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# A preliminary value chain analysis of shark fisheries in Madagascar

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Programme for the implementation of a
Regional Fisheries Strategy for the
Eastern and Southern Africa – Indian Ocean Region

# A preliminary value chain analysis of shark fisheries in Madagascar

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ANGAP | Association Nationale pour la Gestion des Aires Protégées |
| ASH | Autorité Sanitaire Halieutique |
| BAD | Banque Africaine de Dévelopement |
| CBD | Convention on Biological Diversity |
| CCPS | Cellule de la Coordination de la Politique Sectorielle/MPRH |
| CLB/VOI | Communauté Locale de Base/Vondron'Olona Ifatony |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| COI | Commission de l'océan Indien |
| COS | Certificat d'Origine et de Salubrité |
| CSP | Centre de Surveillance des Pêches |
| CMS | Convention on Migratory Species |
| DGRH | Direction de la Gestion des Ressources Halieutiques/MPRH |
| DPRH | Direction de la Pêche et des Ressources Halieutiques/MPRH |
| DRPR | Direction Régionale de la Pêche et des Ressources Halieutiques |
| FAO | Food and Agricultural Organization of the United Nations |
| RFMO | Regional Fishery Management Organization |
| GEF | Global Environnement Facility |
| GTZ | Gesellschaft Für Technische Zusammenarbeit |
| IPOA | Sharks – International Plan of Action for the Conservation and Management of Sharks |
| IOTC | Indian Ocean Tuna Commission |
| IUU | Illegal, Unregulated and Unreported |
| JICA | Japan International Cooperation Agency, Agence Japonaise de Coopération Internationale |
| MAEP | Ministère de l'Agriculture, de l'Elevage et de la Pêche |
| MGA | Malgasy Ariary |
| MNP | Madagascar National Parks (previously ANGAP) |
| MPRH | Ministère de la Pêche et des Ressources Halieutiques |
| NGO | Non Governmental Organisations |
| SWIOFP/OISO | South West Indian Ocean Fisheries Project, Programme de l'Océan Indien Sud-Occidental |
| UNGA | United Nations General Assembly |
| WIO | Western Indian Ocean |
| WWF | World Wild Fund for Nature |

# EXECUTIVE SUMMARY


Madagascar's extensive (~6,500 km) coastline comprises the most diverse and extensive shallow marine habitats in the Western Indian Ocean, supporting an estimated 123 shark and ray species. Sharks have featured in Madagascar's fisheries for at least 100 years, with exports recorded as early as the 1920's. Globally, shark fins are one of the most highly valued seafood items and represent a critical and significant source of cash for some of Madagascar's isolated fishing communities.

The global shark fin trade is estimated to be worth between US$400-500 million a year. Increases in the shark trade over the last two decades is closely linked to economic growth in China, where the market is concentrated, and the ripple effects of this increase in demand have been felt worldwide. Scientific estimates for the number of sharks killed annually can be up to 100 million individuals and sharks are on the whole overexploited. Today, thirty percent of all shark and ray species are now classified as 'Threatened' or 'Near Threatened' with extinction according to the IUCN Red List, although this number is likely to be higher given that the status of almost half (47%) of shark species cannot be scientifically assessed due to a lack of data.

There is strong evidence that shark overexploitation occurs in Malagasy waters and that shark populations in the area are declining rapidly. Although reliable figures on Madagascar's domestic shark fishery are sparse, anecdotal observations report declines in shark numbers within the last two decades. According to national studies based only on official export data, recorded shark fin exports stood at approximately 32 tonnes in 2010, a decrease from 65 tonnes in 1994. Lack of data on catches, particularly from artisanal fisheries, bycatch by licensed industrial vessels, and by illegal, unregulated and unreported (IUU) fishing by foreign industrial vessels, means these official export figures are likely to be gross underestimates of the actual production.

Madagascar's shark fishery is comprised of three main fisheries according to Malagasy legislation: artisanal, traditional and industrial fisheries. Madagascar's artisanal and traditional shark fisheries extend along the entire west coast, with the most important traditional fisheries along the southwest coast. Overfishing has led to fisher migration, spreading the fishery along the entire west coast and also much of the north. There is no established traditional shark fishery along the east coast due to adverse sea conditions, whilst the south is the least developed of all sites surveyed for this report. Throughout the country, surveyed fishers report catching shark for the purposes of income from selling fins (88%) and meat (77%), and as a source of food (31%), demonstrating the important link to the international shark fin trade. Shark fin exports reach the international market mostly through two principal buyers and exporters, namely the Sea Reine and Sin Hing, Chinese companies based in Antananarivo.

The supply chain for shark fins is both complex and rather fluid with fishers selling either fresh (wet) or dried fins to collectors and fins graded in value according to size and quality. Some fishers bypass the local collectors and sell dried fins directly to main buyers in larger towns to obtain a better price, which can be a mark-up of 40% for high quality fins. The value of shark fins during the study period (2012) varies according to their condition (wet or dried), quality (four recognised grades) and their position in the supply chain. Robust data was collected for the first two levels of the supply chain but was lacking for the higher levels (main buyer to exporter). Guitarfish fins were on the whole, twice as valuable as shark fins and therefore both in demand and a fishing target. Since 2012 the average value of shark fins has dropped.

Trade in shark meat is also well establishedin Madagascar, with meat sold into a supply chain that serves mainly local and national (provincial) markets but can also be exported to the Comoros. Shark meat does not fetch a high price compared to other fish or meats but can be an important supplementary source of income or nutrition in some cases. Generally fresh meat is sold and consumed locally whilst dried salted meat is bought by collectors and transported to inland urban markets in Madagascar. Some dried shark meat is also exported.

Foreign commercial fishing fleets have also been prevalent in Malagasy waters since at least the 1980's and primarily target shark and larger pelagic fish, with significant shark bycatch for those fisheries not directly targeting sharks. Almost none of the sharks caught are landed in Madagascar. IUU fishing within Madagascar's Exclusive Economic Zone (EEZ) is a well-established issue, with the shark fishery specifically targeted by both licensed and unlicenced vessels.

Despite the significant pressures on Madagascar's shark fishery and the enormous socio-ecological and economic value of the trade, the country has no coherent or functioning shark conservation strategy or legislation. The lack of a national strategy is largely due to deficiencies in data on fishing effort, catches, landings and discards in all commercial fisheries for shark. This is compounded by a paucity of information on shark ecology, fisheries status and the socioeconomic value of the trade throughout Madagascar. Furthermore, in isolated coastal areas with little infrastructure, the sale of high value dried shark fins has been one of the few ways local Malagasy fishermen can earn cash. In this context, the diverse and unconnected stakeholders have no basis or motivation to enact meaningful conservation measures, particularly when economic imperatives outweigh any other consideration. In a country as poor as Madagascar, even minor poverty relief is important, leading fishers to continue shark fishing despite low catches and diminishing returns for fishing effort, further threatening the future of the fishery.

There is an urgent need to actively and aggressively manage Madagascar's shark fishery. The rapid decline of sharks is likely to have several negative socioeconomic and ecological impacts, including the loss of livelihoods and protein for those people who rely on them and potentially altering the trophic structure of marine and coastal ecosystems. However, putting in place conservation measures and enforcing regulations remains a formidable challenge. Much of Madagascar's fishery takes place in remote fishing grounds scattered over thousands of kilometres of coastline; the fishers are highly mobile and move great distances to seek productive fishing grounds; the government lacks the means to monitor these fisheries and enforce regulations; and the markets are informal and closed.

Significant steps must be taken in order to effectively prevent the collapse of Madagascar's shark fishery. A widespread campaign to regulate both international and local shark fishing must occur simultaneously for any significant positive change to occur. For this to take place scientifically robust data must be collected over the long term. For any national conservation strategies to be implemented effectively, they should be based on data collected through participative monitoring and implemented at the national level. Such strategies should apply to artisanal and traditional fisheries, as well as to international commercial fishing vessels operating within the EEZ. Madagascar's existing locally-managed marine areas are a vehicle through which coastal shark management strategies could be implemented. However an increase in both technical and logistical capacity will be required for effective management at the local, regional and national level, together with strong enforcement support to LMMAs.

Although it is recommended that the government develops appropriate national legislation and put in place proper monitoring and export restrictions, the onus remains heavily on the international community, with global legislation driving the regulation or lack of regulation of the global shark trade. Particular attention needs to be paid to those countries with distant water fleets / vessels operating within Madagascar's EEZ, both legally and illegally. Without proper regulation of their shark fishing effort, partly through RFMO's, little progress can be made.

# Introduction

# INTRODUCTION

## General Overview

Overfishing is causing dramatic declines in shark populations throughout Madagascar, as in almost all other Indopacific coastal nations. Sharks and other elasmobranchs constitute high value fisheries, targeted for international export by many countries including those in Europe, Asia and North America, primarily to Chinese markets. As apex predators, sharks play a fundamental role in marine food webs, and their overfishing is likely to have a strong detrimental effect on the sustainability of Madagascar's marine ecosystems, from benthic coral reefs to pelagic environments.
A chronic lack of monitoring data for Madagascan shark fisheries means that little is currently known about the status or problems facing the fisheries, in particular the scale, temporal characteristics and species composition of shark landings, as well as the trade of shark products. What little data exist are generally restricted to official records of national exports, which are likely to be significantly under-reported. An unknown component of shark catches is also exported illegally, for which there are currently no data. It is thought that some exports leave Madagascar illegally via ships from various ports as a way of avoiding taxation on these expensive items. Such factors make the estimation of total catches in the country a complex and difficult challenge due to the large number of landing sites and a lack of monitoring and enforcement.
There is currently no legislation in place to limit fishing effort for sharks in Madagascar, or to control export of landings. Given the enormous challenges facing fisheries monitoring, control and surveillance (MCS) in Madagascar's extensive coastal waters and EEZ, any future effort to legislate for sustainable management of these fisheries, for example through limiting fishing effort, is likely to be largely ineffective. Future legislation aiming to improve the sustainability of the fisheries should approach the problem from a higher level of the supply chain, possibly through regulating trade and/or export.
Understanding the nature and scale of existing markets for the shark fisheries in Madagascar, as well as their economic importance to the country, will be a fundamental prerequisite to the improvement of monitoring and reporting systems and the development of any future fisheries management legislation. For example, better understanding of the beneficiaries and economic contributions of these fisheries will enable predication of potential impacts of future fisheries management, both positive and negative. Such information is currently lacking for shark fisheries within Madagascar. There is an urgent need to undertake a full market analysis in order to understand the nature of these fishery supply chains, as well as their importance to Madagascar's fishing economy.

## Value Chain and Shark Trade Analysis - Rationale

Characterising the trade in shark fins at the local level is critically important. Domestic commodity chains need to be understood in terms of structure and incentives along the chain if effective policy is to be designed and implemented. Accurate information on the volume of trade in shark products, and examining the role of trade regulation for conservation and sustainable use, is needed considering the importance of international trade in driving the global exploitation of shark populations (FAO, 2009).
Monitoring of shark fisheries and trade needs to be substantially improved for conservation and management measures to be implemented successfully. However, few shark fishing states are committed to collecting the level of data required to inform and implement management measures (FAO, 2009; Fowler and Séret, 2010).
The absence of reliable statistics for the volume and trend of international trade in shark species is a major hindrance to formulating management plans aimed at limiting overexploitation. Alternative methods for estimating harvest levels have been developed for species mainly taken for international trade (e.g. Clarke et al. 2006); monitoring trade volumes can act as a proxy for the scale of shark catches. A number of complications in estimating volumes and trends of international trade include: discrepancies between source data (i.e import and export records) and the lack of taxonomic resolution across the market chain allowing the verification of trade and catch information (FAO, 2009).
The analysis of trade structure is important in circumstances where compliance is limited because it can highlight gaps where management intervention could be most effective. The difficulties surrounding shark management illustrate the importance of using various complimentary techniques including trade-based studies to assess exploitation rates and population status (Stevens et al. 2000).

## Study Objectives

This study aims to assess existing markets for both traditional and artisanal shark fisheries in Madagascar to better understand the nature of relationships and linkages among buyers, suppliers, exporters and other market actors. In doing so, this analysis will provide information that will help to quantify the financial benefits brought to Madagascar as a result of trade and export in these two fisheries. A review of existing information on shark takes by industrial fishing vessels in Madagascan waters was also undertaken, which also highlights the potential for lost revenue from sharks caught by large-scale fishing.

To achieve the main objectives, this market analysis seeks to address the following key questions:

1. Who are the key stakeholders in collection, sale and export trades of shark products in Madagascar?;
2. What are the respective roles and interests of different stakeholders?;
3. What are the main fishing gears and techniques used?;
4. What are the collection activities and processes for shark products, plus the, organisation and logistical issues along the supply chain for these fisheries?;
5. What is the flow of product, information and payment along the chain for the fisheries?;
6. What are the relative values of shark products at different levels of the supply chain?;
7. What are the product requirements for collectors and exporters, in terms of species, volume, quality, packaging, delivery schedules, grades and standards?;
8. What are the external influences (eg. regulatory requirements, policies, etc.) for trade and export in the fisheries?

## Survey Design and Methodology

The analysis was comprised of two main components. The first part focused on a general industry/market assessment for all shark fisheries (traditional, artisanal and industrial-based) using existing literature and available secondary data.  The second component was an interview-based assessment of the traditional and artisanal shark fisheries conducted in order to build up a detailed supply chain map covering, as far as possible, the key questions outlined above.

The supply chain mapping exercise included both upstream and downstream components of the supply chain for both fisheries. The fishers, village-level assemblers/processors and local traders/collectors constitute the upstream part of the chain, and were sampled at key sites in coastal towns and villages along the west coast of Madagascar.  An assessment of the downstream players; trading firms, buying stations and exporters in Antananarivo and other key cities, was also undertaken.

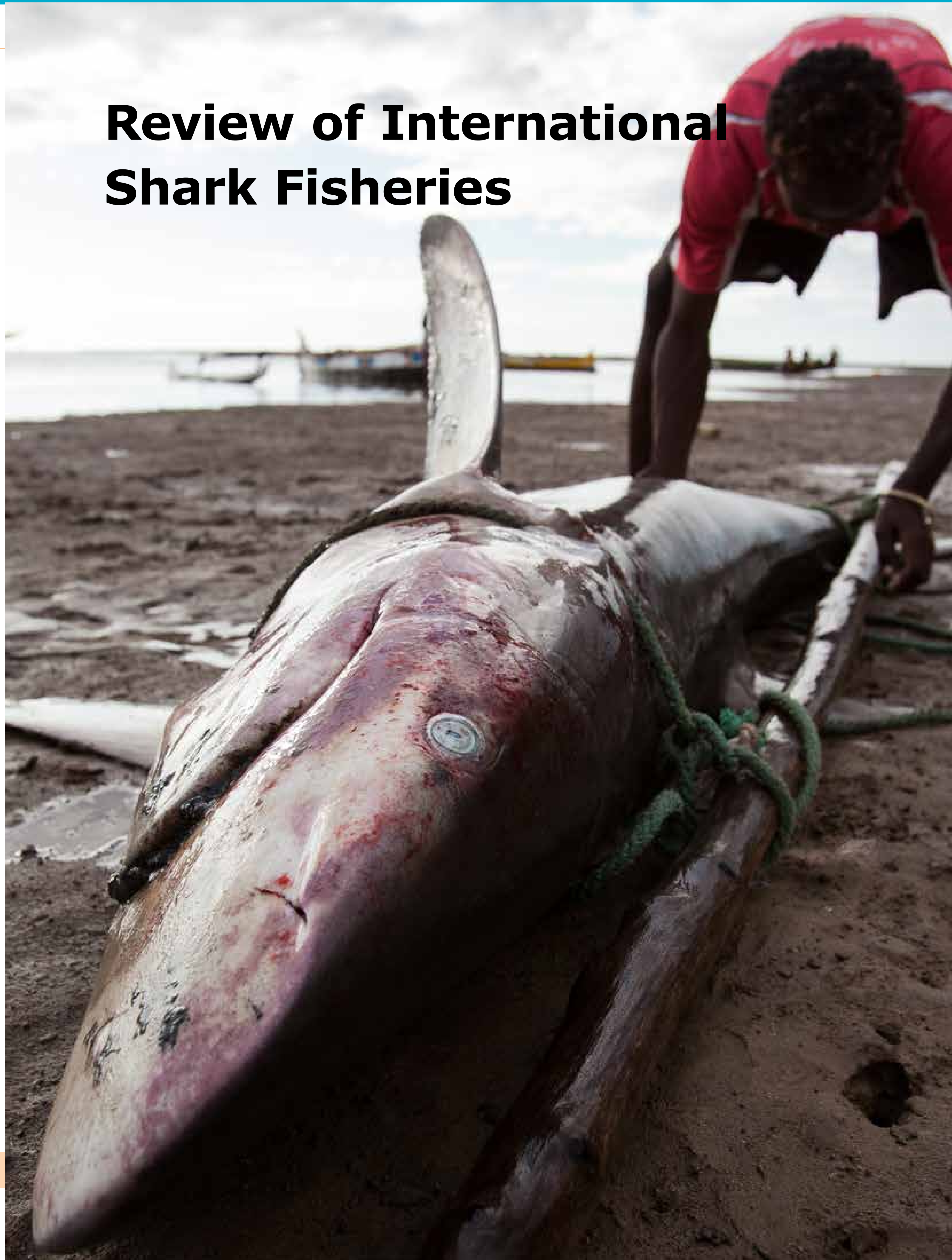
Shark fishers were interviewed using semi-structured questionnaires (Appendix 1) to derive information on quantity of collection, specific activities and cost schedules, technologies/practices, grades/standards being employed and information about their major buyers. Traders/middlemen and processors were interviewed to understand procurement, processing and distribution related activities and costs, as well as prices and margins. Interview techniques consisted of one-to-one, focus group and key informant interviews.

The mapping exercise was both qualitative and quantitative. The qualitative part involved identifying the players and their roles, the relationships/linkages among players, the product requirements, the activities/processes along the chain as well as logistical and policy issues. The quantitative part entailed the construction of a costs and earnings schedule covering the entire upstream and downstream components of the supply chain.

Information was collected during interviews on the trade of all types of shark products (fins, meat, teeth, jaws) but the main data presented in this report is for the established trade in fins for export and meat for human consumption (mainly nationally).

The location sites of the interviews along the west coast are depicted in a series of figures in Appendix 2. The main locations were the cities of Toliara, Morombe, Morondave, Maintirano and Mahajanga and their surrounding towns and villages.





# Review of International Shark Fisheries

# REVIEW OF INTERNATIONAL SHARK FISHERIES

Commercial shark fisheries exist throughout the world.[1] Sharks are caught primarily for their fins for making shark fin soup and for their meat, but also for their cartilage, liver oil and skin (Morgan, 2010). Economic growth in Asia, particularly China, has markedly increased the value of shark fins, driving the commercial exploitation of sharks worldwide. Trade in shark fins has expanded on a global scale, with trade through Hong Kong growing at six percent a year between 1991 and 2000 (Clarke et al., 2004a). An increasing demand for shark fins has been accompanied by a significant increase in global prices, making shark fins one of the most valuable seafood commodities (Abercrombie et al., 2005). Both industrial and subsistence fisheries worldwide have increased shark catches in order to meet this demand (Rose, 1996). In some cases, the Food and Agricultural Organisation of the United Nations (FAO) and some governmental and non-governmental organisations (NGOs) have assisted in the development of targeted shark fisheries as a development tool (Rose, 1996). An analysis of the Hong Kong shark fin trade in 2000 estimated that between 26 and 73 million sharks are killed a year (Clarke et al., 2006). As many as 100 million sharks are caught a year if those targeted for other products such as meat are included (Worm et al., 2013).

## Drivers of shark fishing

### Meat

While shark meat has been eaten for thousands of years (Vannuccini, 1999), it is only over the past several decades that there has been an increasing demand for it in certain regions (Gilman et al. 2007). It is worth far less than shark fins or the meat of more popular pelagic fish species, such as tuna and swordfish (Anak, 2002). The high urea content of shark meat makes it more difficult to process and less paletable than meat from most fish species (Vannuccini, 1999). However, the meat of shortfin mako, thresher and porbeagle sharks is traded in the European and U.S. seafood markets and for sashimi in Asia (Vannuccini, 1999). Many smaller species, such as the spiny dogfish, are also commonly used for food (Vannuccini, 1999; Ketchen, 1986). Other shark species, such as blue and hammerhead sharks, are targeted only for their fins because of the poor quality of their meat (Vannuccini, 1999).

### Fins

Economic growth in China has increased the value of shark fins, driving the commercial exploitation of sharks worldwide (Clarke et al., 2004a; Clarke et al. 2007). Within China, economic, traditional and cultural factors drive the shark fin trade (Clarke et al., 2004b). Shark fins are sold in several forms, including wet, raw, semi-prepared and fully prepared; fin nets; and "ready to eat" (Verlecar et al., 2007). Fins are graded by type, size and color, each of which affects the price (Verlecar et al., 2007). In Hong Kong, fins are placed in 30 to 45 market categories (Xiang et al., 2005). From 1985 to 1998, shark fin imports to Hong Kong and Taiwan increased by more than 214 and 42 percent respectively (FAO, 2001; Vannuccini, 1999). Shark fins are considered one of the most valuable food items in the world (Fong & Anderson, 2002), reaching prices as high as US$700 per kg (Clarke et al., 2004b). The minimum value of the global trade of shark fins has been estimated at $400 million to $550 million a year (Clarke et al., 2007). The high value of fins and increasing demand has meant that the market for shark fin reached to the remotest coastlines in countries such as Madagascar, where fins fetched up to US$52 a kilogram for wet fins in the early to mid 2000's (McVean et al., 2006). It also encouraged illegal, unregulated or unreported (IUU) fishing for sharks, increasing IUU fishing effort, just as global and regional regulations began to emerge (Lack & Sant, 2008).

1 *"Sharks: The State of the Science" by Morgan (2010), provides a detailed review of shark fisheries and the state of shark populations; much of this introduction is drawn from this review.*

### Oil, cartilage and other products

Several parts of sharks are used to treat a wide range of human illnesses (Walsh et al., 2006; Ostrander et al., 2004). Research has been conducted into the use of shark liver oil in the treatment of cancer (Lewkowicz et al., 2006; Hajimoradi et al., 2009); bacterial, viral and fungal infections (Lewkowicz et al., 2005); and the treatment of illnesses caused by poor immune responses (Lewkowicz et al., 2006). Squalene, found in the liver oil of all sharks, is an adjuvant that stimulates the immune system and is used in several vaccines (Saul et al., 2005; Clarke et al., 2009; Fox, 2009). It is also an important constituent of numerous products, including cosmetics and in the production of vitamin A (Vannuccini, 1999). Though research has suggested that shark cartilage may be used in the treatment of cancer (Walsh et al., 2006; Hassan et al., 2005), is it not clear whether it effectively inhibits cancer growth (Loprinzi et al., 2005; Ostrander et al., 2004).
Shark skin is used as leather (Anak, 2002) and as food (Vannuccini, 1999). Jaws and teeth are sold as souvenirs, and sharks can be used in fishmeal and as fertilizer (Rose, 1996).

## Commercial shark fishing

Commercial fisheries target sharks throughout the world, where almost all large-bodied species of shark are taken, primarily for their fins and meat but also for their cartilage, liver and skin (Visser, 2002; Vannuccini, 1999). Directed shark fisheries are characterized by a "boom and bust" pattern, with high initial catches that rapidly diminish, and little recovery of the species even if fishing is restricted. There are several well-documented collapses of directed shark fisheries in developed counties, including: the spiny dogfish (*Squalus acanthias*) (Ketchen, 1986; Hoff and Musick, 1990; Holden, 1968); soupfin (or school) sharks (*Galeorhinus galeus*) (Olsen, 1959; Ripley, 1946); porbeagle sharks (*Lamna nasus*) (Anderson, 1990; Campana et al. 2001; Campana et al. 2008); and sandbar and dusky (*C. obscurus*) sharks (Cortés et al. 2006; National Marine Fisheries Service 2006).
While these and some other directed shark fisheries are well-documented, globally the status of most other shark fisheries is unknown. Most such fisheries operate in the Indo-Pacific region, where shark biodiversity and endemism is high. For example, India and Indonesia are two of the top shark-fishing nations by recorded landings, but little is known about the species composition in these fisheries (Camhi et al., 2009). This suggests that many rare or range-restricted sharks may be in danger of biological extinction.

## Shark bycatch fisheries

Sharks are caught as bycatch throughout the world's oceans, in fisheries that use surface, mid-water and bottom longlines, drift and set gill nets, and trawls. The amount of shark bycatch varies among fisheries and typically depends on the gear used and location (Gilman et al., 2008). The global distribution of blue sharks means that they make up a particularly large fraction of shark bycatch in pelagic fisheries (Smith, 2001; Nakano & Seki, 2003; Gilman et al. 2008).
Several pelagic longline fisheries that target tuna and swordfish (*Xiphias gladius*) have high levels of shark bycatch (Bailey et al. 1996; Herber and McCoy, 1997; Gilman et al., 2008; Mandelman et al. 2008) and are a major cause of mortality for many shark species (Gilman et al., 2007; Mandelman et

al., 2008). Table 1 summarises shark bycatch rates for industrial longline fisheries that have reliable data. In pelagic longline fisheries throughout the world for which there is data, sharks frequently make up more than a quarter of the total catch (target and bycatch). In general, shallow-set pelagic longlines and those that use wire leaders or squid for bait have the highest levels of shark bycatch (Gilman et al., 2008).

**Table 1. Summary of shark bycatch for industrial longline fisheries for which reliable data exist (source: Morgan, 2010)**

| Fishery | Shark bycatch (% of total bycatch) | Reference |
|---|---|---|
| Western Pacific Ocean | 27% | Bailey et al., 1996 |
| Subtropical pelagic fisheries | 18% | Herber & McCoy, 1997 |
| U.S. pelagic longline tuna-and-swordfish fishery (1992 - 2003) | 25% | Abercrombie et al., 2005 |
| Southeastern U.S. pelagic fishery (1992 - 2000) | 15% | Beerkircher et al., 2002 |
| Australian tuna-and-billfish fishery; Fiji tuna fishery | 32% | Gilman et al., 2008 |
| South African fishery (1998 - 2005) | 16% | Gilman et al., 2008 |
| Portuguese waters, semi-pelagic fisheries | 33% | Erzini et al., 2001; Coelho et al., 2005 |

Sharks are reported to make up part of the bycatch in a range of other industrial fisheries, including: coastal trammel net fisheries (Monteiro et al., 2001), shrimp trawl fisheries (Martinez & Nance, 1993; Stobutzki et al., 2002; Shepherd & Myers, 2005) and some industrial trawl fisheries (Zeeberg et al., 2006).

## State of fisheries

Sharks are K strategists and apex predators, exhibiting low fecundity, slow growth and late maturity (Camhi et al., 1998). Consequently they are particularly vulnerable to overfishing and current fisheries are unsustainable (Schindler et al., 2002; Clarke et al., 2007; Dulvy et al., 2008; Graham et al., 2010). Globally, large shark populations have declined by 80% or more% (Lotze & Worm 2009). Thirty percent of all shark and ray species are now classified as 'Threatened' or 'Near Threatened' with extinction, according to the IUCN Red List[2]. This number could be much higher given that the status of 47% of shark species cannot be scientifically assessed because of a lack of data (Camhi et al. 2009).
Throughout the world's oceans, the status of shark fisheries for which reliable data exists show that the vast majority are overexploited (Table 2). Some populations, such as those of the porbeagle shark in the northwestern Atlantic and spiny dogfish in the northeastern Atlantic, have been reduced by up to 90%.

2 *http://www.iucnredlist.org/*

**Table 2. Summary of the status of shark fisheries for which reliable data exist (source: Morgan, 2010)**

| Shark fishery | Population and fishery status | Reference |
|---|---|---|
| Sandbar sharks, Northwest Atlantic Ocean | depleted by 64 to 71%; overfished | NMFS, 2006 |
| Dusky sharks, Northwest Atlantic Ocean | declined by at least 80%; overfished | Cortés et al., 2006; NMFS 2009 |
| Hammerhead sharks, Northwest Atlantic Ocean | declined by 83% from 1981 to 2005; overfished | Hayes et al., 2009 ; Jiao et al., 2009 |
| Blacknose sharks, Northwest Atlantic Ocean | at about 20% of unexploited levels in 2005; overfished | NMFS, 2006; NMFS, 2009 |
| Porbeagle sharks, Northwest Atlantic Ocean | at 10 to 20% of "virgin" levels; overfished | Campana et al. 2008; NMFS 2009 |
| Shortfin mako shark, North Atlantic | at about 50% of virgin levels; approaching an overfished status | ICCAT 2008; NMFS 2009 |
| Spiny dogfish, Northeast Atlantic | less than 10% of unexploited levels | ICES 2006 |
| Sandbar sharks, northern shark fisheries, Western Australia | biomass caught is 35 percent of virgin levels | McAuley 2008a |
| Demersal gillnet and longline fishery, Western Australia | Gummy shark population is acceptable; Dusky and sandbar shark populations are depleted | McAuley 2008b |

## Impacts of shark fishing

The rapid decline of shark populations has several negative outcomes, including the loss of livelihoods and protein for those people who rely on them, changing the trophic balance and structure of marine ecosystems and the irreplaceable loss of genetic value of one of the most stable and successful taxonomic groups on earth (Kitchell et al., 2002).
Sharks are top predators, have generalist diets, are highly connected within food webs and are often the primary or sole predator of other marine megafauna (Ferretti et al., 2010). They exert a top-down control on food webs and play a major role in maintaining ecosystem structure and function (Stevens et al., 2000; Piraino et al., 2002).
Although the ecological effects of shark removal are difficult to research and quantify, ecosystem models and some empirical studies show that the loss of sharks can cause dramatic and unpredictable changes in marine ecosystems. The elimination of sharks can alter ecosystems through trophic cascades (Dulvy et al., 2004) and mesopredator release (Ferretti et al., 2010), and by influencing the populations of prey by changing their behaviour (Creel & Christianson, 2008).
Current levels of shark fishing undermine ecosystem-based fisheries management (CBD, 2003), both through shark fisheries themselves and the associated effects of removing top predators. Modern industrial fisheries have 'fished down the food chain', decreasing global marine predator abundance by more than 90% (Myers & Worm, 2003) and leading to a significant drop in mean trophic level (Pauly et al., 1998). The lack of data, time lags between cause and effect, which could span decades to centuries

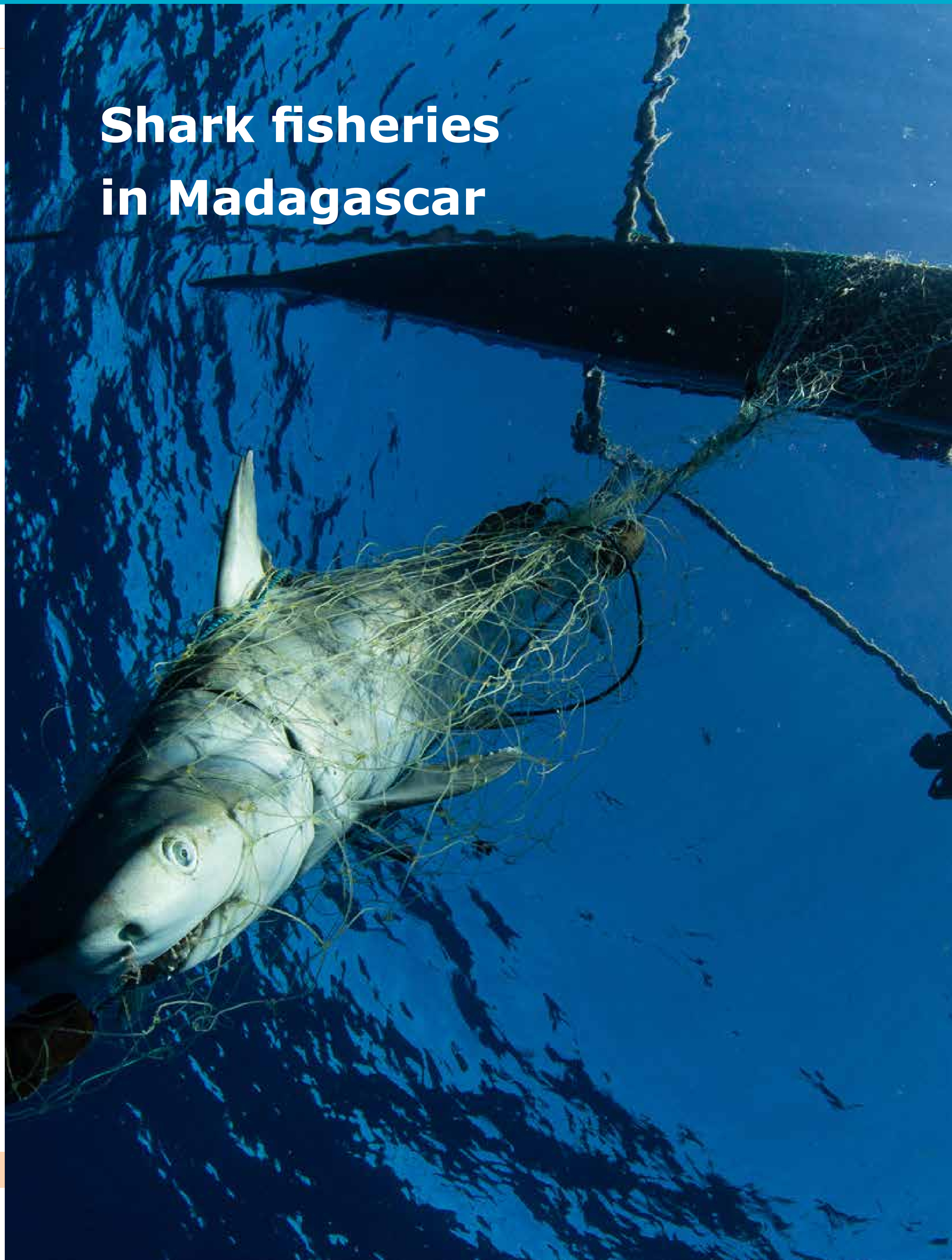
(Jackson et al., 2008), and continued exploitaton, which masks effects (Myers et al. 2007), make it currently impossible to predict the full socio-ecological consequences of shark over-exploitation.

### Non-destructive uses

Marine ecotourism founded on live sharks, such as recreational diving, snorkelling, and shark watching, makes this taxon a valuable economic asset. Whale shark tourism, for example, is estimated to be worth $47.5 million annually worldwide, while shark tourism in the Bahamas generates $78 million annually for the national economy. Shark tourism can often make sharks far more valuable as a living reusable resource than their value in fisheries.



# Shark fisheries in Madagascar



# SHARK FISHERIES IN MADAGASCAR

## Introduction

Sharks have featured in Madagascar's fisheries for at least 100 years and their fins have been of notable value since at least the early part of the twentieth century (Cooke, 1997). Shark fin exports to Zanzibar, China and La Réunion were observed in 1919 and 1925 (Petit, 1930). An export market for shark meat in the Comoros, and shark oil and cured sharkskin exports also existed at this time (Petit, 1930). The production and effective price of shark fins in Madagascar apparently remained relatively modest until the late 1980s (Dockerty, 1992), but in 1991–1992 there was a rapid rise in local prices, from about 0.30 to 15.00 $/kg (Cooke, 1997). Based on 1995 FAO statistics, there was a significant increase in directed shark fisheries in the early to mid 1990's (Cooke, 1997). In 1987 shark fin exports were just 3t but by 1992 they were almost 50t (Cooke, 1997) and in 2000 were approximately 20t (Cooke et al., 2003). Field investigations showed that sharks were intensively exploited along much of Madagascar's coastline in the 1990s and early 2000s (Cooke, 1997). By 2006, fishermen in most regions had reported substantial local declines in capture rates. The high value of shark fins on East Asian markets continued to drive the targeting of sharks. There was also a growing meat market in the resource depleted Comoros islands from the mid 1980s. In 2002, the price of fins could reach $45 $/kg in Madagascar (Cooke et al. 2003) whilst meat was worth around $0.60 $/kg.

Prior to 2004, the Ministere de la Peche et des Ressources Halieutiques (MPRH), responsible for fisheries policy in Madagascar, regarded sharks as an under-utilised marine resource to be targeted (Anon, 1996). This policy, coupled with the high value of shark fins and the seemingly inexhaustible demand for these products in the Far East, resulted in the promotion of shark fisheries by development organisations as a means of increasing income in coastal fishing communities. For example, Projet MAG/9/008—Composante Peche Programme Sectoriel Peche, a FAO initiative, distributed large quantities of fishing equipment, including long line gear, to villages south of Toliara to promote the targeting of elasmobranches. In 1990 the German development agency Gesellschaft Für Technische Zusammenarbeit (GTZ) and MPRH began a project to promote the fishing of migratory pelagic species using large-meshed drift gillnets in the northwest. This fishery evolved largely into a shark fishery (Cooke, 1997).

Malagasy regulation of general fisheries (decree 94-112 of 18 February 1994) defines three types of fishing[3], virtually all of which are reported to have a significant impact on sharks (Cooke et al., 2003):

- Traditional fisheries (on foot or dugout canoe (pirogue));
    - Along the entire west coast of Madagascar, but particularly in the southwest (Toliara up to Maintirano), target sharks using bottom set gill nets
- Artisanal (motorised boats using engines less than 50hp);
    - Notably those based out of Mahajanga (NW), Nosy Be (NW), Diego Suarez (NNW) and previously in Antongil Bay (NE)
- Industrial (boats with engines greater than 50hp).
    - Offshore industrial long-line tuna and billfish fisheries conducted by foreign fleets – roughly 80 to 100 licensed EU and Asian long line vessels operate in Madagascar's EEZ and sharks are reported to account for about 10% of total catch
    - Offshore tuna purse seine fisheries conducted by foreign fleets – roughly 35 licensed vessels, largely EU but also Asian, operate in the northern part of Madagascar's EEZ, with shark bycatch estimated to account for around 0.5% of total catch
    - Tuna and swordfish fishery conducted by a fleet of eight small Malagasy longliners since 2010, of which most of the bycatch is sharks
    - Industrial demersal finfish fishery based in Mahajanga and established in 2000 – about 6 - 8 operational vessels use a combination of trawling and gill-nets, the latter of which catch significant numbers of sharks
    - Shallow water industrial shrimp trawl fishery, which had up to 70 vessels, mainly on the west coast, with unknown shark bycatch

*3 Though these definitions are used in literature on Malagasy fisheries (Cooke, 1997, McVean et al. 2006), the lines between them are not clear, particularly between traditional and artisanal fisheries (Cooke, 1997). This is particularly true for northwest Madagascar (Short, 2011). Similarly, Cooke notes the ambiguity between 'subsistence' and 'commercial' fishing. However, in keeping with Malagasy regulations, we present Malagasy shark fisheries as traditional, artisanal and industrial. The study also showed that along the west coast from the Maintirano region southwards, traditional and artisanal fishers are two distinct groups.*

The following sections present Madagascar's traditional, artisanal and industrial shark fisheries in more detail.

New information on the shark trade and supply chain that was collected by interviewing fishers, collectors and buyers (where possible) at different stages of the value chain is provided for both the traditional and artisanal fisheries on the west coast of Madagascar. The section for industrial fisheries does not present any new information but rather reviews existing knowledge of shark catches by industrial vessels in Malagasy waters.

## Traditional fisheries

In 2002, traditional fishing was estimated to account for 53% of the total marine fish catch in Madagascar (Soumy, 2004). The FAO recorded 22,000 Malagasy pirogues with around 50,000 fishermen in 1996 (FAO, 1996), a four-fold increase since 1982, indicating a significant increase in the traditional sector. Increases in the number of artisanal vessels were also noted (Kroese & Sauer, 1998; Cooke, 1997; Laroche et al., 1997; Davies et al., 2009), especially in the northwest. These fisheries combined (excluding subsistence activity) accounted for approximately 75% of national fisheries in 1994 (Cooke, 1997).

FAO (1996) quoted a national fishing effort of 5.8 boats/km for Madagascar, and used this to estimate a shark catch of 500 kg/km of coastline. Analysis of target species and gear use indicated a preference for gillnets, which were used to catch sharks and a number of other high value species, such as large teleosts and sea turtles. Gillnets allowed fishermen to target a relatively large number of shark species, which is preferable in a market where certain species carry large premiums based on the higher density of ceratotrichia (cartilage fibres) in their fins. More detailed species-specific catch data is conspicuously absent throughout the literature.

### Processing and products

For both traditional and artisanal fisheries, shark fins, meat and jaws are used as a source of cash; meat and liver are used as food; and skins are discarded. Dried fins are exported to Hong Kong. Shark meat is eaten fresh in the village, or salted and dried for sale in towns and cities, including most of the major inland towns of Madagascar, or exported to the Comoros. The liver is eaten or used to make oil for cooking in the village; sometimes the liver oil is sold as a traditional medicine. Cooke reports that oil is used locally for waterproofing (Cooke, 1997). There is no real trade in shark oil, though data from the MPRH shows that oil has been exported in the past (from 1992 to 1995, and in 2000), but this is no longer the case. There has been some minor, seemingly grey market trade in the oil of *beledake* – a small, deepwater shark - in the villages just south of Toliara. This was driven by a Korean buyer, but was sporadic and is no longer active. Shark teeth and jawbones are sold locally to tourists. There is no trade in ray products, but dried ray meat is exported along with shark (Cooke, 1997).

### Supply chain and market structure

There are different supply chains for the two main products of traditional shark fisheries in Madagascar; shark fins and shark meat. Both are quite complex and rather fluid with trading routes within the chains altering according to location (proximity to urban centres), price, buyer availability, personal contacts or know-how of the individual fisherman, demand and product condition.

#### *Shark Fin Supply Chain*

The supply chain for shark fins caught by traditional fishermen, predominantly for south-western Madagascar, is depicted below (Figure 1). The final destination for the vast majority of Madagascan shark fins is export to overseas markets such as Hong Kong, although the number of links the product goes through to reach the final market can vary considerably. Traditional fishers are seeking the best price for shark fins and will bypass links in the supply chain if they are able to, in order to increase their income. This is possible for fishers that live within reasonable proximity to towns and some will transport their fins to these hubs to sell directly to main collectors or occasionally regional traders. This is particularly true if they have caught a large shark or guitarfish, the value of the fins making such a trip viable. Other fishers do not travel from their villages and sell fins to a local village collector. For fishers in more remote locations (e.g. smaller villages with inferior transport links or offshore islands), travelling collectors can visit each site to buy fins and then sell them on the main collectors in the larger towns. Some fishers will also set up long-term fishing camps in more remote locations such as offshore islands (e.g. the Barren Isles) and transport fins back to towns on a regular basis to sell directly to collectors.
If possible, fishers will sell salted, wet (undried) and untrimmed fins to local village collectors rather than dried ones to try to obtain a better price per kg. Local collectors then usually dry the fins out to meet the specifications of their buyers and sell dried fins to collectors or traders in regional nodes. Fishers will keep fins in salt for up to three days whilst waiting for travelling collectors, drying them out for two hours just before sale. Other fishers, who know the main collectors and have the financial means to travel, will dry the salted fins themselves and sell them directly to the main collectors in towns.
The price paid for fins depends on fin quality and processing (i.e. whether sold fresh or dried) (Table 3). Fins are graded primarily according to how fibrous they are (the density of needles in the fin) which varies between species and also according to size. Four main grades of fin are recognised in the trade, as well as a further 'extra' quality grade for unusually large fins of those species that have fins with many needles. The general size specifications for fin grades is: Extra - > 30 cm; First quality – 25-30 cm; Second – 20-24 cm; Third – 11-20 cm; Fourth - < 10 cm. The fins of guitarfish are of high quality, containing a large number of needles, and fetch a higher price than all sharks. They are traded separately to shark fins. Some collectors grade fins according to size and wet weight.

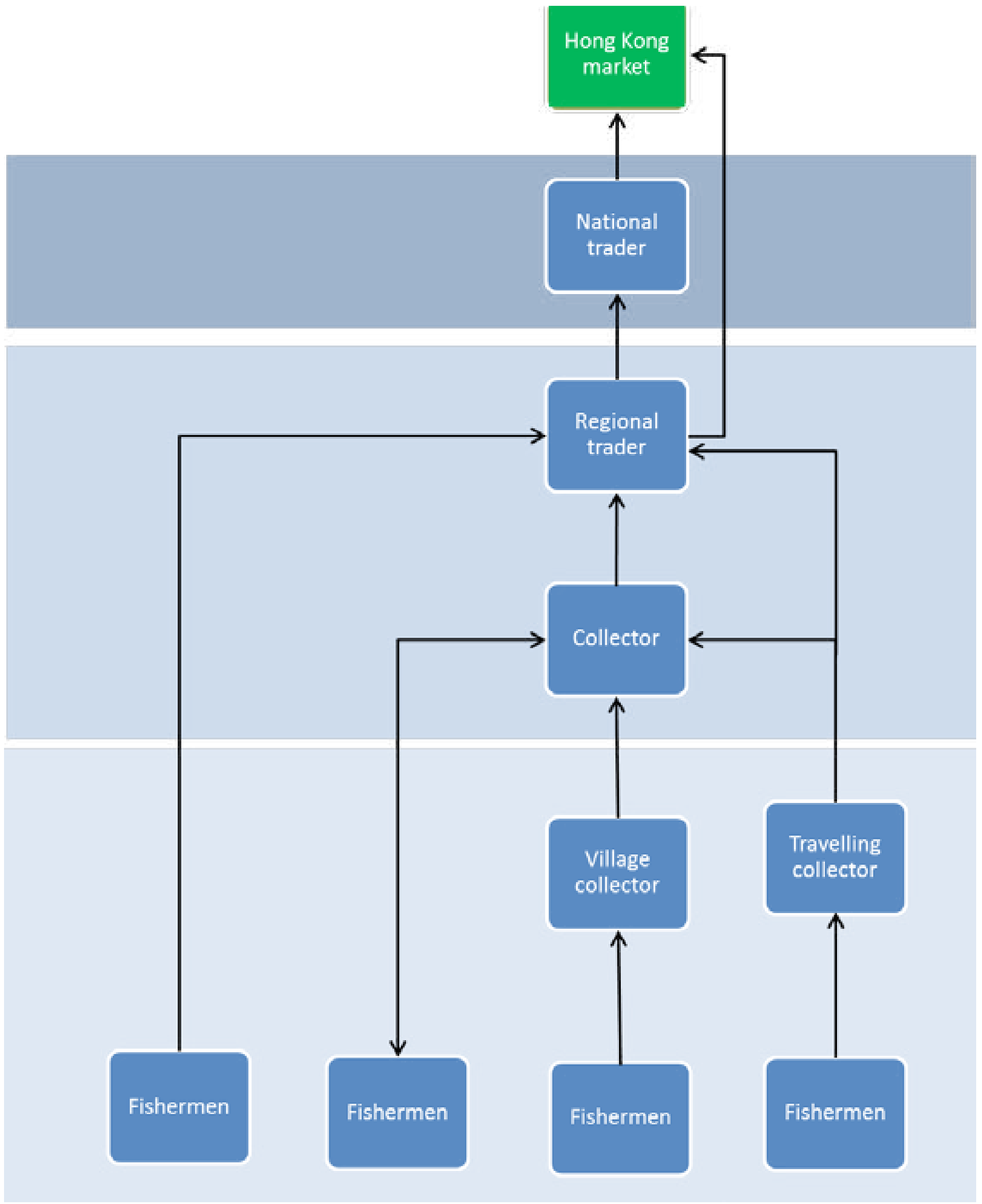



**Figure 1: Supply chain for the shark fin trade for sharks caught by traditional fishers**

An analysis of shark fin prices for fishing sites on the west coast of Madagascar between Befasy in the south and Maintirano in the north is provided in Table 3. Prices are mean minimum or maximum values paid for both fresh and dried shark fins for two links in the supply chain: fisher to local collector (Table 3a); and fisher or local collector to main collector (Table 3b). Values for other links in the supply chain were not available during the assessment period of the first quarter of 2012 as the collectors interviewed were not willing to disclose these. Prices are in Madagascan Ariary (MGA), but also in US dollars (using

2012 exchange rates[4]) for the added value if fishers sell direct to main collectors (Table 4).

**Table 3: Average shark fin prices according to quality, processing and supply chain level (MGA/kg)**

**3a: Fisher selling to local collector**

| Quality | Wet fins | | Dried fins | |
|---|---|---|---|---|
| | Minimum (n = 4) | Maximum (n = 5) | Minimum (n = 4) | Maximum (n = 6) |
| First | 95 000 | 134 000 | 148 750 | 173 333 |
| Second | 50 000 | 62 000 | 75 000 | 96 667 |
| Third | 17 500 | 30 000 | 35 000 | 51 667 |
| Fourth | 6 667 | 12 000 | 7 500 | 18 333 |

**3b: Fisher or local collector selling to main collector in towns**

| Quality | Wet fins | | Dried fins | |
|---|---|---|---|---|
| | Minimum (n = 3) | Maximum (n = 3) | Minimum (n = 4) | Maximum (n = 6) |
| First | 143 333 | 170 000 | 203 333 | 242 000 |
| Second | 80 000 | 100 000 | 115 000 | 138 000 |
| Third | 33 333 | 50 000 | 55 000 | 75 000 |
| Fourth | 10 000 | 21 000 | 20 000 | 37 500 |

It should be noted that the price paid for shark fins can fluctuate substantially according to the status of the export market. One of the main collectors on the west coast stated that the price dropped by 10 000 MGA/kg in just one month (January 2012) and fell further in the next two months. From a high in 2011, prices have also fallen by 40 to 50% from 2012 to 2014. There is also variation in prices paid by collectors either on site in the fishing villages or in the towns. This can depend on whether the collector has provided financial or logistical support to the fisher, which is more common for the artisanal fishery (see following section) Overall, the values obtained by the main traders and exporters will determine, to a great extent, the prices at the various links in the supply chain. Current prices (late 2014) are less than those recorded during the 2012 assessment. Fins prices for dried fins sold to collectors in the Maintirano region in November 2014 are less than the minimum average values recorded in 2012 (e.g. 140 000/kg for first quality fins compared to 200 000/kg in 2012). This drop in value is thought to be linked to a global drop in demand for shark fins and a larger amount of fins therefore available for a smaller market.

The data collected in 2012 indicates that there is a considerable mark-up in price as you move up the supply chain, although robust information was only collected for the first two links in the chain. If fishers can sell their fins directly to the main collectors rather than to local buyers they can increase their income by almost 40% for first quality fins, which in 2012 was equivalent to just under $20 and $29 per kg for wet and dried fins respectively (Table 4). Higher value can also be obtained for other fin grades (generally 50-60% increase) with the greatest percentage increase recorded for dried fourth quality fins (136%). There are no data for the costs to fishers of transporting fins to the main buyers or for the time spent drying and sorting fins.

*4 Exchange rate of USD $1 = 2146 MGA (01/02/2012). Source: http://www.oanda.com/currency/historical-rates/*

**Table 4: Value added by selling shark fins direct to main collectors (per kg of fins) (average of minimum / maximum price markup)**

| Quality | Wet fins | | | Dried fins | | |
|---|---|---|---|---|---|---|
| | MGA | USD | % | MGA | USD | % |
| First | 42 167 | 19.65 | 38.9 | 61 625 | 28.72 | 38.2 |
| Second | 34 000 | 15.84 | 54.8 | 40 667 | 18.95 | 48.1 |
| Third | 17 917 | 8.35 | 59.7 | 21 667 | 10.10 | 51.2 |
| Fourth | 6 167 | 2.87 | 51.4 | 15 833 | 7.38 | 135.6 |

Although there was little information available for fin transactions higher up the supply chain one main collector stated that his Chinese buyer in Antananarivo paid 50 – 100 000 MGA per kg of fins on top of the prices paid by the collector to fishers or sub-collectors. It is not known if this applies only to certain fin grades.

The value for guitarfish fins is substantially greater than that for any type of shark fin for both wet and dried fins. These high quality fins were generally at least twice the value of shark fins for either wet or dried products and the two links in the supply chain analysed (Table 3 vs. Table 5). There is also a clear mark-up in the value of dried guitarfish fins over the first two links of the chain although the percentage increase is less than for shark fins (15-20 % increase in fin values for first or second quality guitarfish fins). There was insufficient data to allow a comparison of wet fin prices for the first two links of the supply chain.

**Table 5. Average guitarfish fin prices according to quality, processing and supply chain level (MGA/kg)**

**5a: Fisher selling to local collector**

| Quality | Wet fins | | Dried fins | |
|---|---|---|---|---|
| | Minimum (n = 1) | Maximum (n = 1) | Minimum (n = 5) | Maximum (n = 3) |
| First | 200 000 | 300 000 | 278 000 | 416 667 |
| Second | 150 000 | 225 000 | 192 000 | 283 333 |
| Third | 60 000 | 75 000 | 92 000 | 170 000 |

**5b: Fisher or local collector selling to main collector in towns**

| Quality | Wet fins | | Dried fins | |
|---|---|---|---|---|
| | Minimum (n = 1) | Maximum (n = 1) | Minimum (n = 3) | Maximum (n = 5) |
| First | 300 000 | n.a. | 366 667 | 450 000 |
| Second | 150 000 | 250 000 | 228 333 | 310 000 |
| Third | 60 000 | 80 000 | 105 000 | 140 000 |

*Shark Meat Supply Chain*

The supply chain for the trade of shark meat is also quite complex (Figure 2). Traditional fishers in the south-west returning daily to their home villages may keep fresh shark meat to feed their families, give it away for free to the other members of the community (e.g. the poor or old) and sell any excess to other villagers or buyers for the local markets. Fishers in more remote locations will dry and salt the meat before sale. Meat is sold as fresh or dried/salted in local and nearby urban markets. Generally fresh meat is sold and consumed locally whilst dried meat is bought by collectors and transported to inland urban markets in Madagascar. Some dried shark meat is also exported.

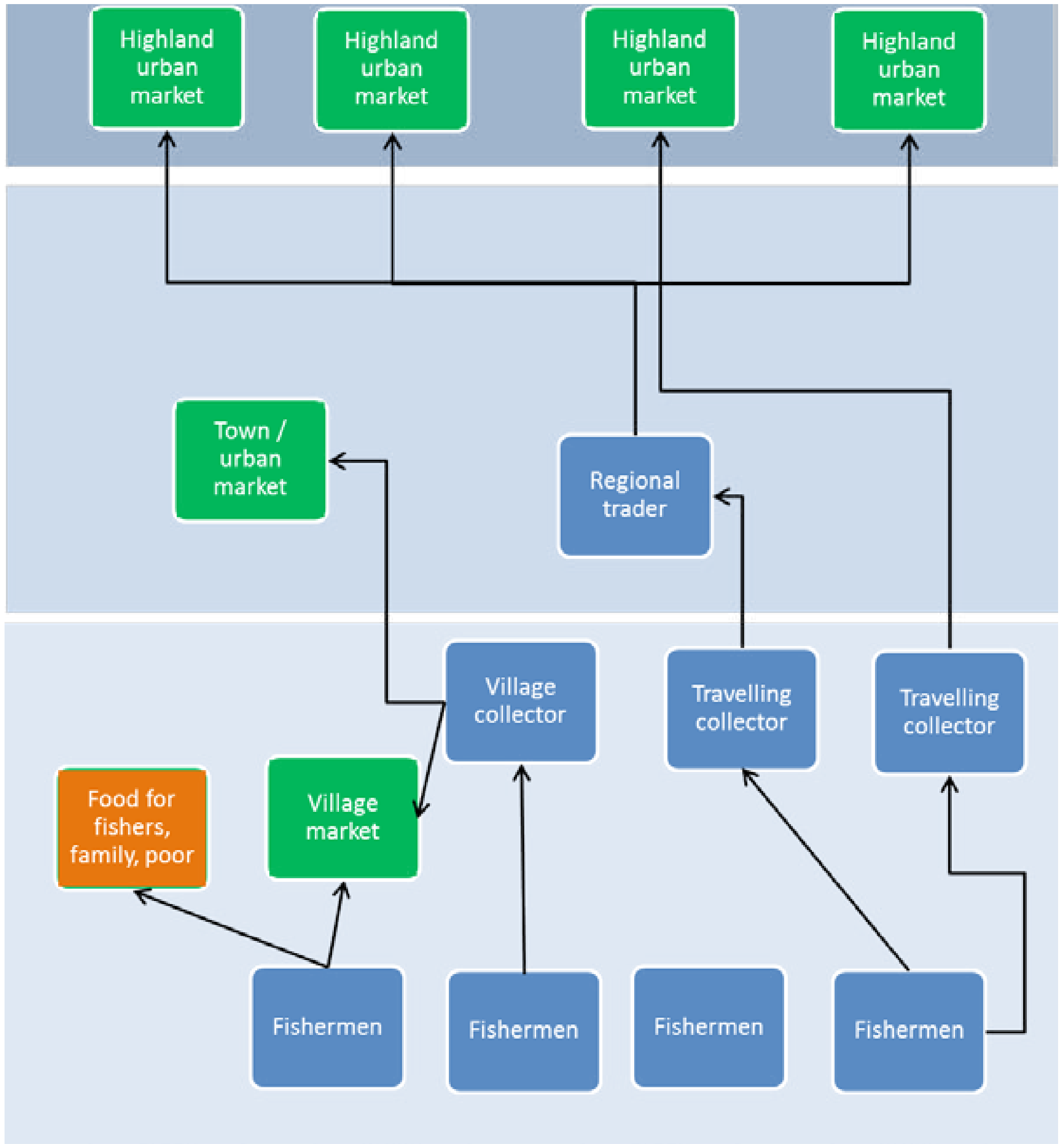



**Figure 2. Supply chain for the shark meat trade for sharks caught by traditional fishers**

The values for shark meat at various links in the supply chain are provided in Table 6. Most of the available information is for the price of shark meat at the first point of sale from fishers to local collectors and villagers. Data for other links in the supply chain is rather scarce but does indicate an increase in value for fresh meat sold at local or regional coastal markets, and for dried salted meat sold to buyers for inland markets. However no data was forthcoming for the sale prices of dried shark meat in either coastal or inland markets. The mark-up in value for fresh meat sold at coastal markets was on average 1000 MGA/kg, equivalent to almost $0.5 USD per kilogramme. The increase in value of dried shark meat between main collector and regional buyer was 500 MGA/kg.

**Table 6: Shark meat prices according to processing and supply chain level (MGA/kg)**

| Transaction | Fresh Meat | | Dried Meat | |
|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum |
| Fisher to Villagers / Local Collector* | 570 (10) | 1029 (7) | 1362 (7) | 1633 (6) |
| Coastal market sale | 1600 (1) | 2000 (1) | n.d. | n.d. |
| Local collector to main collector | n.a. | n.a. | 1400 (1) | 1800 (1) |
| Main collector to regional trader | n.a. | n.a. | 2000 (1) | 2200 (1) |
| Highland market sale | n.a. | n.a. | n.d. | n.d. |

Where: Figures in brackets depict number of replicates; n.d. = no data; n.a. = not applicable;

Note: *dried meat sold to local collector only (not villagers)

## Gear and fishing

The vast majority of traditional fishermen use three types of non-mechanised fishing gear to catch sharks: palangre, jarifa and ZDZD (see below). Hand lines can also catch small sharks unintentionally.

***Palangre*** is a form of long-line fishing. It normally uses high-strength nylon fishing line and 8 cm hooks with trace made from steel cable. The hooks are often hung together in pairs with ca. 20 cm of trace separating them. As traditional fishermen make the palangre themselves, a range of constructions are used. In the southwest, traditional Vezo[5] fishermen mainly use two types of palangre. In the first the long line is anchored at either end, with the hooks held in mid-water, and floats marking both ends and the centre. In the second the long line is anchored only at one end and is free to rotate with the current. This latter method is favoured by fishermen based in mainland villages, where they place it in turbid water 30 m deep. Palangre is an increasingly popular technique amongst migrant fishermen from southwest Madagascar, both for fishing in shallow (ca. 30 m) and deep (ca. 100 m plus) water. Some shark fin buyers supply fishermen with the material to make palangre.

***Jarifa*** are large baited gill nets set in deep water to target sharks. They are generally around 100 to 200 m long with a fall length of around 5 m and a mesh size of between 12 and 25 cm. The net was introduced in the southwest in the 1990's. Many fishermen make their own jarifa.

5 *Coastal people in south-west Madagascar who depend on the sea for their livelihood*

***GTZ or ZDZD***[6] are gill nets up to 150 m long with a fall length of 6 to 8 m and mesh size of 8 to 10 cm. Its name comes from GTZ, the German government's development agency that introduced it in northwest Madagascar in 1992 with the objective of reducing fishing pressure on near shore reefs through the development of offshore fishing (Langley, 2006). *ZDZD* nets are regarded as being more effective than *jarifa*, particularly as they allow shark fishers to capture a larger variety of pelagic species. However, they are also more expensive than *jarifa*, difficult to make and so are mostly bought new, making them less common. Traditional fishers stated that the use of *ZDZD* results in more bycatch than *jarifa*, including rays, turtles and, infrequently, dolphins.

To target shark on the west coast *jarifa* or *ZDZD* are set beyond the barrier reef in water normally 120 to 300 m deep. Fishing sites are selected according to features such as seamounts and deep reefs where sharks are known to congregate, but also away from rocky reefs, in places where the seabed is flat, to avoid gear loss. *Jarifa* are baited, usually using baitfish netted the night before, or with ray or moray eel. *ZDZD* are not baited because they catch large pelagic fish, which then act as shark bait.

Fishers from certain villages of the southwest prefer to join a *ZDZD* with a *jarifa*. The struggling and bleeding of fish caught in the *ZDZD* attracts larger sharks, which are then caught in the *jarifa*. The combination is necessary because large hammerhead sharks are easily caught in the *ZDZD*, but large, pointed nosed sharks are able to break it. Use of *ZDZD* combined with *jarifa* also brings other catch, such as small sharks, pelagic fish, rays and turtles, which the *jarifa* alone would not, making the fishing trip more viable even if sharks are not caught.

### Distribution of the traditional fishing effort

#### *Summary*

In Madagascar, both traditional and artisanal fishing is concentrated along the west coast. Traditional fishers target sharks along the entire west coast of Madagascar, from Itampolo / Androka in the south to Antsiranana in the north. The largest concentration of traditional shark fishermen is the Vezo fishers of southwest Madagascar in Toliara province. As shark catches declined in the southwest in the late 1990's Vezo fishers have increasingly migrated to unexploited areas along the west coast, both in the far south and northwards. In doing so they are targetingsharks along the entire west coast north of Morombe up to Cap St. Andre, both for offshore isles[7] as well as from mainland fishing villages (such as Ampataky, Bemakoba, Benjavily and Mozambika).

Resident traditional fishermen also target shark along the entire coast between Cap St. Andre and Cap d'Ambre in the north. However, Short (2011) argues that the distinction between traditional and artisanal fishermen in this region is blurred.

There are no significant traditional shark fisheries, where sharks are specifically targeted, on the east coast of Madagascar because rough seas severely limit traditional fishing here. More detailed descriptions of traditional shark fishing, which draw on both the literature and the results of this study, are given in the following sections by region.

#### *Northwest, North*

In 1990 GTZ and MPRH began to promote the fishing of migratory pelagic species using large-meshed drift gillnets (Cooke, 1997). This fishery included both artisanal and traditional fishermen. They supplied 400 nets to local fishers and trained them in their use and maintenance. In return fishers were required to complete catch data sheets (du Feu, 1998). The nets were increasingly used for bottom fishing, targeting sharks. The use of bottom-set nets rose from 60% in 1990 to over 95% between 1994 and 1998, except 1997 (88%). Despite fishing rates remaining low, average incomes increased from US$10-15 to US$150 per month. Catches increased every year until 1996, when they reached 1,013 t and then declined slightly to an estimated 852 t in 1998 (du Feu, 1998; Cooke, 1997, 2003). Sharks made up about 50% of the catch over the same period, with 510 t in 1996 (about 40,000 sharks based on an average weight of 12.5 kg). The species most frequently caught in this fishery were *Carcharhinus amblyrhynchos*, *C. sorrah*, *S. lewini*, *Loxodon macrorhinus*, *C. melanopterus*, *Triaenodon obesus* and *C. albimarginatus*.

A study in the northwest of 324 shark fishers, found that the majority of fishers (67%) used smaller (up to 6 m length) pirogues with sails, while 33% used larger (> 7 m length), motorised boats (Short, 2011). Whether fishers targeted sharks or took them as accidental capture differed with boat type, with 35% of pirogue fishers and 72% of motorised boat fishers claiming to target shark. Half (51%) of total respondents used nets (inclusive of GTZ nets and nets of smaller / variable mesh size), 33% longlines, 23% jarifa, and 2% harpoons (Short, 2011). Both types of vessel commonly used longlines, with 54% of pirogue and 64% of motorised boat fishermen using longlines. These numbers suggested that the use of longlines to target shark has increased significantly (Short, 2011). The majority of these lines had just one (61%) or two hooks per line (32%), but up to 20 hooks per line were reported.

Artisanal shark fishers in the far northwest use predominantly *jarifa* (Short, 2011). The gillnet mesh size is not standard, with mesh sizes ranging from 15 to 60 cm being commonly found within one net. Crews consist of six to eight fishermen per boat. Typically, nets are set in the morning and checked and reset the following morning.

Traditional fishermen in this area caught most sharks as "non-targeted" catch (Short, 2011). Their gear was indiscriminate (such as line fishing and nets of various mesh sizes) and was used to catch not only adult sharks, but a range of fish species, and small and juvenile sharks. Traditional fishermen often ate smaller sharks rather than selling them, indicating that shark fishing was important for subsistence (Short, 2011).

Both artisanal and traditional fishers reported that the number and size of sharks caught varied seasonally (Short, 2011). Collectors and traders likewise reported that, while they traded shark fins all year, the volume and size of shark fins changed with the season. Most fishers regarded the peak season, in terms of volume and shark size, to be the rainy season or *lohataogno*, roughly from November until March (Short, 2011).

#### *West*

Cooke (1997) noted that in the Menabe region (Morondave to Belo-sur-Tsiribihina), shark fishing was entirely traditional, with no motorised artisanal or industrial fishing. Shark fishing with nets was intensive during the warm season from November to March (Cooke, 1997). Surveys of traditional fishermen conducted for this study confirmed this observation. Itinerant artisanal fishermen from the northwest (Mahajunga and even as far as Antsiranana) fish these areas occassionally.

In Morondava, targeted shark fishing is almost only done by Vezo migrants from the south, mainly from Morombe and Befandefa communes. For example, there are six teams living in Betania using *jarifa* who are all migrants from Morombe and Befandefa. The number of shark fishers increases when the migrants make their seasonal move up to Morondava. The characteristics of the fishery are the same as those described by Iida (2005). Fishermen use mainly *jarifa*, but also *ZDZD* and *palangre*. In addition to working their nets, they free dive for sea cucumber ("*manarike zanga*"), and spearfish. Sea cucumbers currently bring an essential and consistent income and fishers cannot rely solely on shark fishing. They see shark fishing as something to fall back on, particularly when there is low visibility, and as a "gamble" that brings in good money if there are catches, but not as a reliable livelihood. They

6 *Vezo fishers in the southwest call it ZDZD, while in the north it is GTZ.*

7 *Andriamitaroke; Nosy Be and Andrevo offshore of Belo-sur-mer; the Barren Isles; Nosy Vao offshore of Tamboharano; and Nosy Kely off Cap St. Andre*

fish on the *riva* (rocky reefs) 30 to 40 km west of Morondave, with fishing trips lasting between 12 to 20 hours and sometimes longer if the wind is strong. As fishermen normally combine shark fishing with diving for sea cucumbers, they prefer winter over the rainy season. They set their nets at 100 - 150 m; and free dive on nearby *riva* (25 - 30 m). *Jarifa* fishermen reported catching 1 - 3 sharks a week or 5 - 20 a month. They only catch larger sharks (1 - 2.5 m in length). Multiple species with fins of high value are targeted (including the Malagasy shark names[8]: *viko* (hammerhead spp.), *maintilabosy*, *dofokoro*, *bevombotse* and *maragnitsoro*); and those of less value, even if they have very large fins (eg. *kary* and *ragnaragna*).

Vezo fishers based in Morondave handline fish (*maminta*) on the same *riva* in 30 to 60 m of water, targeting jack, trevally and mackerel and also catch small sharks (including the Malagasy names given of *viko*, *fesoke*, *foty vombotsy*, *kary* and *meso*). The catches are high, with fishermen reporting that they catch between three to five small sharks a day; and during the hot season, they catch higher numbers of juvenile sharks. Fishers estimated that there are between 50 and 80 pirogues from Morondave and Betania handline fishing on the western *riva* every day.

### *Southwest*

Directed shark fishing in this region began to develop around 1992, driven by the shark fin trade (Cooke, 1997). Most villages still have teams who fish for shark, some of which operate all year round. Cooke (1997) reported that the number of shark fishers increased continuously since 1992, and the sale of fins became an important part of their income. Shark fishing was considered to be difficult, with the number of shark fishers remaining lower than other types of fishing. For example, in Anakao there were only four teams fishing specifically for shark, representing 5% of all fishing teams in the village (Cooke, 1997).

The Toliara region supports Madagascar's largest traditional fishery, with some 20,000 fishers operating in the province, most of who are centred around Toliara itself. In southwest and western Madagascar, traditional shark fishers predominate over artisanal fishers, particularly in the southwest. Traditional shark fisheries of this region are low-tech and reliant to a great extent on favourable weather conditions and the daily investment of considerable time and effort (McVean et al., 2006; Cooke, 1997). Frequent high winds and swell make fishing in deeper water further offshore (ca. 15 km) difficult, so fishing pressure is not as constant as it is in the northwest, except in protected lagoons (Cooke, 1997). November to January is seen as the best season, with shoals of small fish arriving and generally good weather. Fishermen will fish whenever the weather permits it, with fishers estimating approximately 300 fishing days per year (McVean et al., 2006).

In the southwest, traditional fishermen use non-motorised monoaxyle out-rigger sailing pirogues to fish and as a means of transport. The hulls vary in size depending on the fishing technique used. The use of *palangre* is possible with smaller pirogues, while fishing with *jarifa* and *ZDZD* requires the use of pirogues six to eight metres long – considered to be larger than average.

McVean et al. (2006) report that in the area of Anakao, south of Toliara, static and surface-set *jarifa* and *palangre* are the most commonly used gear. Fishermen used nets 200 m long of 15 cm mesh, made in the village using 5 mm rope. These nets were considered expensive (1 to 2 million FMG each, US$220 to US$440) and theft of the gear was widespread (Cooke, 1997). In his 1997 review of shark fisheries in Madagascar, Cooke notes that gill nets are the commonest shark fisheries gear in use in Madagascar. McVean et al. (2006) found that in the region south of Toliara this gear preference had shifted from gill nets to long lines. They ascribed this shift mainly to the intervention of third parties. For example, Projet MAG/9/008—Composante Peche Programme Sectoriel Peche, a FAO initiative, distributed large quantities of fishing equipment, including long line gear, to villages south of Toliara to promote the targeting of elasmobranches (McVean et al., 2006).

In 2001, fishermen sold fins to collectors for about 40 US$/kg, and up to 70 US$/kg for the highest grade fins. Fishermen were reported to sell shark meat on the local market for about 1.00 US$/kg. Shark fishermen in the area enjoy incomes substantially greater than the regional average (Frontier, 2002).

For the village of Soalara with 20 shark fishers, the reported catch during the five-month period of August 2001 to February 2002 was about 450 sharks. This would indicate an annual catch rate of 1,000 sharks for 20 fishermen, or 50 sharks a fisher a year. Estimates carried out during the 1995 survey for Traffic indicate that shark fishermen in the Toliara area fish as teams and that one team might catch a maximum of six sharks per outing or about 800 sharks a year per team.

### *Southeast*

Based on interviews with fishermen and traders, Cooke (1997) reports the shark fishery of this area to be perhaps the least developed of the sites surveyed. No further information was collected during this assessment to update the situation.

### *East, Northeast*

Traditional fisheries in this region were noted to be growing as indicated by the increased number of pirogues for the province of Toamasina (Cooke, 1997). Silky sharks (*Carcharhinus falciformis)* were the main species caught here. Shark fishing on Isle Saint Marie were incidental to other fisheries, with small volumes of fins (300 kg a year according to one trader) (Cooke, 1997).

Previously shark fishing was reported to be significant in Manakara area, with several villages having teams fishing almost only for shark (Cooke, 1997). Several nets of 100 m by 2.5 m were used in both shallow and deep water. Catches were reported to be high at four to fifteen sharks per trip and carcasses were often discarded after removal of the fins. Interviews conducted for this study indicated that there was no longer an active shark fishery in the Manakara region, nor were there any fin buyers active in Manakara.

Catches of sharks (*Sphyrna leweni* and Charcarinidae species) and guitarfish were also reported for traditional gillnet fisheries in Antongil Bay in the north-east (Doukakis et al., 2007) although these were not thought to be eaten according to a local taboo. It is not known if fins were removed and sold for these shark catches but this appears unlikely for respected taboo species.

## Shark species recorded in catches

Appendix 3 provides a list of shark species recorded in the catches of traditional and artisanal fisheries of Madagascar. The appendix also includes some accompanying text that summarises published reports of shark species caught by these fisheries.

## Catch estimates

Past production of shark meat in Toliara has been substantial: the SPRH data stated that in 1994, 11 t of meat was consumed locally in the town of Toliara, and 36 t produced for the province as a whole (Cooke, 1997). Since only large sharks tended to be recorded, the actual production of shark meat was most likely much higher. Local shark landings for 1998 were reported to be 21 tonnes, with rays at 8 tonnes. Reported exports of shark fin for the same year were 2.4 tonnes. Data for 1999 indicate 7.3 t of shark meat exported, and in 2000 3.1 t of fins were exported (DRH statistics).

*8 Shark names in Malagasy can vary dramatically bewteen villages, regions and people. For this reason names are only given here in the Malagasy from the interviews. Reviews of shark names and their identifications throughout Madagascar can be found in Fourmanoir, 1961, Cooke, 1997, McVean et al., 2006, Doukaksi et al., 2011, Robinson & Sauer, 2013.*

Catches (all species) recorded in the GTZ-MPRH fisheries development project in the Mahajunga region increased every year to 1996, when they reached 1,013 t and then declined slightly to a projected 852 t in 1998 (du Feu, 1998). Sharks made up about 50% of the catch over the same period, with 510 t in 1996 (about 40,000 sharks based on an average of 12.5 kg a shark).

Shark catch data collected in Anakao (McVean et al,. 2006) indicated that the scale of shark fisheries was largely unexpected, with an estimate of over 123 t of sharks caught within 13 months. This amount greatly exceeds the estimated mean annual catch of 500 kg of elasmobranches per km of coastline in Madagascar stated by Kroese and Sauer (1998) in their review of African elasmobranch fisheries.

Anecdotal catch information collected from traditional fishermen during this study on the west coast of Madagascar is provided in Table 7. The number of sharks caught per month for the shark fin trade can vary substantially between sites and also between individual fishers from the same site. For example fishers from Ambatamilo / Fiherenarnsay catch considerably more sharks if they are able to fish further offshore in deeper water. Catches are also rather sporadic with no individuals caught in some months for sites where shark fishing is more established (e.g. Andavadoaka, Anakao, Ifaty). The highest catch rates reported were 30 individuals per month for Befandefa and offshore fishing (25-30 km) at Antsepoke / Bevohitse and Ambatamilo / Fiherenamasay. However an estimate of total catches of sharks by traditional fishing cannot be determined without knowing the number of full-time and part-time shark fishers operating from each site.

**Table 7. Catch rates for larger (valuable) sharks for sites on the west coast of Madagascar compiled from fisher interviews in 2012.**

| Site | Sharks caught / fisher / month | | Notes |
|---|---|---|---|
| | Minimum | Maximum | |
| Andavadoaka | 0 | 10 | |
| Bevato | 2 | 15 | |
| Antsepoke, Bevohitse | 6 | 30 | offshore |
| Ambatamilo, Fiherenamasay | 1 | 5 | inshore |
| Ambatamilo, Fiherenamasay | 6 | 30 | deep water |
| Ifaty | 0 | 7 | |
| Morombe | 2 | 12 | |
| Morondave | 5 | 20 | |
| Anakao | 0 | 6 | |
| Befasy | 1 | 2 | |
| Befandefa | 6 | 30 | |

Some fishers also reported that catches of individuals are higher if smaller sharks are included e.g. up to 50 sharks are caught per month by Befandefa fishers and up to 40 sharks per week by fishers from Morombe using ZDZD. High catches of immature sharks were reported by fishers during the hot season at some sites such as Morondave, where between 5 and 15 immature sharks were caught per day. Although these catches of smaller sharks are not a significant contribution to shark fin production or fisher income they do suggest that current fishing levels are over-exploiting local shark populations which could affect both fishery and population status.

Shark fin production can also be tentatively assessed by looking at the amount of fins collected by five main collectors in some of the larger towns on the west coast (Table 8). In a single month between 1.1 and 1.5 tonnes of shark fins can be collected which is equivalent to 13.5 - 16.5 tonnes of fins per year. One collector also provided anecdotal information on the decline of fin production over a three year period (2010 – 2012) for the coast between Morondave and Maintirano. The amount of fins collected decreased from 900 kg per month in 2010 to 210 kg per month in 2011. By 2012 between 60 and 250 kg of fins were being collected each month.

**Table 8. Shark fin collection at selected main towns on Madagascar's west coast in 2012**

| Site | Dried shark fins (kg per month) | Annual Estimates (kg) |
|---|---|---|
| Morombe | 500 | 6000 |
| | 400 | 4800 |
| Morondave | 70 – 180 | 840 – 2160 |
| | 60-150 | 720 – 1800 |
| Maintirano | 100-150 | 1200 – 1800 |
| Total: | 1130 - 1480 | 13560 - 16560 |

Total shark fin production by Madagascar's traditional fisheries cannot be estimated from the data collected during fisher or collector surveys for this study, but the information provided above does indicate that shark fishing for fins is still an important fishery along the west coast that provides both income and a source of food for local communities. However, there are signs of overexploitation with fishers having to travel further to catch larger sharks, the retention of small and immature individuals and a rapid decline in fin production for more remote areas (previously less fished for sharks) in recent years.

## Socioeconomic characteristics

The literature and shark export volumes show a rapid growth in shark exploitation during the 1990's and early 2000's. This exploitation was previously encouraged by development agencies, such as GTZ, in line with the government's aims of reducing poverty and using what was seen as an under-exploited resource (McVean et al., 2006). These efforts stopped because of declining populations, but shark fishing remains an activity for traditional and artisanal fishermen throughout western Madagascar. Information on the extent that fishing communities depend on shark fishing and how the decline of the fishery will impact livelihoods is needed, but will be difficult to measure.

Socioeconomic surveying in northwest Madagascar found that fishermen caught sharks to earn money from fins (88%), from meat (77%), as well as for food (31%) (Short, 2011). No respondents stated that they targeted shark as replacement for decreased catches of other species. The majority of reasons given were for additional income, rather than subsistence or necessity. Anecdotal information suggests that consumption of shark meat within fishing communities is generally low despite its low cost (~1,000 MGA/kg), compared to about 5,000 MGA/kg for zebu (beef), as the meat is not sort after (Short, 2011).

However, the prices paid for shark fins, the high utilisation of shark parts and the amounts landed indicate an increased reliance on shark as an additional income (Short, 2011). Moreover, in a country as poor as Madagascar, all additional sources of income and food are important (Short, 2011). This is particularly true for isolated fishing communities where there is no cold chain infrastructure or access to fresh seafood markets. Here, salted shark fins are one of the few high value products fishermen can sell, the other being trepang.

The decline in catches and drop in prices since 2012 have meant that many traditional Vezo shark fishermen have turned increasingly to sea cucumber diving as their main cash income. Nonetheless, for some of them, shark fishing remains an important activity.

Catch declines may be initially masked in trade data because as supply lags behind demand, prices will increase, driving a greater fishing effort (Clarke et al., 2007). The potential for fishermen to earn large amounts of money compared to other fishing activities, combined with them being able to catch other species of commercial and subsistence value, means that the fishery can remain viable even with a significant drop in catches. This socioeconomic context is known to lead to the collapse of a fishery (Randall, 1987). The overall outcome of fishery collapse would be a substantial decrease in both additional income from the sale of fins and to a lesser extent, meat, as well as a loss of shark meat as a cheap source of protein. This could further contribute to creating poverty traps in a country that has low adaptive capacity, (Adger & Vincent, 2005; Cinner et al., 2009) especially for 'bespoke' shark fishers.

## Artisanal fisheries

This section particularly focuses on the artisanal shark fisheries of Mahajanga, north-west Madagascar, where the new information on the fishery and supply chain for this study was mostly collected.

### Processing and products

Meat and fins are the only products of the artisanal fishery, with the jaws, head, tail and liver generally being thrown away (though sometimes the liver is kept for eating). The processing is much the same as that described for the traditional fisheries in the southwest: fishers dry and salt the fins and meat to make *maskita* during the fishing trips. Sharks are normally butchered on the vessels whilst at sea. The patrons may also pay for the processing of fins and meat when the crew returns to Mahajunga. This involves simply cleaning, salting and drying the fins. The higher level patrons and the main collectors cut off the excess flesh, wash the fins in fresh water and dry them, as described for traditional fisheries.

### Supply chain structure

The different levels in the value chain are illustrated in Figure 3. The cost of the fishing gear and cash needed for a fishing trip are major barriers to shark fishing for the average Malagasy fishermen. Consequently, in contrast to traditional shark fishermen, here the fishermen rarely own the boat and gear, but work as crew for a captain. The captain himself has a contract or agreement to work with a patron, who himself works for a higher-level patron, or in some cases, directly with the buyers. The patrons may own the boat and gear entirely themselves, own a share of it in partnership with the Chinese buyers or have no ownership. In 2012 there were said to be two principal buyers in Mahajanga, both of whom are also important players in the sea cucumber trade. The vast majority of actors in Mahajunga's shark fin business ultimately work for or sell to these two buyers. Those interviewed said that in turn, these two buyers work for Sea Reine and Sin Hing, Chinese-run companies based in Antananarivo.

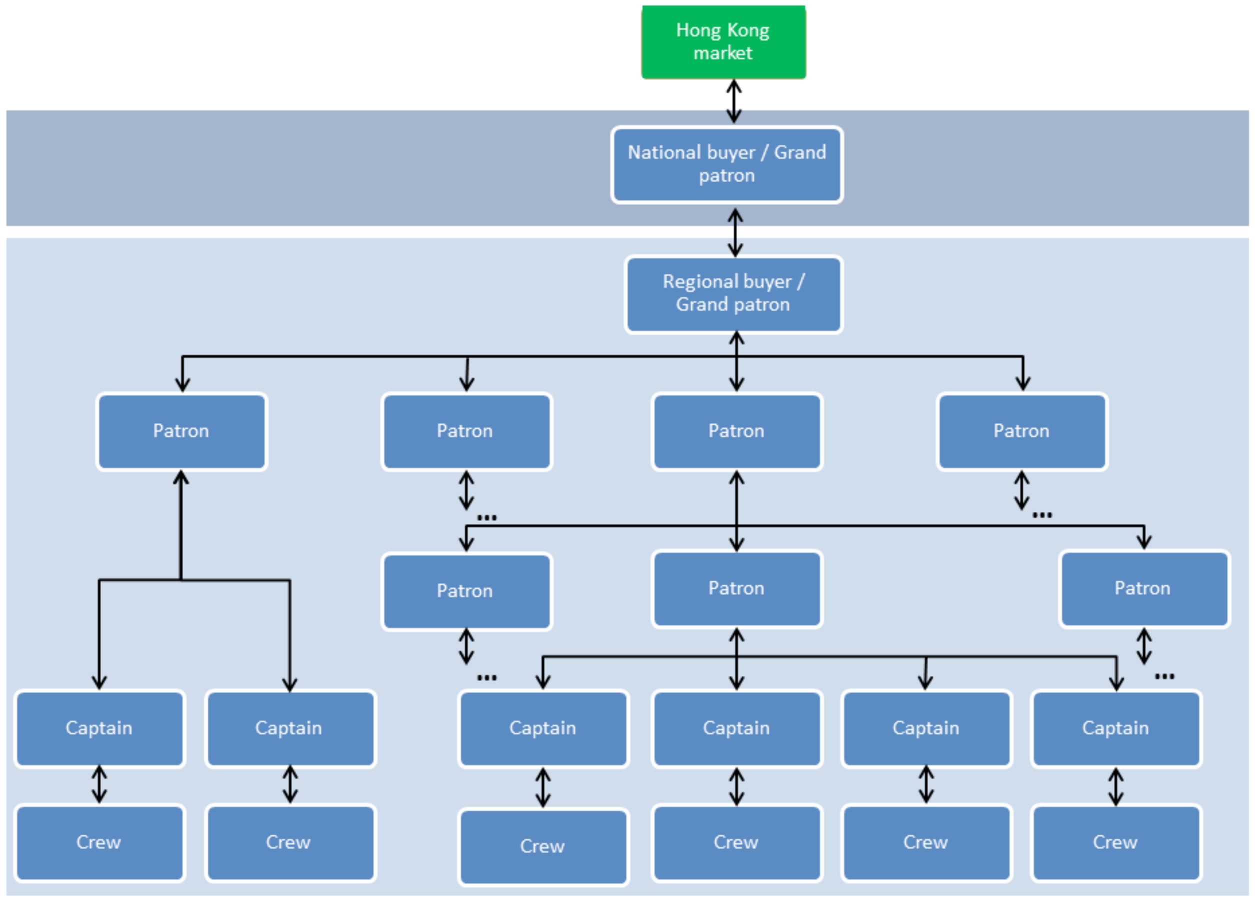



**Figure 3. Shark fin trade value chain in Mahajunga for artisanal fisheries. The dots indicate that there are other branches of the same type repeated, with patrons and captains working under these patrons and similarly having the same sub-value chain repeated under them.**

The regional Chinese buyers loan the patrons cash to cover all the costs of a fishing trip (diesel, food, money (though not salaries); and contracts the boat and gear to the patrons if he does not own these. It is a form of loan; which the patrons must then pay back when they bring back dried fins to sell to the buyers, who also set fin prices. The credit extended by the Chinese traders can be between 1 and 10 million Ar, which can be repaid in instalments. The buyers do not work directly with the fishermen, but through the patrons.

The patrons establish contracts with experienced fishermen whom they trust. These experienced fishermen are the captains, responsible for the fishing and are paid higher wages than the rest of the crew. The captains are responsible for finding and managing their own crew. Patrons often have more than one boss and boat working for them. Crew members are paid by kilogram of shark or guitarfish fins caught, with the patron having covered all of the costs of the fishing trip. Most patrons pay the crews a lower price for fins, and take off the costs of food or loans that they made to the crew. Some patrons just divide the money from the sale of the fins, less the cost of the food, into two: half for themselves and half for the crew.

It is not possible for a captain to bypass his patron and sell fins directly to a buyer, as the entire network ultimately relies on two buyers with a few main collectors working beneath them. The patrons do not normally buy or trade fins from other fishermen; they only sell what their crews bring in, though they

do often build up stocks of fins over two or three months before selling them to the main buyers.
A breakdown of the value of fins for sharks and guitarfish for artisanal fishing in Mahajanga is provided in Table 9. Only figures for the lower levels of the value chain were obtained during the study: the price paid to crews and to lower-level patrons by the main patrons / regional buyers. The basic crew are paid 50 ooo MGA/kg for shark fins and slightly more for guitarfish fins (60-70 ooo MGA/kg). The price paid by patrons or buyers for fins can vary considerably depending on the particular buyer and on the fishing arrangement i.e. whether the buyer or patron owns the fishing vessel and gear. However, most patrons were paying at least 200 000 MGA/kg for first quality shark fins and at least 400 000 MGA/kg for first quality guitarfish fins. Patrons also gave incentives in terms of greater values per kg for fins if the crew could bring back at least 100 kg of guitarfish fins from the fishing trip (Table 9, Bonus Value column)

**Table 9: Fin values for the Artisanal Shark Fishery Trade centered in Mahajanga.**

| Fin Type | Supply Chain Level | Fin Quality | Value range ('000 MGA/Kg) | Bonus Value ('000 MGA/Kg |
|---|---|---|---|---|
| Shark | Basic crew | n/a | 50-60 | n/a |
| | Lower level patron | First | 80-240 | 400 |
| | | Second | 50-180 | 240 |
| Guitarfish | Basic crew | n/a | 60-100 | n/a |
| | Lower level patron | First | 150-480 | 550 |
| | | Second | 80-260 | 300 |

Entry into higher levels of the supply chain is not possible for ordinary fishermen and they must work beneath people who are not normally fishermen, but who have the credit to buy the gear and start up the enterprise. Shark fishermen also stated that most people do not have the appropriate knowledge of the sea needed to fish far offshore.
The two main buyers buy from the patrons who either manage the boats and gear of the buyers under contract, or own them. They also buy small amounts from sous-collecteurs who collect from traditional fishers and sous-collecteurs in the rural areas of the Mahajunga region. However, this source of fins is not seen as of any consequence to their business and is negligible compared to that of the system of patrons working underneath them. The study was only able to interview one of the main buyers. There are about 30 patrons who worked consistently with his business; and there are an even greater number of additional patrons and sous-collecteurs who work with them periodically. It should also be noted that the principal business of the large shark fin buyers is the sea cucumber trade, with shark fins being an ancillary business.
The only shark products the buyers purchase are fins; shark meat follows a separate supply chain (Figure 4). Artisanal shark fishers prepare and dry meat during a fishing trip, which is then sold by the patron to collectors in Mahajanga or other main ports once the fishing trip is complete. The mark-up for shark meat sold to the highland traders by main collectors was roughly 500 MGA/kg. These main collectors also purchase shark meat from travelling sous-collectors who buy meat directly from traditional fishers. Some of the meat is sold in local markets, but most is bought by highland traders and transported to inland markets in the main towns and cities. The final market price of shark meat in either coastal towns or inland centres was not ascertained during this study but the mark-up may be similar to the previous level in the supply chain (~500 MGA/kg.)

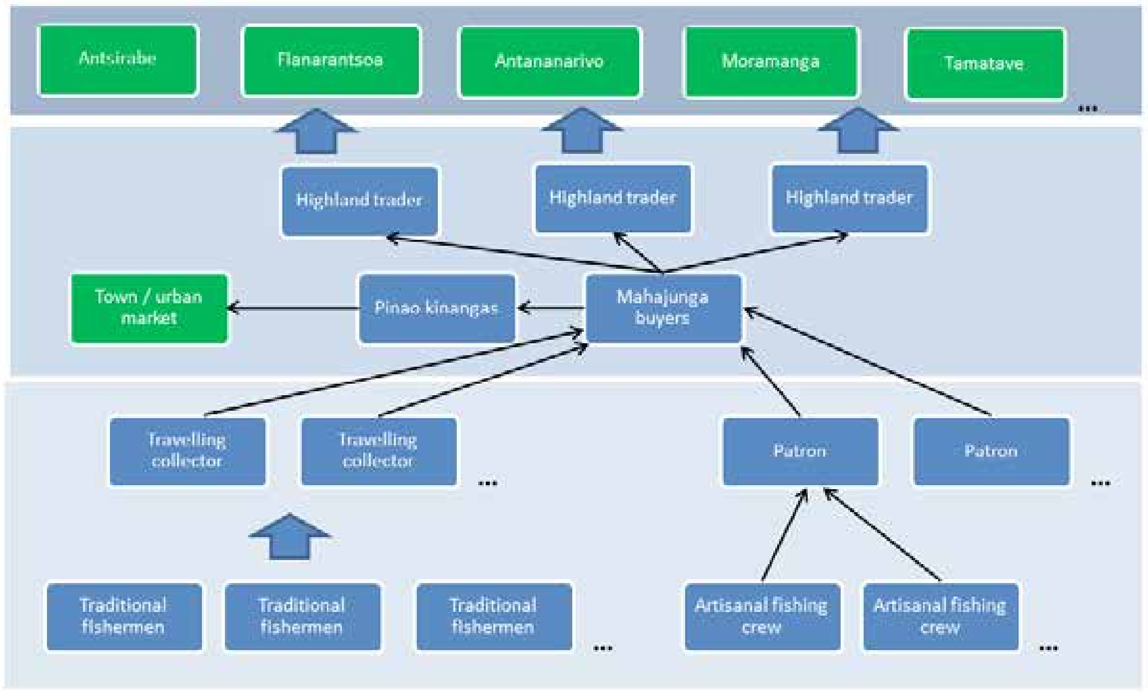



**Figure 4: Shark meat supply chain for sharks caught by artisanal fishers in northwest Madagascar. The dots indicate that there are other branches of the same type repeated. Pinaokinanga = women who buy shark meat (normally fresh) from the fishermen/central buyers and then sell it directly to individual customers in the markets or neighbourhoods / quartiers/**

### Distribution of the artisanal fishing effort

The northwest coast has been identified as the area of greatest production for shark with the highest trade in shark products, particularly in Mahajanga (Cooke, 1997). The northwestern Mahajanga region, running up and into Antsiranana, houses the majority of the artisanal shark fishermen who, thanks to the warm and calm weather, can fish for most or all of the year. (Cooke, 1997; Short, 2011). These fisheries, initially considered underdeveloped, were subject to development projects by GTZ and the MPRH in the early 1990s (these included traditional fishermen and have been described in more detail in the traditional fishing section above).
Information collected from focus groups and key informants consistently reported that there were about 200 teams of artisanal fishers, using small *botry* and fishing the entire coast between Maintirano and Nosy Be, with about 25 to 30 teams based in Mahajunga. Ananalava, Nosy Be and Nosy Faly were also noted as important home bases for shark fishermen. As for the teams based out of Mahajunga, many of these are itinerant, fishing the coast until Maintirano (sometimes further south until Belo-sur-Mer and Morombe) and moving according to catches and the weather. A boat captain from Nosy Faly stated that he had begun fishing seasonally out of Tamatave in 2010, giving an indication of the mobility of artisanal fishers and the distances that they will go to find still productive fishing grounds.
In the northeast, within the the Baie d'Antongil , there were five to seven groups of artisanal shark fishermen using motorised vessels and bottom-set gillnets at the turn of the last century (Cooke et al., 2003). Sharks constituted a significant part of their catch. The fins were exported to Hong Kong while

the meat was salted, dried and sold locally (Barnes, 2001; Doukakis et al., 2007). Little quantitative information existed on these fisheries and they were largely unregulated (Cooke et al., 2003 and references cited therein, including: Smale, 1998; Doukakis et al., 2007). The Baie d'Antongil is one of the few fairly large shallow-water habitats on the eastern coast of Madagascar and may serve as an important breeding ground for several shark species. Fishermen indicated the presence of gravid females from September to February (Cooke et al., 2003 and references cited therein; Doukakis et al. 2007).

### Gear and fishing

Gear used by artisanal fishers includes *palangre*, *jarifa* and GTZ nets (Cooke, 1997). In the northwest, artisanal fishermen have greater access to gear specifically targeting large pelagic fish and sharks than do traditional fishers (Short, 2011). They also reported catching a larger volume of sharks, with sharks making up a larger proportion of targeted catch (Short, 2011). Short also observed that artisanal vessels took longer fishing trips, often with time spent staying on islands in temporary camps.

Most artisanal fishers interviewed for this study use *bemaso*, which is similar to the *jarifa* used in southwest Madagascar. *Bemaso* are gillnets of about 30 cm mesh, 4 m tall and 1 km in length. The large mesh size of *bemaso* reflects that these nets are specifically designed to catch sharks and guitarfish, and not large pelagic teleost fish. Three or four such nets are used together and set on the seabed to form a *barrage*, often encircling a *riva* so that sharks and guitarfish moving on or off the reef at night are trapped. The *barrage* can be up to several kilometres long: for example, the study observed two *botry kely* working together that set between them about 10 km of *barrage* (54 nets, each 200 m in length). Fishers will set the *bemaso* 20 to 60 km offshore in 25 - 60 m of water. The nets can also be set as a form of drifting gillnet. *Bemaso* are made using Chinese-manufactured nylon rope supplied to the bosses, or *patrons*, of the fishing crews by the principal Chinese collectors, who also supply buoys and other material needed to make the nets. The patrons hire a team to make the net. The costs of *bemaso* range from 250,000 to 400,000 Ar/100 m of net.

Artisanal fishermen also reported using other gear similar to those used by traditional fishermen, but of a larger size, higher cost and made more specifically to target sharks. Such gear included: *jarifa talirano* (or *jarifa talirano 50*), a *jarifa* made of made of nylon monofilament instead of rope that is about 1 km long with a 9 m fall; *GTZ's* joined together to form a net of about 600 m long; and *palangre*. The costs of *GTZ* are around 450,000 Ar/100 m; *jarifa talirano* 75,000 Ar/100 m; and *palangre* of 100 m cost 500,000 Ar.

Fishing vessels are large enough to enable trips to the offshore reefs. Most commonly artisanal fishers use small wooden *botry kely* (about 8 m long, 3 to 5 tonnes), which are equipped with both a sail and a diesel motor (*tef tef*). Some fishermen use fibreglass *botry kely,* as the large diesel motors tend to shorten the life of the wooden vessels. Crew size varied from 6 to 12, but most are between 8 and 10. Fishing trips for small *botry* mostly last about two months, normally until food and diesel runs out, but can be from 1 to 6 months. Boats from Mahajunga work the entire coast between Maintirano and Nosy Be and will stay in the numerous small villages along the coastline or on islands. Fishermen check the nets every 3 days and trips out to the nets take between 12 and 16 hours. While fishermen in small *botry* mostly make single trips to set and check the nets, they will also sleep on the *botry kely* near to the net to conserve fuel. Sometimes small *botry* will work in pairs.

Some artisanal fishers also use fibreglass boats, mostly longer than 7 m, equipped with 15 to 60 hp outboard motors. With these boats fishing trips last from 12 hours up to four days.

There are also about 15 large *botry* (each about 40 tonnes) working from Mahajunga. The *botry* are equipped with inboard diesel engines and are used primarily as motherships for scuba sea cucumber diving, but also for shark fishing, on far offshore reefs. They anchor near to *riva* 40 to 50 km offshore and stay out there for 1 to 2 months, taking adequate water and food. The crew comprises 25 to 30 people, with 20 to 25 fishers (one team of scuba divers and another for shark fishing) and about 5 boat crew. The shark fishers use the fibreglass skiffs when the divers are not using them, to set and check the shark nets. Income from sea cucumbers is more than enough to cover the costs of the trips, but the patrons can make additional profit by shark fishing at the same time.

Fishermen specifically target sharks, which bring enough income that they do not need to catch anything else. The large meshes of the shark nets are generally too big for most fish, but do catch larger fish, such as large groupers and trevally, as well as turtles and rays. Turtles are discarded at sea, but fish and rays are kept for sale. A small *botry* can earn about 400,000 MGA a fishing trip from such bycatch. However, boat captains stated that the sale of the bycatch does not change the financial viability of fishing, which would not be viable without the sale of shark fins. Patrons see income from bycatch as an added benefit providing money to help pay for food and running costs. Fishermen using *bemaso* estimated bycatch to be quite low, about 5% of the number of sharks, or 5 large fish and 20 rays a month. *GTZ* nets have a much higher bycatch, particularly of small sharks, fish and rays. Fishermen could not estimate this reliably, but said there were sometimes hundreds of small sharks a month. However, other captains interviewed stated that bycatch of rays could be significant – up to several tonnes during a fishing trip, and that it was the sale of ray meat that allowed them to continue operating if they did not catch enough sharks.

Fishing takes place year round, only stopping during cyclones. Seasonal winds also determine where fishing takes place. Before the strong *varatraza* winds begin in May, fishing can take place far offshore. By the end of May, fishermen favour more sheltered areas and do not go far offshore. Most fishermen reported that there was no period when fishing was best, but that catches varied and depended on luck. Some, however, said the best period was March to September, because of the absence of cyclones. Fishermen also reported that they are able to catch bigger sharks when they go further offshore.

Fishing vessels and gear represent a significant investment. The table below provides some of the combinations and costs of gear used by the artisanal fishers interviewed, which give an indication of the upfront investments owners make (Table 10). The combinations of the types of vessel, engine and nets used vary, and consequently changesthe costs. One patron interviewed had two fibreglass boats that worked together, each costing 24 million MGA, excluding the cost of nets. The costs of a *botry kely*, the most commonly used vessel, complete with an engine, sail and nets, ranged from 10 to 20 million MGA.

**Table 10: Artisanal fishing costs for fishers operating from Mahajanga**

| Estimated total cost (million Ar) | Fishing vessel | Motors | Nets | Other |
|---|---|---|---|---|
| 8.3 | Fibreglass boat (about 8 m) equipped with both an engine and a sail - 5 million Ar | 15 hp outboard motor - 3 million Ar | | GPS - 300 k Ar |
| 24 per boat | Two fibre glass boats - 12 million Ar each | 60 hp outboard motors - 12 million Ar each | | |
| 12.5 | Botry kely, diesel motor and sail - 12,5 million Ar | | | |
| 20 | botry kely - 6 million Ar | Engine - 2 million Ar | 4 x 1 km bemaso – 12 million Ar | |
| 10 - 15 | A complete botry kely, nets, motor | | | |

Fishing trips are also a significant upfront investment. For example, costs for a typical two month trip include food for a crew of 6 to 8 (600,000 - 1,500,000 MGA), about 1,000 L of diesel (3 million MGA), or for boats using outboard motors, about 2,000 L of petrol (6.5 – 7 million MGA).

#### Catch estimates

The fishery is not monitored and it is presently not possible to make reliable estimates of catches. Artisanal fishing boats also used a range of gear types and sizes, and the duration of fishing trips vary, so catches from boat to boat vary. Nonetheless, overall it is clear that the catches of the artisanal fishery are much greater than that of the traditional fishery. In interviews conducted for this study, catches of adult sharks for a *botry kely* ranged from 16 to 40 a month. Fishermens' estimates of the weight of dried fins from fishing with *GTZ*/barrage nets varied from 10 to 60 kg a month of adult shark fins; 40 to 80 kg a month of small shark fins; and 20 kg a month of guitarfish fins. Other crews of *botry kely* using *bemaso* said that after a two-month fishing trip they bring in between 25 and 80 kg of dried adult shark fins and 12 and 25 kg of guitar fish fins. All fishermen and fishing crews interviewed said that catches are decreasing, mainly because there are too many boats fishing for shark.
One patron, who owned four *botry* that worked in pairs, reported that he sent between 50 and 200 kg of dried fins a month to a Chinese buyer in Antananarivo, together with about 400 kg of trepang. A sous-collector reported buying between 150 to 500 kg of dried fins a week, depending on the number of crews returning and how good the fishing was.
Each crew member usually earns between 500,000 and 1 million MGA for a two-month fishing trip. Fishing crews working on the large *botry* for shark and sea cucumbers earn 200,000 to 400,000 MGA a month; with their food on the boat being paid by the patron. The non-fishing crew are paid 80,000 MGA per week.
Interviews with collectors also indicate that the traditional shark fishery in the Mahajanga region is catching progressively smaller sharks. Many of the individuals caught are likely to be immature which could effect ongoing recruitment within shark populations and further contribute to population demise.

### *Malagasy longline fisheries, west Madagascar*

The collapse of Madagascar's wild shrimp populations and the end of most industrial and almost all artisanal shrimp trawling around 2005 led to part of this fleet being refitted for longline fishing along the edge of Madagscar's continental shelf. There are ex-artisanal shrimp trawlers working as longliners from the ports of Morondava and Mahajunga. Most of the species caught are snappers and emperors, but also include groupers, trevally and jacks. Many are demersal species associated with reefs and all catch is for export. Reports from fishermen working on boats from Mahajanga indicate that juvenile sharks (often referred to as *kasioke*) are caught, but are not retained.
Longliners operating out of Morondave do catch small sharks (up to 50 cm total length). Until 2010, sharks were regarded as low value and were discarded at sea. However, because of decreasing fish catches since about 2010, sharks are now landed and processed in the Sopemo factory. The fresh or frozen shark meat is sold locally for 3,000 MGA/kg. Crew reported catching 5 to 12 small sharks a week on a single boat. However, at particular locations where sharks occur in large numbers, vessels can catch 50 or more a week. The factory processes generally between 50 to 250 kg of shark a week.

## Industrial fisheries

This section briefly reviews the types of industrial or large-scale fishing that affect shark populations in Malagasy waters through direct fisheries targeting sharks or indirectly as a bycatch of other fisheries. However, most of the sharks taken as targeted or incidental catch by industrial fishing vessels are not landed in Madagascar. Any sharks or fins landed in the country enter into the same supply chains that exist for fins or meat provided through the artisanal or traditional fisheries.
It is important to note that no new information for the supply chain and market structure of the shark fin trade supplied by industrial fisheries for sharks caught legally or illegally in Malagasy waters was collected during this study. The reason for this was that the vast majority of fins collected by these fisheries do not enter the national fin trade and it was beyond the logistical remit of this study to collect new information from large-scale commercial vessels fishing offshore within the Madagascan EEZ.
Information on imports and exports has been gathered from reports and also through contacts in Madagascar and Hong Kong.

#### Shark bycatch

Industrial fishing in Madagascar is essentially made up of foreign longliners and purse seiners targeting tuna and associated species, Malagasy shrimp trawlers and, since 2010, a small fleet of Malagasy longliners. Foreign fleets have been present in Madagascar's waters since at least the 1980s. These fleets target mainly tuna-like species, but in some instances also sharks. Shark bycatch has been identified as potentially significant, both from the domestic shrimp fishery when this was active, and the international tuna fisheries (Cooke et al., 2003). A brief summary of each main type of fishery that catches sharks is provided below.
The EU possesses the largest Distant Water Fleet (DWF) in the Indian Ocean, with 124 vessels having the right to fish in Madagascar's EEZ. In 2011, 68 vessels were officially licensed to fish in Malagasy waters (source: Ministry of Fisheries). There were also eight other agreements with foreign countries to fish industrially within Madagascar's EEZ in 2011, with number of vessels per agreement ranging from 1 to 26.
It is difficult to accurately assess the number of foreign industrial vessels fishing with Madagascar's EEZ for any given year. Vessels follow the movement of tuna stocks, moving across multiple EEZs so the number of vessels that actually fish within Madagascar's EEZ can be less than the agreed number of licenses within the fisheries access agreements. In addition, while EU fisheries partnerships agreements (FPAs) are public, those struck with most of the Asian fleets, as well as some of the EU vessels, are private.
Furthermore, the reporting of shark bycatch by foreign industrial vessels is extremely inconsistent depending on the fleets concerned, with only retained catch reported in most cases (Ardill et al., 2013; Oceanic Développement & MegaPesca, 2011)

### *Purse-seine tuna fishery*

Based on available data, between 85 and 92 seiners were active in the Indian Ocean between 2006 and 2008, of which about 40 were European vessels (Oceanic Développement & MegaPesca, 2011). A European tuna purse-seine fleet has fished in the northern and western parts of Madagascar's EEZ since 1984, with vessels spending about 45 to 50 days in the EEZ a year as they follow the movement of tuna (Cooke et al., 2003). In 2011 there were 35 licensed industrial seiners fishing within Madagascar's EEZ: 23 European vessels; the rest being Asian (Taiwanese, Korean, and Indonesian), and Seychellian. Catches declared by the European Union each year since 1986 of species allowed in fisheries access agreements quickly reached the exact quota of 10,000 t./year (Le Manach et al. 2011, 2012). However,

actual catches are more likely to have been about 18,000 t./year (Le Manach et al. 2011, 2012).
Shark bycatch of WIO purse seine fisheries is dominated by carcharhinids, the most important being the silky sharks (*Carcharhinus falciformis*, 79%) followed by the oceanic whitetip shark (*C. longimanus*, 11%) (Stretta et al., 1998; Ardill et al., 2013). Many of the silky sharks taken are immature and are discarded (Amandé et al., 2008). Lablache and Karpinski (1988) estimated the shark bycatch rate of the WIO tuna purse-seine fishery to be 0.51%, which would indicate a bycatch of about 50 t of sharks annually within the Malagasy EEZ, based on the declared tuna catch of 10,000 t.
In Madagascar, shark fins from the purse-seine fishery have been landed illegally at Antsiranana, although the quantities are unknown (Cooke, 1997).

### *Foreign longline tuna fishery*

Longline tuna fisheries operate within all Malagasy waters, targeting mainly yellowfin and skipjack in the northern part of the EEZ (Cooke et al., 2003). Catches of the longline fishery are unknown because the catch is not landed in Madagascar, reporting requirements are not enforced and there have been substantial numbers of unlicensed vessels. Total annual longline catch in the Malagasy EEZ is likely to approach or even exceed 50,000 t (Le Manach et al., 2011, 2012). The bycatch and discards of longline fisheries in the Indian Ocean tuna fisheries is higher than for other gears, except for gillnets (Ardill et al., 2013). In the past, bycatch of sharks by longline vessels has been reported as 6 - 11% of the total catch (Cooke, 1997). No recent data are available on the rate of bycatch by industrial vessels within Malagasy waters, but in the Western Indian Ocean the actual shark catch of those fleets not targeting sharks was probably up to three times that reported, bringing the bycatch level to about 19% of target catches (Ardill et al., 2013). Furthermore, with the exception of the Spanish fleet for which blue sharks are a target species, sharks listed by the IUCN are the largest component of bycatch (Ardill et al., 2013). A probable bycatch of sharks for the longline fisheries has been estimated as 2,500 t annually (based on 5% of 50,000 t) (Le Manach et al., 2012). In these longline fisheries, there is also some switching of target species from tuna to billfish and sharks (Le Manach et al., 2012). The Spanish and Portugues swordfish longline fleets use wire leaders and now effectively consider blue shark as a target species (Ardill et al., 2013).

### *Industrial pole-and-line tuna fishery*

A pole-and-line fishery operates in Madagascar's eastern EEZ, targeting mainly swordfish (*Xiphias gladius*), tuna species and other large teleosts (René et al. 1998 cited therein; Le Manach et al., 2011, 2012). The principal shark species affected by this fleet are mako (*Isurus oxyrinchus*), oceanic white-tip (*Carcharhinus longimanus*), scalloped hammerhead (*Sphyrna lewini*), common hammerhead (*Sphyrna zygaena*) and blue shark (*Prionace glauca*) (René et al., 1998), although bycatch rates are unknown. Though the catch for targeted species is unknown, Le Manach et al. (2011, 2012) estimates it increased to 5,000 t in 2008.

### *Shrimp trawling*

The industrial shrimp fishery officially began in 1967, and the number of vessels steadily increased from initially 11 to 71 between 1993 and 2003 (Le Manach et al.. 2011, 2012). The number of vessels declined since 2003, to reach 30 by 2010. After a historical peak of 13 700 t in 2003 (of which 70% were industrial), total catches from all sectors (industrial, artisanal, and traditional) began to drop and reached 5 400 t by 2010. Vessels operate mainly on the west coast and are characterized by an average length of 7 - 8 m and engine power between 50 and 500 hp. The usual gear is a double-twin bottom trawler, which is used no deeper than 30 to 40 m, the limit for economically viable exploitation.
Cooke (1997) reported an estimated bycatch rate of up to two to three sharks for every two to three hours of shrimp trawling around Nosy Be. A few years later, for the same fishery, du Feu (1998) reported an estimated three to five sharks per trawler a day amounting to a total annual bycatch of about 180 t. Substantial catches of sharks were reported in the early 1990s (up to 10/ day) between Morombe and Monrodave, but decreased substantially in the late 1990's (to 1 - 2/week), with sharks becoming absent from shallow water trawls in the early 2000's (Cooke et al., 2003). These observations suggested a bycatch of up to 15,000 to 20,000 sharks annually by the shrimp trawling fleet, based on an average weight of 12.5 kg a shark, but which declined substantially in the early 2000's (Cooke et al., 2003).
Fishermen interviewed for this study reported that large shrimp trawlers operating from Mahajunga fishing about 20 km offshore do have shark bycatch. The size of the sharks varied from 30 cm to 1.5 m in length, and with the species caught included hammerheads and *beloha*, the generic name for round-headed sharks. For each trawl, between 5 and 10 juvenile sharks are caught with larger numbers recorded during the hot season. Between 3 and 5 larger-sized or adult sharks are caught each week. Crew may try to fin larger sharks, discard the carcass and retain the fins. However they risk being caught as the national fisheries enforcement agency (Service de Peche) periodically inspects vessels when they arrive in port.

### *Malagasy tuna and swordfish longline fisheries, east Madagascar*

Following exploratory fishing from 2008 to 2009, in 2010 and 2011 three Malagasy companies began to exploit tuna and tuna-like species with 8 small (12 – 16 m) vessels (Rahombanjanahary, 2012). Based on catch declarations of the companies, the total catch in 2010 was 498 t, of which 32% was bycatch. Sharks made up 53% of the bycatch (Rahombanjanahary, 2012). The stated total catch in 2011 was 421 t, sharks making up 43% of the 24% bycatch.

## Directed Shark Fisheries

Over the last two decades there have been a number of authorised industrial shark fisheries. From 1990 to 1992, the Mahajunga-based company Somapeche carried out the only industrial fishery targeting sharks (Cooke, 1997). Somapeche targeted an unidentified, oil-bearing shark known as "*requin marron*" – brown shark. The shark was caught by deep sea fishing around the French island of Juan de Nova. Whether Somapeche and other industrial fishers continued to fish for shark, as well as the extent of their activities, is not clear (Cooke, 1997). There are some reports that Somapeche continued to engage in shark fishing after 1992, exporting shark fins, meat and oil (Cooke, 1997). They fished as far south as Morombe, discarding carcasses, and keeping only the fins and liver.
From 2000 to 2004, 10 Thai trawlers belonging to the "Thailand Madagascar Fisheries Group", based in Mahajunga, operated in northwest and western coastal waters of Madagascar. They were licenced to fish for a broad range of demersal species, specifically including sharks (CSP pers. comm.). However, the Malagasy government did not renew their licence in 2005 because of their use of highly destructive fishing practices.
A short-term agreement to carry out experimental fishing of sharks to "evaluate stocks" was established between a Korean company, Dae Young, and the government of Madagascar in 2011. It allowed five longliners to fish within Madagascar's EEZ, six miles beyond the coast for all sharks except great white sharks, basking sharks and whale sharks. The weight of shark fins on board was restricted to 5% of the weight of carcasses; and the total weight of bycatch of other species could not exceed 15% of the weight of the total catch of each vessel. Under the fishing agreement, Dae Young was under obligation to provide the Malagasy authorities with a report on catch. At the time of writing this study, Dae Young had not yet produced this.
Other industrial shark fishing has been conducted as short term prospecting or experimental fisheries: in

2007, experimental fishing for deep water sharks using longlines at at 1 to 1.2 km deep took place over 3 months (CSP pers. comm.). Other experimental fisheries took place in 2010 with 3 licenced vessels, and in 2011 with a total of 9 vesssels. Under the experimental fishing agreements these fisheries were authorised to target sharks for their meat, although it is likely they also exploited fins and liver oil (CSP pers. comm.)

#### Illegal, Unregulated and Unreported fishing

Illegal, Unregulated and Unreported (IUU) fishing within Madagascar's EEZ is an established problem and Madagascar's sharks are currently heavily targeted by illegal foreign vessels (Le Manach et al., 2011, 2012). IUU fishing for sharks by foreign trawlers takes place in two forms (CSP pers. comm.):

- Vessels licenced to fish other species frequently target sharks instead, either adapting their gear for sharks, or by exceeding the allowed bycatch levels for sharks;
- Unlicenced vessels operate illegally in Malagasy waters and take sharks as either targeted catch or as bycatch.

##### *IUU by licenced vessels*

Industrial fishing fleets, such as the European tuna fishing fleet, have high bycatch rates (Kroese & Sauer, 1998), yet the shark bycatch of these fisheries has not been assessed. Industrial vessels are able to fish for sharks asthey are authorised in the fishing agreements to land species 'associated' with the licenced target species; and are permitted a certain level of bycatch. Shark bycatch ratios depend on gear type, and were estimated to be 0.5% for purse-seiner catches and 7.5% for longliner catches (Cooke, 1997). However, they are likely to be higher. Le Manach et al. (2012) estimated that such shark bycatch amounted to 4,000 t in 2008. Although these sharks are not landed in Madagascar, it is highly likely that they are finned and sold to the Asian market.

In particular, checks by the CSP show that the shark bycatch of longliners authorised to fish tuna and associated species is high. Previously, fishing agreements with the Malagasy government authorised a shark bycatch for longliners of 5%. However, in 2010, the Indian Ocean Tuna Commission (IOTC) passed a resolution increasing allowable bycatch to 20%. Checks by the CSP indicate that longliners readily reach this limit; and often exceed it (CSP, pers. comm.) Published estimates of shark bycatch significantly underestimate the problem. In 2011 there were a total of 87 longliners: 42 Spanish and 35 Asian (Taiwanese and Japanese) (CSP pers. comm.). The exact shark bycatch of this fleet is unknown, but likely to be substantial.

In 2010 the IOTC also passed a resolution that aimed to prevent finning by prohibiting the removal of fins from the carcass. Industrial vessels are able to legally sidestep this regulation on the basis that the fins need to be cut off the carcass in order to preserve them; the fins are still kept together with the carcass. However, they are able to discard shark carcasses of low value (such as blue sharks) while keeping their high value fins along with the carcasses of high value sharks. Some vessels have the machinery on board to extract shark liver oil and so are able to further dissimulate their actual catch.

The definition of the 'associated' species, which are authorised for retention together with the permitted target species, can also be ambiguous, (CSP pers. comm.). Inspections of foreign vessels with large quantities of shark led to a clearer definition of 'associated' species in fishing agreements, with a listing of shark species that cannot be kept. However, this list is limited to only a few species which are given protection under CITES. Nor does this regulation prevent finning.

##### *IUU by unlicenced vessels*

Asian longliners fish in Malagasy waters, with unreported catches of up to 50,000 t/year (Fowler & Cavanagh, 2005; Le Manach et al., 2011, 2012). From 1991 to 1994, official access agreements existed between Asian countries and Madagascar, with declared catches varying between 6,000 and 8,000 t/year. With the exception of 1991 to 1994, Asian flag countries had no official access agreements with Madagascar, making any catches illegal under international law (Le Manach et al., 2011, 2012). Asian fleets in the WIO region target sharks, as evidenced by recent catch seizures[9]. Between 5 and 10% of the bycatch of these long-line fleets are sharks, of which only the fins are retained (Le Manach et al., 2011, 2012). In addition to IUU vesselss originating from Asia, there are also European ones (namely Spanish and Portuguese).

Both traditional and artisanal fishermen, and crew of the large *botry* used for sea cucumber diving, surveyed during this study reported seeing Asian trawlers longlining in the Mozambique Channel. In addition to unlicenced European and Asian industrial vessels, there are large numbers (as much as 700 to 800) of small (11 m) Sri Lankan fishing vessels operating illegaly within Malagasy waters in the Mozambique Channel (CSP, pers. Comm. 2012)[10].

A number of known IUU vessels, which previously targeted Patagonian toothfish (*Dissostichus eleginoides*) in the Southern Ocean, have been reported to have converted to shark fishing in southern and western Madagascar by substituting bottom trawl nets with bottom-set gillnet gear to target sharks for liver oil and fins (Le Manach et al., 2012).

Shark products caught from both authorised bycatch and IUU fishing are not landed in Madagascar and the country derives absolutely no benefit from them. Part of the shark catch passes via Mauritius and then mostly on to Hong Kong; the other part is transported to Taiwan, Korea and, to a lesser extent, Japan. Sharks caught in Malagasy waters are mixed with those from other origins, so that when the products arrive at market, their origin cannot be reliably identified. Establishing the amount of shark caught by industrial fisheries is further complicated because large fishing and processing vessels often spend long periods at sea, fish in several regions and are serviced by smaller boats. European trawlers return to their port of origin annually while Asian vessels can spend several years at sea.

The true extent of IUU fishing that take sharks in Madagascar's waters, both historical and current, is unknown. Though Madagascar has made signigicant steps in strengthening the monitoring of its EEZ since the early 2000's, Madagascar still does not have the means to adequately patrol its vast EEZ, and cannot properly monitor licenced vessels nor prevent unlicenced ones from entering its waters. Furthermore, IUU vessels often fish the edge of the EEZ or in the seas south of Madagascar, which are rough and inaccessible.

#### Supply chain structure

Almost none of the sharks caught by industrial trawlers are landed in Madagascar. The exception to this are some illicit shark fins sold to buyers in Antsiranana by EU tuna seiners when they land there. These fins would enter the same supply chain described for traditional and artisanal fisheries.

*9 For example: Peche illegale: Un bateau chinois arraisonne´ a Toliara. 2010. La Gazette. Available at: /http://www.lagazette-dgi.com/index.php?option=com_content&view= article&id=5927:peche-illegale-un-bateau-chinois-arraisonne-a-toliara& catid=45:newsflash&Itemid=58S ; and http://www.linfo.re/Madagascar-un-palangrier-interpelle-avec-3-2-tonnes-d-ailerons-de-requins*

*10 For example see: http://theindependent.mu/local/3549-illegal-fishing-convoy-reaches-mauritius.html*

## National Production

Comprehensive and consistently reported data on Madagascar's production of sharks across both small-scale (traditional and artisanal) and industrial fisheries do not exist. The catch of small-scale fisheries are not monitored and reported; nor do foregin industrial vessels fishing within Malagasy waters consistently declare shark catches. Government fisheries export statistics are the only data available at a regional and national level. However, they are often inconsistent or incomplete, reporting categories change or are confounded, exporters do not consistently declare volumes to the government, and there are contraditions between regional and national data, as well as that released by different agencies.

In an effort to give a measure of the overall national production, this section presents firstly the production reported in the literature, secondly the production estimated from a published reconstruction of historical catches of Madagascar's fisheries, and thirdly offical trade statistics on shark fins from various sources.

The official production and effective price of shark fins in Madagascar were low until the late 1980s (Cooke, 20o3). In 1991 and 1992 there was a rapid rise in the local price, from about $0.30 to $15.00 a kg (Cooke, 1997). In 1987 official shark fin exports reported by the MPRH were just 3 t, but by 1992 they were 29 t (Cooke, 1997). They remained high in 1993 (23 t), but dropped in 1994 (17 t) and by 2000 fin exports had declined to approximately 14 t (Cooke, et al., 2003). Given the high fishing pressure on sharks, this drop is likely a sign of overexploitation. In fact, many anecdotal observations by local scientists, fishers and scuba divers report a dramatic decrease in shark numbers over the last few decades.

The reconstruction of historical shark catches between 1950 and 2008 reveals much higher levels of exploitation than reported in official data (Le Manach et al., 2011, 2012). Le Manach et al. (2011, 2012) based their estimates of total domestic shark catches on trade data and the imports of dried fins to the Hong Kong and Singapore markets; and included shark bycatch of the domestic industrial shrimp trawl fleet. They also considered small scale shark fishing as having existed since at least 1950 as it had been documented to have already being taking place then (Petit, 1930; Cooke, 1997). Le Manach et al. (2011, 2012) found that the official imports of dried fins to Hong Kong and Singapore grew from 34.5 t in 1986 to a peak of 64.7 t in 1995. From 1996 to 2008, they conservatively assumed that the 1994 per fisher catch rate decreased by 3% a year.

The reconstruction of domestic shark catches conservatively estimated low catches until 1980, averaging 350 t/year, followed by a rapid increase from approximately 500 t in 1980 to almost 7,000 t/ year in 1992 (Le Manach et al., 2011, 2012). From this peak shark catches decreased to 3,800 t/year in 2008. Le Manach et al. (2011) found that foreign catches of mainly tuna and sharks in Madagascar's EEZ, both legal and illegal, have increased markedly since the mid-1980s. In 1990, catches were estimated to be 45,000 t/year, and increased to about 80,000 t/year by 2008 (Le Manach et al., 2011, 2012). The majority of these catches are taken illegally, mainly by the Asian longline fleet (Le Manach et al., 2011, 2012). Based on bycatch rates from the tuna fisheries, the total catches of sharks taken by foreign vessels will have also increased steeply since 1950, and were estimated at 4,300 t/year in 2008. These estimated shark catches do not include targeted shark catches, the amount of which is currently unknown.

Thus, total catches of sharks taken by both domestic (3,800 t/year) and foreign fishers (4,300 t/year) in Madagascar's waters in 2008 were likely to have been well over 8,000 t/year (Le Manach et al., 2011, 2012).

Table 11 below presents trade data on shark fins from Madagascar from 1984 to 2011. It includes official exports of fins from Madagascar; and imports to Singapore and Hong Kong.

**Table 11. Shark fin trade data for Madagascar, Singapore and Hong Kong from various sources.**

| Year | WTMU (kg) | MPRH (kg) | SING (kg) | HK (kg) | HK+SING (kg) | (HK+SING)-MPRH (kg) |
|---|---|---|---|---|---|---|
| 1984 | 6,563 | | | | | |
| 1985 | 1,744 | | | | | |
| 1986 | 915 | | | | | |
| 1987 | 3,581 | 2,909 | | | | |
| 1988 | 8,978 | 13,689 | | 5,272 | 5,272 | -8,417 |
| 1989 | 14,376 | 11,535 | | 13,376 | 13,376 | 1,841 |
| 1990 | | 6,657 | 3,318 | 8,460 | 11,778 | 5,121 |
| 1991 | | 15,094 | 880 | 22,416 | 23,296 | 8,202 |
| 1992 | | 29,213 | 6,000 | 31,921 | 35,261 | 6,048 |
| 1993 | | 23,891 | 5,000 | 21,240 | 23,079 | -812 |
| 1994 | | 16,565 | 11,000 | 19,370 | 29,070 | 12,505 |
| 1995 | | 19,045 | 100 | 33,554 | 33,654 | 14,509 |
| 1996 | | 11,300 | | 15,115 | | 3,815 |
| 1997 | | 1,300 | | 25,452 | | 24,152 |
| 1998 | | 24,500 | | 10,741 | | -13,759 |
| 1999 | | 10,480 | | 5,206 | | -5,274 |
| 2000 | | 14,221 | | 19,630 | | 5,409 |
| 2001 | | 14,961 | | 17,481 | | 2,520 |
| 2002 | | 20,093 | | 20,401 | | 308 |
| 2003 | | 18,384 | | 13,106 | | -5,278 |
| 2004 | | 43,410 | | 29,701 | | -13,709 |
| 2005 | | 57,653 | | 24,524 | | -33,129 |
| 2006 | | 26,080 | | 30,795 | | 4,715 |
| 2007 | | 37,893 | | 22,460 | | -15,433 |
| 2008 | | 37,732 | | 29,785 | | -7,947 |
| 2009 | | 43,315 | | 13,868 | | -29,447 |
| 2010 | | 31,902 | | 25,874 | | -6,028 |
| 2011 | | 41,981 | | 29,478 | | -12,503 |

Key: WTMU = data from Dockerty, 1992; MPRH = shark fin exports reported by the Ministère de la Pêche et des Ressources Halieutiques; SING = Singapore imports from Madagascar, data from Cooke et al. (2003), only available for 1990 - 95; HK = Hong Kong imports of dried fins from Madagascar, 1988 – 1991 data from Cooke et al. (2003), 1992 – 2011 data from Y. Sadovy, personal communication, University of Hong Kong; HK+SING = Total imports of shark fins to Hong Kong and Singapore. Data from the MPRH by region / district, the ASH by export destination, and the ASH by exporter are not included as these data were largely incomplete / inconsistently reported.

It is difficult to draw conclusions from shark fin trade data for Madagascar as there are a number of limitations to it, including:

- Offical data released by different agencies often does not agree. For example, national shark fin exports for 2005 were reported to be 57,653 kg by the MPRH, while regional MPRH production stated them as 36,511 kg, and the ASH as 12,400 kg by exporter and 11,350 kg by export destination. For the same year, Hong Kong imported 24,524 kg of dried fins from Madagascar.
- Categories of shark fins seem to be confounded: for example, the MPRH reported 37,732 kg of shark fins exports in 2008, while Hong Kong imported 29,785 kg of dried fins and 16,128 kg of wet fins from Madagascar in the same year. In some years it looks as though other shark products (meat, oil) are mixed in with shark fins.
- There is some evidence that exporters do not always declare the true weight of shark fins that they are exporting (for example, see Cooke 1997). Traders may also stockpile fins from year to year as political and market conditions change.
- There is a conflict between official imports of dried fins to Hong Kong and Singapore of 64.7 t in 1995 given in Le Manach et al. (2011, 2012) and those received by the authors for 1995.

In interpreting the data it also has to be borne in mind that Hong Kong is not the only export market for Malagasy shark fins. The ASH data for exports by country destination are incomplete and mostly inconsistent with the MPRH export data. Nevertheless, they show that for 1999 – 2009 (excluding 2006, for which there is no data), 90.5% of Madagscar's total shark fin exports were exported to Hong Kong (Table 12). Over the same period, the second largest importer was Malaysia (6% of total exports), followed by Thailand (1.8%). The other 1.7% of exports went to a number of countries, in order of priority: Canada, Singapore, South Africa, China, the USA, Japan and Mauritius. Until 1997, official imports of shark fins to Hong Kong were mostly greater than Madagascar's total official exports (Table 11). From 1998 onwards, with the exception of 2000 – 03 and 2006, Madagascar's exports are consistently greater than imports to Hong Kong. This would indicate that Hong Kong is not the only significant importer of Malagasy shark fins but that this is not reflected in the ASH export destination data.

**Table 12. Total shark fins exports from Madagscar by destination country for 1999 to 2009 (excluding 2006)**

| Export destination | Total exports 1999 - 2005, 2007 - 09 (t) | % total exports 1999 - 2005, 2007 - 09 (t) |
|---|---|---|
| Hong Kong | 170,575 | 90.5 |
| Malaysia | 11,392 | 6.0 |
| Thailland | 3,339 | 1.8 |
| Others | 3,110 | 1.7 |
| Canada | 1,467 | 0.8 |
| Singapore | 1,079 | 0.6 |
| South Africa | 240 | 0.1 |
| China | 187 | 0.1 |
| USA | 85 | 0.0 |
| Japan | 50 | 0.0 |
| Mauritius | 2 | 0.0 |

*Source: ASH exports by desintation*

Broadly the MPRH export data shows that Madagscar's production of shark fins reached a high in the early 1990's (29.2 t in 1992) and then declined until the early 2000's (exports from 1994 to 2003 averaged 15.1 t a year). Since then production increased again, exports averageing 40 t a year from 2004 to 2011. Production is therefore higher than it was in the early 1990's and has not diminished as assumed by Le Manach et al. (2011, 2012). Foreign imports of Malagasy shark fins show a similar trend: Imports of fins to Hong Kong and Singapore peaked in 1995 at 33.6 t; from 1996 to 2003 Hong Kong imports average 15.9 t a year; and from 2004 to 2011 they averaged 25.8 t a year but never regained their peak of the early 1990's.

## Value of Shark Exports

### Prices

Between 1989 and 1995 the price paid to fishers for dry fin increased from about 6 US$/kg to between 45 and 67 US$/kg for the highest quality fins (Cooke, 1997), a price increase, at minimum, of 650%. As the average size of sharks landed decreases, the premium paid for large sharks with higher quality fins has increased. In late 2011 and early 2012 when surveys were undertaken for this study, fishermen in coastal villages in southwest Madagascar sold first quality, dried fins for between 72 and 86 US$/kg. Lower level sous-collectors and artisanal fishermen in Mahajunga earned hire prices for the same quality of fins. The sustained upward trend in the prices of shark fins combined with sharks being an open access resource in Madagascar, will continue to drive exploitation, and is highly likely to result in population collapse for sharks and other exploited elasmobranchs. In recent years (2012-2014) the price of fins has dropped by about 40 – 50% of their 2011 values. In November 2014 the average price paid to fishers in Andavadoaka for first quality dried fins was approximately $45/kg for sharks and $70/kg for guitarfish. However, the income obtained from shark fins is still likely to far exceed that gained by most other types of traditional or artisanal fishing in Madagascar, with the exception of the sea cucumber trade.

### Madagascar exports

Official records of shark fin exports and their value between 1995 and 2011 are provided in Table 11. When the stated value of the exports are divided by the total amount of fins exported for each year the resulting unit value (USD/kg) is, for most years, significantly lower than the recorded observed value of shark fins bought and sold in the country within the supply chain based on shark fin prices Malagasy shark fishermen earned observed in both this study and other published literature.

If known supply chain values are taken into account then, using estimated lower and higher values that take into account all grades of shark fins traded, we can estimate the range of actual value of official shark fins exports (Table 11). This suggests that stated value of the shark fin trade is substantially underestimated. For example in 2009 the official value of the shark fin trade for Madagascar was $465 000 whilst the estimated value was in the range of $0.975 to $2.6 million USD. Furthermore the estimates for shark fin values used in this case are for the lower levels of the supply chain. The actual value of fins obtained for the final link in the supply chain when exported out of the country is not known but is likely to be significantly higher.

It should also be noted that there is an even greater level of lost revenue for Madagascar in terms of the shark fins harvested by offshore industrial fisheries in Malagasy waters that are not landed in the country. Assuming that all sharks caught by the large-scale fisheries are processed for fins then, given that industrial fisheries are estimated to catch more sharks than artisanal and traditional fisheries combined (4300 tonnes compared to 3800 tonnes per year, respectively) it follows that the value obtained will be higher than for the national shark fishery.

**Table 11: Estimated actual value of shark fin exports compared to the stated value between 1995 and 2011. FMG is the old currency and is exactly five times higher than MGA.**

| Year | Stated exports (t)* | Stated total value (FMG/ Ar)* | Stated total value (USD) | Unit value (USD/kg) | Estimated lower unit value (USD/kg) | Estimated lower total value (USD) | Estimated upper unit value (USD/kg) | Estimated upper total value (USD) |
|---|---|---|---|---|---|---|---|---|
| 1995 | 19 | 1,226,800,000 | 307,405 | 16.18 | 22.5 | 427,500 | 45 | 855,000 |
| 1996 | 11.3 | 644,200,000 | 162,978 | 14.42 | 22.5 | 254,250 | 45 | 508,500 |
| 1997 | 1.3 | 230,800,000 | 52,679 | 40.52 | 22.5 | 29,250 | 45 | 58,500 |
| 1998 | 24.5 | 985,500,000 | 189,311 | 7.73 | 22.5 | 551,250 | 45 | 1,102,500 |
| 1999 | 10.48 | 1,422,100,000 | 233,304 | 22.26 | 22.5 | 235,800 | 45 | 471,600 |
| 2000 | 14.221 | 661,726,222 | 100,025 | 7.03 | 22.5 | 319,973 | 45 | 639,945 |
| 2001 | 14.961 | 2,191,387,333 | 344,499 | 23.03 | 22.5 | 336,623 | 45 | 673,245 |
| 2002 | 20.093 | 803,782,292 | 128,951 | 6.42 | 22.5 | 452,093 | 45 | 904,185 |
| 2003 | 18.384 | 1,002,835,748 | 174,382 | 9.49 | 22.5 | 413,640 | 45 | 827,280 |
| 2004 | 43.41 | 4,003,795,256 | 485,301 | 11.18 | 22.5 | 976,725 | 45 | 1,953,450 |
| 2005 | 57.653 | 2,455,562,188 | 1,239,569 | 21.50 | 22.5 | 1,297,185 | 45 | 2,594,370 |
| 2006 | 26.080 | 837,793,226 | 403,563 | 15.47 | 22.5 | 586,793 | 60 | 1,564,782 |
| 2007 | 37.893 | 914,068,499 | 501,348 | 13.23 | 22.5 | 852,586 | 60 | 2,273,562 |
| 2008 | 37.732 | 866,548,362 | 518,966 | 13.75 | 22.5 | 848,975 | 60 | 2,263,932 |
| 2009 | 43.315 | 896,138,230 | 465,962 | 10.76 | 22.5 | 974,588 | 60 | 2,598,900 |
| 2010 | 31.902 | 890,756,370 | 430,960 | 13.51 | 22.5 | 717,805 | 60 | 1,914,147 |
| 2011 | 41.981 | 1,265,993,690 | 635,775 | 15.14 | 22.5 | 944,573 | 60 | 2,518,860 |

** Source of stated exports and stated total value: MPRH; The estimated unit value of shark fins (USD/kg) is derived from observed values Malagasy shark fishermen sold dried fins for found in this study.*

## Status of Malagasy shark fisheries

Shark catches in the Indian Ocean make up about 28% of global shark landings and include those of both India and Indonesia, which have the world's two largest shark fisheries. Yet very little is known about the catch trends and composition of the region, even compared to other poorly studied regions (Camhi et al., 2009; Dulvy et al., 2008). Similarly, little is known about western Indian Ocean and sub-equatorial African shark fisheries, despite this region having nearly 290 species of shark, 79 of which are endemic (Kroese & Sauer, 1998). However, local fishers and studies in a number of countries report a trend of decreasing shark catches (Laroche & Ramananarivo, 1995; McVean et al., 2006; Kroese & Sauer, 1998; Le Manach et al.,2011).

Western Indian Ocean catches are considered relatively low compared to other parts of the Indian Ocean, and Madagascar is not listed as a significant contributor to global shark catches (FAO, 2009). However, the international community has not managed to gather reliable data on shark catches (FAO, 2009), and Madagascar itself has not had the means to reliably monitor its shark fisheries.

Available production figures show that shark fisheries in Madagascar are now overexploited with the overall shark production falling from 50 t in 1997 to 15 t in 2002 (Soumy, 2004). Legal exports of shark fins seem to have peaked in 1994 at almost 65 t of fins, corresponding roughly to 6,500 t of live sharks. In 2010, shark fin exports were of 32 t - a 50% drop in exports over 16 years. Recent estimates of overall catches by Le Manach et al., 2011 suggest they could be twice that reported, not inclusive of subsistence fishing. These authors estimate unknown levels of targeted shark catch and potential bycatch to be well over 8,000 t/year. Additionally, no large-scale specific management measures to control or reduce this exploitation of shark stocks have been taken.

Other small-scale shark fisheries in the region of the Mozambique Channel, for example those of Zanzibar, have been assessed as potentially unsustainable (Shehe & Jiddawi, 2002). Whether attributed to the commercial or artisanal fisheries, many anecdotal observations by local scientists, fishers and divers report a strong decline in shark numbers over the last few decades. Given the high fishing pressure on sharks, this drop is very likely to be a sign of overexploitation. The marked drop in shark catches in southwest Madagascar is a driver of fisher migration further northwards in search of more remote and relatively unexploited fishing grounds off the west coast of Madagascar (Cripps, 2009).

# CHALLENGES

## Ecological

Shark and other chondrichthyan species generally have relatively low productivity and therefore require careful management and monitoring if they are to be utilized sustainably. Hence, in multispecies fisheries where the main target species are bony fishes, sharks landed as non-target species or caught as discarded bycatch might require 'special management' to prevent severe depletion. Some species of shark are apex predators and naturally have comparatively small population sizes. Whereas some species have very wide geographic distributions, others have very restricted ranges falling within the full range of a fishery or the range of other anthropogenic influences. Some species have critical habitats such a nursery, parturition and mating areas and migration lanes, which might need special protection.

## Data paucity in artisanal and traditional shark fisheries

Industrial fishing targeting shark species has gained much notoriety in recent years. However, smaller scale fisheries contribute considerably to global elasmobranch landings (Bonfil, 1997; Vannuccini 1999; Bizzarro et al., 2009); likely contributing to the declines in abundance for shark populations in inshore and coastal waters (Walker, 1998). Artisanal and traditional fisheries are generally data poor, with limited knowledge on volumes and composition of direct catch, often owing to the logistical difficulties in surveying such fisheries in remote and developing areas (Humber et al., 2011).

Gathering species-specific information in developing countries can be time consuming and expensive (Humber et al., 2011), and such baseline information is greatly lacking in artisanal shark fisheries (Bizzarro et al., 2009). Data deficiency surrounding life histories of target species, combined with a large uncertainty regarding the scale and dynamics of such fisheries, highlight an urgent need for a robust framework integrating biological and socioeconomic assessment (Curtis & Vincent, 2008; Dulvy et al., 2008). As without an understanding of these characteristics, development and implementation of any management plans will be ineffective by not reflecting the importance of shark catch to local livelihoods (Bizzarro et al., 2009).

Due to data paucity, high complexity, and the difficulties in assessment and monitoring, management of artisanal fisheries is often inadequate or absent (Martin-Smith et al., 2004; Curtis & Vincent, 2008). Regulations can be equally challenging to enforce (Curtis & Vincent, 2008), and the documented declines in shark numbers in regions where some management exists (e.g. North Atlantic stocks) have raised concerns for those areas whose management is poorly enforced or non-existent, where declines may be even greater and largely unreported (Abercrombie et al., 2005). In order to ensure the sustainability of artisanal fisheries, filling these data gaps to form strong scientific foundations for management is a priority.

## IUU fishing

IUU fishing continues to be a major issue for Madagascar and is thought to contribute substantially to shark takes in offshore Malagasy waters. IUU fishing occurs on both licenced and unlicenced vessels.

## Monitoring, Control and Surveillance (MCS)

An inadequate MCS regime is a major bottleneck for managing fisheries in a sustainable manner. Over 25 years of EU fishing agreements, Madagascar and the EU have not succeeded in establishing an MCS regime that gives sufficient confidence in verifying catches and FPA-conditions for industrial / large-scale vessels in Madagascar waters.

In the current Madagascar FPA, on-vessel monitoring is only allowed for longliners of more than 250 GT on the basis of 10% sampling on the basis of the fleet concerned. According to the protocol seiners cannot be inspected upon leaving Malagasy waters. Signals of under-reporting also exist in Madagascar, where unconfirmed anecdotes indicate that longliners may not pay the full licence fee that would be required for their catch volume.

The traditional and artisanal shark fisheries in Madagascar are not monitored or controlled either at the provincial or national level and are in effect unregulated.

# RECOMMENDATIONS

This section outlines a number of recommendations for the shark fisheries and trade currently operating in Madagascan waters. The bulk of the recommendations are concerned with improving the management of shark populations to conserve or rebuild stocks and ensuring that future exploitation is maintained at a sustainable level. A number of recommendations are also provided for the shark trade itself with regard to the supply chain and value of shark products.

## Shark Fisheries Management

First and foremost, Madagascar needs to develop a national plan of action (NPOA) for the conservation and management of sharks through consulting with the various stakeholders identified in this analysis. The process should be led by the Ministry of Fisheries through the CSP and should include interviews of stakeholders, national workshops and iterative stages of consultation. The eventual measures taken to manage Madagascar's shark fisheries would have to be defined through this stakeholder driven-process, and should be realistic and practical given the limited means for enforcement, but could include the following suggested actions under a series of key areas:

*Monitoring, Control and Surveillance*

- 100% observer coverage on large-scale commercial vessels that take shark directly or as bycatch. Observers would also undertake robust monitoring of elasmobranch bycatch at the species level, to provide the basic data required for stock assessment and analysing trends.
- For industrial fishers, require that fins remain naturally attached until sharks are landed. This helps with identifying the catch and prevents the practice of finning. Sharks with fins attached to be landed in country by all vessels licenced to fish within the Madagascan EEZ.
- Ban shark finning at sea for all shark fisheries in Madagascar. All sharks, rays and other taxa to be landed with their fins naturally attached.
- Require exporters and authorities to enumerate in detail shark exports under separate customs codes, including accurate weights, quantities and sizes of dried, frozen, processed and unprocessed fins. The current system prevents tracking the trade in shark fins and severely limits our potential to understand the magnitude of the trade and to identify those stakeholders most active. As fisheries data on sharks is poor, trade data may currently be the best way to assess exploitation levels. The establishment of customs codes should occur both regionally and nationally, supported by multi-lateral environmental or economic instruments such as CITES, CMS or the WTO. Receiving countries could require imports to be declared using a shark fin-specific code before they will accept shipments. A lack of transparency in the shark fin trade is a major obstacle to making links from shark fisheries to markets, and fundamental difficulties in identifying fins to species level is a major obstacle to the development of a sustainable trade. It is also imperative with the listing of new shark species to CITES and CMS that are regularly landed within Madagascar's EEZ by all fisheries (CITES 2014; CMS, 2014).
- Better stock assessments are needed for shark species that are commercially fished and more research is needed on unknown shark species before they are targeted by fishing fleets (as in the case of exploratory fishing agreements for deep sea sharks).
- Eliminate bycatch of sharks: Consistent with the new FAO international guidelines on bycatch management and reduction of discards, all fishing entities should seek binding measures to eliminate, to the extent possible, shark bycatch and discard mortality through spatial and/or temporal measures and modification of fishing gear and practices. This would be combined with 100% observer coverage on commercial fishing vessels that take sharks either as by-catch or directed fishery. Efforts should be concentrating on reducing by-catch (e.g. smart hooks) and developing standardized release practices to ensure high post-release survival.
- Explore the use of Compliance Bonds. Different fishing associations become jointly liable for violations by their vessels. The provisions in the bond could include failure to provide timely reporting of catch, catch location and other parameters as to be determined. A compliance bond would form a better financial safety fund against non-performance, since Madagascar could draw upon the entire amount lodged instead of the sum assigned to each vessel. This would create an effective incentive to ensure that compliance and enforcement requirements are met.
- Commercial foreign vessels should be obliged to explicitly refer to the 31 sharks species identified on the IOTC-code chart (www.iotc.org) as part of a standardised regional (WIO) approach.
- Create a system with penalties that requires RFMO members to report their shark catches. In some RFMOs reporting shark catches is a requirement but members who fail to report face no penalties. In other RFMOs reporting of shark catches is not required but should be made mandatory. All reporting should be to the species level to facilitate species-specific assessment of impacts.

*Size-/ Gear-based Measures*

- Limit the upper size of sharks caught. This can be achieved by imposing maximum size limits or using gear that is size selective. This ensures that the breeding stock, which in species where stock and recruitment are closely related, are protected. This has been a successful strategy used in the gummy shark fishery in southern Australia.

*Spatial Measures*

Prohibit shark fishing within existing MPAs and LMMAs, especially artisanal fishing for LMMAs

- Increase the coverage of LMMAs that prevent shark fishing by external fishers (traditional and artisanal) and limit local shark fishing to more sustainable levels. Madagascar's first shark sanctuary has recently been put in place in Antongil Bay and further sanctuaries should be considered (WCS, 2015).
- Implement large oceanic MPAs that include complete no-take areas. Oceanic MPAs (especially for offshore territorial waters) lag far behind existing protected area targets and behind coastal and terrestrial equivalents.
- Work with fishers to identify sensitive areas and estimate the impact of fishing on them. Propose measures for exclusion or management of fishing in those areas.
- Identify and protect areas of essential habitat for chondrichthyans (e.g., breeding and nursery grounds), particularly for threatened species.

*Market-based measures*

- Prohibit the retention of species at risk in all fisheries and the sale of products from these species, including not only any species listed in Appendix I of the CITES (already the case in Madagascar), but any shark species on the IUCN Red List of Threatened Species as Critically Endangered, Endangered or Vulnerable (the "threatened" category).

- Stop calling sharks bycatch. Fishing agreements should recognise that sharks are not bycatch in industrial fisheries but a targeted, valuable species. Industrial fishing agreements should reflect the value of this resource; and include strict regulatory limits on their take and strict enforcement on those limits. Unlike sea birds and sea turtles, management rather than mitigation is the key concept for sharks as long as they remain desirable targets (acknowledged or not).
- Develop the national or export market for shark meat to fully utilise the sharks landed at major ports in Madagascar from commercial licenced fishing operations.

*Education and Awareness*

- Conduct coastal zone location specific awareness programs involving the different stakeholders in the conservation and sustainable management of elasmobranchs.
- Develop long term action plans for the conservation and management of elasmobranch resources involving primary stakeholder communities to ensure their sustainable management.

*Community-based management*

- Explore the use of local laws (Dina) to set up local management of shark fishing through the use of spatio-temporal (e.g. LMMAs, seasonal restrictions) and/or gear-based measures (e.g. mesh size, net length).

*Research for Management*

- Collect life history data (age, growth, reproduction) on the sharks caught and use that the help improve management. Understanding population status can inform management actions that can improve sustainability.
- Better stock assessments are needed for shark species that are commercially fished and more research is needed on unknown shark species before they are targeted by fishing fleets (for example, European fishing efforts catching deep sea sharks)
- Specify the type of rays and sharks caught to the species level (if possible). Generic identification to "rays" or "sharks" tells us nothing about population changes for individual species.
- Conduct research surveys to estimate abundance levels of Chondrichthyes. Complement this action by reviewing historical data from surveys targeting teleost species to reconstruct the historical abundance of species of Chondrichthyes captured as bycatch.

It is common in fisheries research that investigation effort is directed to the target species (object) and information collected for other non-target species is less detailed. Ideally, all Chondrichthyes species should be monitored from plans or specific research projects that include the abundance estimate and its monitoring. There is a wealth of information on life history characteristics, reproductive parameters and length-weight relationships of many shark species, however there is insufficient information on population structure, delimitation of distribution areas and trends in abundance and catches.

*Other (Global) Measures*

- Work towards implementation of CITES Appendix II for marine species in China. Currently mainland China has not implemented CITES Appendix II for any commercially important marine species. This has important implications for several sharks and other marine species and will becoming increasingly an issue if/when more commercial marine species are listed on CITES Appendix II.
- Work towards removing fisheries subsidies globally for industrial and artisanal vessels. This would be a major step towards reducing fishing effort in general which should have positive impacts on both direct and indirect take of sharks (among many other species).
- Recognise that various existing measures such as port state controls, quotas, landing inspections etc are commonly ignored (we know that) but that these are commonly used by various bodies as demonstrating (inaccurately) that 'something is being done'. In the Indian Ocean, a high proportion of countries cannot be relied on for such actions. Thus, downgrade the emphasis placed on this as an effective measure. (That is not the same as saying downgrade existing controls; they are clearly useful measures in some places.)

### Value Chain / Enhancing Value for Fishers

*Traditional Shark Fishery*

Many traditional shark fishers receive a relatively low price for shark fins when selling them to local collectors. Bypassing the first link in the supply chain to sell fins direct to main collectors or buyers in major towns can substantially increase the revenue obtained for fishers. Forming shark fishing cooperatives may enable traditional fishers to obtain a better price for their fins by working together with other fishers to transport batches of fins to main collectors or buyers.

Similarly, transporting shark meat to urban markets could also increase the income fishers receive from this product although the increase in value is much less than that for fins.

*Artisanal Shark Fishery*

It is difficult to see how basic fishers in the artisanal fishery for shark could increase their income given that the supply chain is tightly controlled by a few main buyers. If all fishers working on a *botry kely* were co-owners of the vessel and gear then each could then obtain a more equal share of the revenue from the sale of shark fins and meat.

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# Appendices

# APPENDICES

## APPENDIX 1: QUESTIONNAIRES

**Key Informant / Focus Group Fishermen Survey**

Date:
Location:
Interviewers:

| | |
|---|---|
| Name (s): | |
| Age (youngest - oldest): | |
| Years of Experience (min. max.): | |
| Migrant (yes / no) | |
| Village of origin | |
| Place of residence | |

**Products and processing**
What do they do with the sharks once they bring them ashore?
What parts of the shark do they sell?
What kind of processing do they do themselves?

**Supply chain structure**
Can they draw a picture / map of what happens to the fins and other shark products (the person(s) buying them/ transport routes/ names of places / how they are transported (lakana, motorised pirogue, taxi brousse, 4 x4)?
Who do they sell the different shark parts to?
Do they sell to only one buyer? If so, why?
If they sell only to collectors in the villages, why do they not go to the closest town to sell there?

**Entry and fishing gear**
Why did they start?
What stops other people from becoming shark fishermen?

Do they fish only for shark, or do they fish for other things?
Are shark fins the main earner? Bring the most money? Can they survive with just shark fishing?
If they fish for other things, how much money do they earn from these / how important are the other things? If they don't catch shark, can they make enough money from other jobs?

What fishing gear do they use?
How did they acquire it? Were they supplied / assisted with buying gear?
How did they learn to use it?
How much does the gear cost? (list each item; min. to max.)

What distance they go out?
Depth they fish in?
How long is a fishing trip for shark?
Number of people in the boat?
How are the crew paid?
Length of pirogue / boat (min. – max.)?
Size of motor if they use a motor?

When you catch shark, how much does an average fishing trip cost?
What months of the year do you fish? Is there a favoured fishing season?

Do they know how many boats in the village fish for shark? How many fishermen?
Estimate total number of boats in the village / fishermen in the village?

**Target species**
Which species are most valuable to you and why?
Which species are the least valuable to you and why?
Do you target any particular species?
Why?
How?

What are the names of the species you catch?

Roughly how many adult sharks do you catch a week? a month? (min. – max.)
Roughly how many small sharks do you catch a week? a month? (min. – max.)
Roughly how many kg's of fins a week? (min. – max.)
Roughly how many kg's of fins a month? (min. – max.)
(clarify whether dry or wet!!)

Is the catch staying the same / increasing / decreasing?

**Prices**
Can they tell you how fins are graded / what the qualities are?
What are the prices of these different qualities?
What types of fins fetch the highest price?
How much do they sell the other parts of the shark for?

**Regulations / laws**
Are there any laws?
Can they describe these laws?
Do they respect them?

Can they give us the names and contact details of any collectors they work with? Where do the collectors come from?

### Key Informant Fin Trader Survey

Date:
Location:
Interviewers:

| |
|---|
| Respondent Details: Name: |
| Age: |
| Years of Experience: |
| Contact Details: |
| Nationality |
| City / Village of origin |
| Place of residence |

**Products and processing**
What parts of the shark do they buy?
What kind of processing do they do themselves?

**Supply chain structure**
Can you draw a picture / map of what happens to the fins and other shark products (where the shark products come from / who they buy from / where (a list of which villages) / transport routes/ names of places / how they are transported (lakana, motorised pirogue, taxi brousse, 4 x4, aeroplane??)/ who they sell the shark products to / what is the final destination of the products)?
Do you sell to only one buyer? If so, why?
Do you buy directly from fishermen or do you buy from sous-collecteurs

If you have sous-collecteurs, how many work for them?
Can you explain how this works?

Roughly how many kilograms of shark products do you buy each week / month?
How many kilograms of dried shark products do you transport our each week / month? (clarify that dried)

If you travel to villages to collect, could you estimate how much it costs to collect from the fishers?
How much does it cost to transport the shark products to the market / next buyer?

**Entry**
Why did they start?
How?
Do they supply any fishing gear to fishermen?
If so, what kind of gear? How many fishermen / teams have the given gear to?
What is the cost of this gear?
How do fishermen pay them back?
Do they reduce the price of fins paid to fishermen if the fishermen owe them money?

**Target species**
Which species are most valuable to you and why?
Which species are the least valuable to you and why?

When you collect shark products, how much does an average trip cost?
How long is an average collection trip for shark products?
What months of the year do you collect? Is there a favoured season?

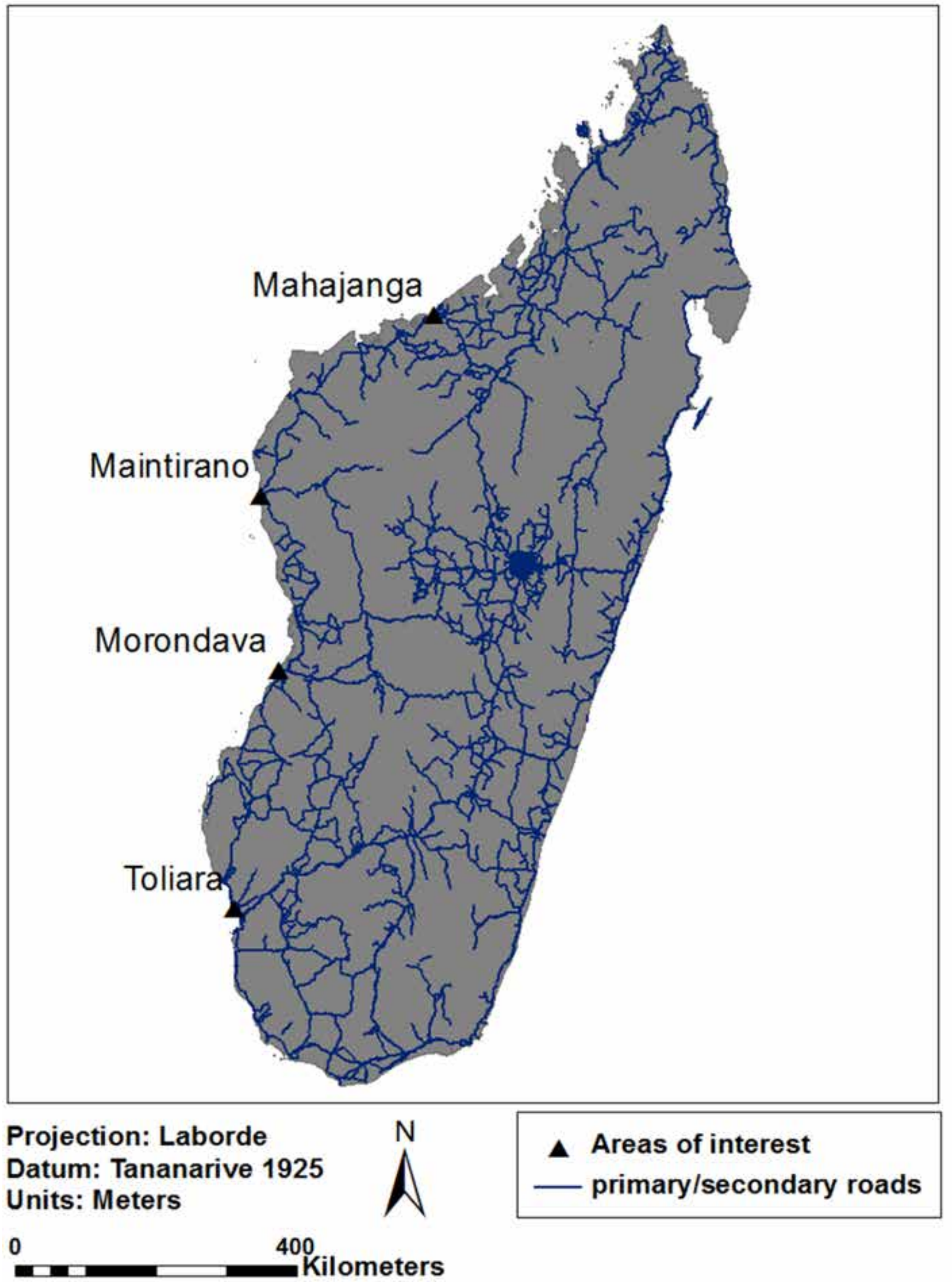
**Prices**
Can they tell you how fins are graded / what the qualities are?
What are the prices paid to fishermen / sous-collecteurs of these different qualities?
What types of fins fetch the highest price?
How much do they sell the other parts of the shark for?

**Regulations / laws**
Are there any laws or permits required?
Can they describe these laws.
Do they respect them?

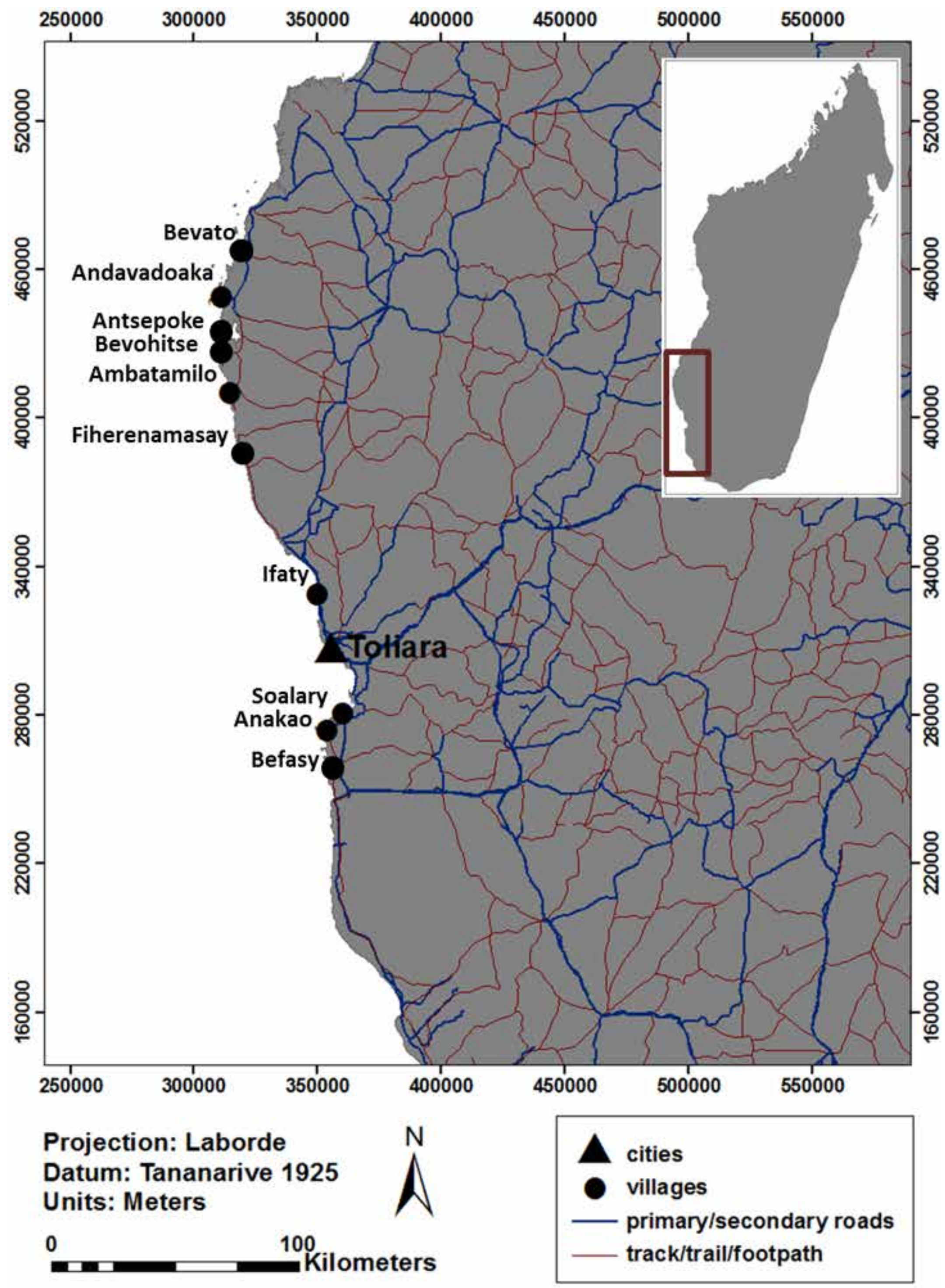
Can they give us the names and contact details of any sous-collectors who work for them?
Can they give us the names and contact details of any buyers they work for?
Do they know how many sous-collecteurs work in the area?
Do they know how many collecteurs work in the area?
Can they give the names of other collecteurs / traders?
Where do the collectors come from?

## APPENDIX 2: LOCATION OF SURVEYS

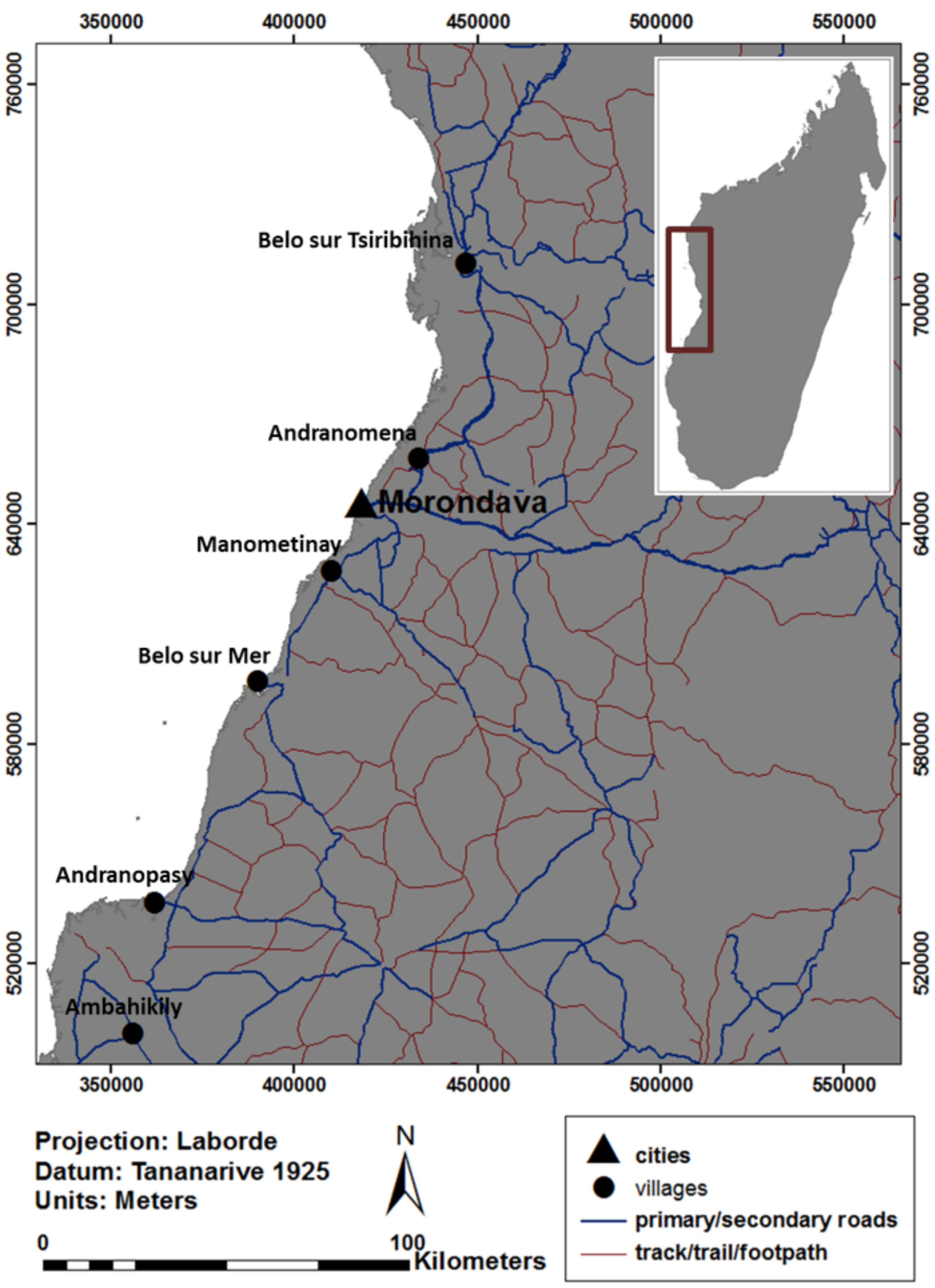
**2a: Map of Madagascar with main fishing centres of the west coast**



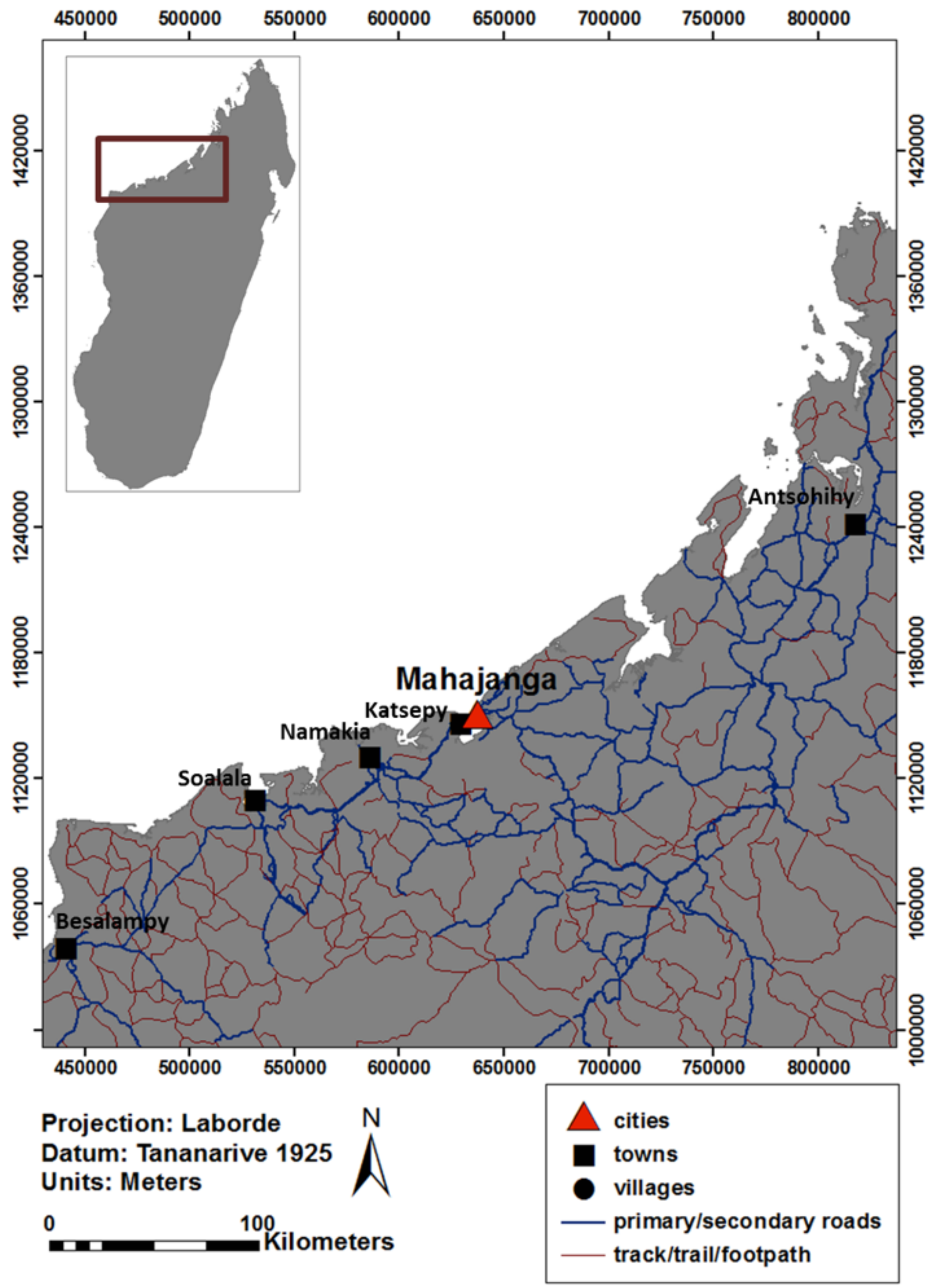

**2b. Rural villages of South West Madagascar**



**2c. Rural Villages assessed around Morondave**




**2d. Coastal towns assessed around Mahajanga**



## APPENDIX 3: CHONDRICHTHYAN SPECIES EXPLOITED IN MADAGASCAR’S COASTAL FISHERIES

| Species | Region | | | | |
|---|---|---|---|---|---|
| | NW/N/NE | E | SE | SW | W |
| Alopidae (Thresher Sharks) | | | | | |
| Alopias vulipnus (Thresher) | x | x | | | |
| A. superciliosus (Bigeye Thresher) | x | x | | x | x |
| Carcharhinidae (Requiem Sharks) | | | | | |
| C. albimarginatus (Silvertip) | x | x | | | |
| C. amblyrhynchos (Grey Reef) | x | x | x | | x |
| C. amboinensis | x | | | | x |
| C. brachyurus (Copper) | | | | | |
| C. brevipinna (Spinner) | | | x | | |
| C. falciformis (Silky) | x | x | x | | x |
| C. leucas (Bull) | x | | | | |
| C. limbatus (Blacktail) | | | | | |
| C. longimanus (Oceanic White-tip) | x | x | x | x | |
| C. melanopterus (Blacktip Reef) | x | x | x | x | x |
| C. obscurus (Dusky) | | | | | |
| C. plumbeus (Sandbar) | | | | | |
| C. sorrah (Spot-tail) | x | x | | x | x |
| C. sealei (Blackspot) | | | | | |
| G. cuvier (Tiger) | x | x | x | | |
| Loxodon macrorhinus (Sliteye) | x | | | | |
| Negaprion acutidens (Sicklefin lemon) | x | | | | |
| Prionace glauca (Blue) | x | | | | |
| Triaenodon obesus (Whitetip Reef) | | x | | | |
| Ginglymostomatidae (Nurse Sharks) | | | | | |
| Ginglymostoma brevicaudatum (Short-tail nurse) | | | | x | |
| Nebrius ferrugineus (Nurse) | | x | | x | x |
| Hemigaleidae (Weasel Sharks) | | | | | |
| Hemipristis elongatus (Snaggletooth) | | | | | |
| Hexanchidae | | | | | |
| Hexanchus griseus (Bluntnose six gill) | | | | | |
| Lamnidae (Mackerel Sharks) | | | | | |
| Carcharodon carcharias (Great White) | | | | | |
| Isurus spp. (Mako) | | | | | |
| Odontaspidae | | | | | |
| Odontaspis ferox (Small-tooth Sand Tiger) | x | | | x | x |
| Sphyrnidae (Hammerhead Sharks) | | | | | |
| Sphyrna lewini (Scalloped Hammerhead) | x | x | x | x | x |
| S. mokarran (Great Hammerhead) | x | x | x | x | x |
| S. zygaena (Smooth Hammerhead) | | | | | |
| Stegastomatidae (Zebra Sharks) | | | | | |
| Stegastoma fasciatum (Zebra) | x | x | x | x | x |
| Hemiscyllidae | | | | | |
| Chiloscyllium griseum (Grey Bamboo) | | | | x | x |
| Chilosyllium caerulopunctatum (Bluespotted bambooshark) | | | | | |
| Rhynchobatidae (Guitarfishes) | | | | | |
| Rhynchobatus djiddensis (Giant Guitarfish) | x | | x | | |
| Pristidae (Sawfishes) | | | | | |
| Pristis | x | | | | |
| Identifications to family level only | | | | | |
| Hexanchidae (Cowsharks) | | | | | |
| Dasyatidae (Whiptail Stingrays) | | | | | |
| Taeniura lymna (Bluespotted Stingray) | | | | | |
| Myliobatidae (Eaglerays) | | | | | |
| Mobulidae (Devilrays) | | | | | |
| Pristidae (Sawfishes) | | | | | |
| Torpedinidae (Torpedo Rays) | | | | | |

*Source: Inventaire des chondrichthyes commerciaux de Madagascar*

Accompanying Notes

Scalloped hammerheads (*Sphyrna lewini*) are caught throughout Madagascar (Cooke, 2001). Blacktip reef sharks, smalltooth sandtigers (*Odontaspis ferox*), spot-tail sharks (*Carcharhinus sorrah*), tiger sharks (*Galeocerdo cuvier*) and grey reef sharks (*Carcharhinus amblyrhynchos*) are also common in the north. Pigeye sharks (*Carcharhinus amboinensis*) and oceanic whitetip sharks (*Carcharhinus longimanus*) were also reported to be important catch species for artisanal fisheries in the northwest. More silky sharks (*Carcharhinus falciformis*) were caught in the east coast fisheries than those of the west coast, in keeping with them being pelagic sharks (Cooke, 2001).

The Toliara shark fishery catches about 25 species of sharks (Cooke 1997; FAO 1998). The identification of species is complicated by local names varying greatly, with differences even between neighbouring villages. This source of error pervades the literature and is a significant barrier to attaining accurate species-specific information.

The GTZ-MPRH fisheries development project in the Mahajunga region required fishermen receiving nets to complete catch data sheets, resulting in the largest data set available on the fishing of sharks and other target species, with a total of some 21,000 records over eight years (du Feu 1998). The species most represented in this fishery were *Carcharhinus amblyrhynchos*, *C. sorrah*, *S. lewini*, *Loxodon macrorhinus*, *C. melanopterus*, *Triaenodon obesus* and *C. albimarginatus*.

At least thirteen species of shark from five families were taken by the shark fisheries in northwest Madagascar (Short, 2011). Of these, sphyrnids were the most frequently caught, constituting 29% of the catch. The exact species of hammerheads caught could not be determined as the fishers did not distinguish between scalloped (*Sphyrna lewinii*) and smooth hammerheads (*S. zygaena*). Other frequently caught species included grey reef sharks (*Carcharhinus amblyrhynchos*), representing 13% of the catch and tiger sharks (*Galeocerdo cuvier*), which represented 9%. The colloquially named *mainte pate* was the third most frequently recorded.

Unpublished results of field surveys in the the Baie d'Antongil of artisanal shark fishermen indicated that more than 13 species were caught, including *Galeocerdo cuvier*, *Carcharhinus leucas* and other *Carcharhinus spp.*, *S. lewini* and other *Sphyrna spp.* and rarely whale sharks *R. typus*. Interviews with local fishermen suggested that many more species were probably caught (Smale 1998). Rays (such as *Aetobatus spp.*) as well as guitarfish (*Rhinobatos spp.*) are also regularly encountered in this fishery.

IOC-SmartFish is a regional fisheries programme managed by the Indian Ocean Commission, funded by the European Union and co-implemented by the Food and Agriculture Organization of the United Nations. IOC-SmartFish, which operates in twenty countries throughout the Indian Ocean Region, Southern and Eastern Africa, focuses on fisheries governance, management, monitoring control and surveillance, trade, and food security.

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