark fishing in Madagascar coincided with the increase in demand for shark fins in Asia (Cooke, 1997), although shark fishing was known as far back as the 1950s (Fourmanoir, 1961; Cooke, 1997). Recorded exports increased rapidly in the late 1980s from 3 t in 1987 to almost 29 t in 1992, with a concurrent rise in local price for shark fin, and the majority of exports going to Hong Kong and Singapore (Cooke, 1997; Cripps et al., 2015). Official imports of shark fins to Hong Kong and Singapore from Madagascar, show growth from 34.5 t in 1986 to a peak of 64.7 t in 1995 (Le Manach et al., 2011, 2012). Despite discrepancies between export and import data (Le Manach et al., 2011, 2012; Cripps et al., 2015), overall trends show export data from the *Ministère des Ressources Halieutiques et de la Pêche* (MRHP) and imports of shark fins both peaking in the early to mid-1990s and declines until the early 2000′s; with increases again from 2004 (Cripps et al., 2015). In addition, there are reports of decreases in shark landings (Laroche and Ramananarivo, 1995; McVean et al., 2006) but shark fins remain a highly valuable marine resource, with the meat retained for local consumption (Cripps et al., 2015).

Previous studies estimate that around 30 chondricthyan species are regularly taken in Madagascar's coastal shark fisheries (Cooke, 1997), that are classified as traditional (local sailing boat which could include a motor) or artisanal (boat with a <50 hp motor) (Repoblikan'i Madagasikara, 1993, 1994). Active shark fisheries have been highlighted along much of Madagascar's coastline, with the SW and NE regions remaining hotspots for fishing and the trade of sharks and their fins (Cooke, 1997; Pascal, 2003; McVean et al., 2006; Doukakis et al., 2007; Robinson and Sauer, 2013). For example, in two villages in SW Madagascar, it was estimated that a total of 123 t of sharks were landed over a 13-month period (McVean et al., 2006).

High numbers of sharks are also landed as direct catch by national and international industrial boats fishing in Madagascar's waters (Randriamiarisoa, 2008; Le Manach et al., 2012; Cripps et al., 2015). Industrial bycatch of sharks has also been reported in the Malagasy longline fleet (Rahombanjanahary, 2012). Madagascar has also signed fishing access agreements with at least 10 fishing partners since 1986 (eg. countries, groups of countries such as the EU, private companies) with an estimated >100 foreign vessels allowed to operate in Madagascar's EEZ (M. Andriamahefazafy unpublished data; Le Manach et al., 2012; Cripps et al., 2015). Furthermore, reported landings demonstrate some foreign vessels are clearly targeting sharks in Madagascar's waters, with Spanish longliner vessels landing 152 MT of sharks compared to 13.98 MT of tuna in 2011 (European Commission, 2013). Le Manach et al. (2012) reconstructed total fisheries landings for Madagascar and estimated that the total catch of sharks is over 8000 t y^{-1} (3800 t y^{-1} domestic catches and 4300 t y^{-1} of catches by foreign vessels).

Here we present the first multiyear assessment of the status of the traditional (non-motorised) shark fishery in Madagascar that lands both sharks and guitarfish species (Rhinobatidae), primarily for their fins. This study set up a network of trained community-based data collectors in order to facilitate landings data collection over an inaccessible coastline, whilst building capacity for participatory fisheries monitoring. The results of this study are contextualised with available information on Madagascar-wide shark catch.

2. Methods

2.1. Study area

The study was conducted in 24 villages in two regions on the southwest coast of Madagascar, within the province of Toliara. Data collection took place in twelve villages surrounding the village of Andavadoaka (region 1; Fig. 1; Table 1) (22°04′19.94″S, 43°14′20.00″E), approximately 150 km north of the regional capital of Toliara from 2007 to 2012. Data collection took place in a further twelve villages and islands surrounding the village of Belo-sur-Mer (region 2; Fig. 1; Table 1) (20°55′4.92″S, 44°23′25.65″E), approximately 60 km south of the city of Morondava from 2008 to 2012. The study spanned over 175 km of coastline from Antsepoke in the south (22°15′50.14″S, 43°13′34.80″E) of region 1 to Ampatiky (20°8′40.15″S, 44°22′10.55″E) in the north of region 2, as well as three offshore islands in region 2 (Nosy Be, Nosy Andravoho and Nosy Andriamitaroke) inhabited by migrant fishers. Region 1 is characterised by two distinct fringing and barrier reef systems separated by a 5 km wide channel in which are situated several patch reefs. Region 2 lies at the northern end of a 55 km long coral reef system, running roughly parallel to the shore at a distance of 10–15 km. This ancient, submerged barrier reef system, with its seven islands and associated shallow reef crests, extends over 600 km to the north.

The human populations in these coastal villages and islands are almost entirely composed of *Vezo* fishers and their families, seminomadic fishers who rely exclusively on the marine environment for their livelihoods (Astuti, 1995). The Toliara province has an estimated 186,658 fishermen (Cornell Census, 2001). All fishing is carried out using pirogues (small sailing canoes) or walking with nets, lines or spears, limiting most fishing effort to the nearby reef systems, with fishing at deeper, offshore sites only possible during favourable sea conditions.