Fishing in the Seychelles:
a historical baseline for threatened species in artisanal fishery

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Abstract

The purpose of this study is to establish a historical baseline for the occurrence and relative abundance of a group of selected threatened species in artisanal fishery in Seychelles and to document the decline in these species. It particularly focuses on a list of species classified as "threatened" on the IUCN red list (Critically Endangered, Endangered and Vulnerable categories). The study seeks to answer the following questions: to what extent have threatened species declined in artisanal catch in Seychelles? How have the changes in fishing methods lead this decline? The goal is to analyze the history of threatened species fishing in the Seychelles, and understand what species were mostly caught and identify the methods used. This historical baseline will then be used to inform the process of developing management measures to reduce the impact of artisanal fishery on threatened species.

The authors reviewed published reports and accounts on fisheries in Seychelles. These included historical fisheries reports, documents or articles from the Seychelles Fishing Authorities archives, the National Archives and libraries on the main island of Mahé. The principal findings of this review indicate important research and data collection issues in the fishery sector. There are very few studies and analyses on the extent, nature, causes and dynamics of the decline in specific threatened species.

Similarly, the extent to which technological change and the gears employed in artisanal fisheries sector affects species decline appears to be subject to limited study. On the other hand, the literature abounds with statements, largely unsupported by empirical evidence, regarding occurrence and relative abundance of some species of interest for this review.

There is also limited understanding on the impact of the decline of threatened species on fishers and on the economy in general. The majority of research centers focuses on indicator species or broader classifications of families that are still economically viable and little attention is given to the stock of threatened species.

While empirical evidence is still very limited on threatened species, the type of gears employed in artisanal fishery is relatively well documented. Nonetheless, the link between the use and changes in gears and species decline remains somewhat elusive. The extent of areas used for fishing and the intensity of fishing in different parts of the archipelago throughout history is also poorly documented. However, investigations of indirect factors such as economic development and fishery management approaches on stocks have, to some extent, been included into some research. In addition, such climate change and destruction of habitats cannot be ruled out as contributing factors in the drastic change of Seychelles marine ecosystems.

The review serves as a benchmark that clearly illustrates the lack of species-specific information with regards to the threatened species and underscores the need for more research that could be pivotal in management approaches for the fishery sector.

Introduction

This paper presents the findings of a literature review conducted by Green Islands Foundation (GIF) under the GEF-Satoyama Project. The project aims to develop a co-management plan, designed by fishers, to minimise the impact of the Seychelles artisanal fishery on threatened species. This review intends to establish the historical baseline for occurrence and relative abundance of selected threatened species, specifically in the artisanal fishery catch. These species feature on the IUCN Red list and are being specifically targeted under the project.

The main objective was to review old technical and historical literature for records of former occurrence/catch of threatened species. The review also examines the different fishing techniques and gears employed by fishers throughout the years and also seek to evaluate the impacts on the threatened species compositions.

Planning for the development of a co-management plan needs to be supported by good quality information on species compositions in the fishery, in order to enable appropriate decision-making. This document aims to bring together existing knowledge on the threatened species in order to consider the status quo and to identify uncertainties and knowledge gaps. Consolidation of this information will equally underpin the development of guidelines and approved methodologies to assess species decline. This information should be particularly useful for research prioritization with regards to the targeted species in the artisanal fishery and ultimately contributing towards management measures.

Scope

This document seeks to address the species classified as threatened on the IUCN red list, particularly those that will be impacted by the GEF-Satoyama Project. The species to be considered (22 in total) are listed below in Table 1. However, broad genera categories are often considered in this paper, when particular species are not referred to in literature. Additionally, although reference is also often made to other types of fisheries to establish context for total catch, the document focuses mainly on artisanal fishery in Seychelles.

Artisanal fishery is defined by Food and Agriculture Organization of the United Nations (FAO) as *"Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption"*. In practice, definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20 m trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial, providing for local consumption or export. They are sometimes referred to as small-scale fisheries. The artisanal fishery of the Seychelles is characterized by a wide variety of boats using different gears and catching various species within the Seychelles Exclusive Economic Zone (EEZ). The variation in gears and targeted species are described in detail, later in the review.

Table 1 - List of species targeted under the GEF-Satoyama Project

	Species	Common Name	Creole Name	IUCN Status
	Teleosts			
1	*Cheilinus undulatus*	Napoleon wrasse	Aya zerar	EN
2	*Bolbometopon muricatum*	Green humphead parrotfish	Filanbaz	VU
3	*Epinephelus lanceolatus*	Giant grouper	Vyey krab	VU
4	*Plectropomus laevis*	Blacksaddled coral grouper	Babonn sesil/zonn	VU
	Elasmobranchs (sharks)			
5	*Sphyrna lewini*	Scalloped hammerhead	Marto rouz	EN
6	*Sphyrna mokarran*	Great hammerhead	Marto blan	EN
7	*Sphyrna zygaena*	Smooth hammerhead	Marto ronn/nwanr	VU
8	*Carcharhinus albimarginatus*	Silvertip shark	Reken waro	VU
9	*Carcharhinus plumbeus*	Sandbar shark	Zelron	VU
10	*Hemipristis elongata*	Snaggletooth shark	Ledan deor	VU
11	*Nebrius ferrugineus*	Tawny nurse shark	Landormi	VU
12	*Negaprion acutidens*	Sicklefin lemon shark	Kabo roz	VU
	Elasmobranchs (guitarfish)			
13	*Rhina ancylostoma*	Bowmouth guitarfish	Gitar/Pantouf	VU
14	*Rhynchobatus australiae*	Whitespotted wedgefish	Vyolon	VU
	Elasmobranchs (rays)			
15	*Aetobatus ocellatus*	Ocellated eagle ray	Lare sousouri	VU
16	*Aetomylaeus vespertilio*	Ornate eagle ray	Lare dore	EN
17	*Mobula alfredi*	Reef manta ray	Dyab	VU
18	*Mobula birostris*	Giant manta ray	Dyab	VU
19	*Mobula mobular*	Giant devil ray	Swarko	EN
20	*Pateobatis fai*	Pink whipray	Lare bannan	VU
21	*Taeniurops meyeni*	Round ribbontail ray	Lare brizan/Soulmann	VU
22	*Urogymnus asperrimus*	Porcupine ray	Lare boukle'	VU

Methods

The study analysed historical documents dating back to early settlers, historical catch data and influences of exploitation levels, technological adaptations, management changes and other documents such as newspaper articles, related to fisheries in general. The information was obtained from historical archives at the National Archives Center and libraries on the main island of Mahé and also included written reports by Seychelles Fishing Authority (SFA).

Review of Literature

Species of Fish Caught

For the purpose of this paper, the 22 species listed in Table 1 are divided into four main categories as indicated in the table: teleosts, sharks, guitarfish and rays. However, given that there were no records on the guitarfish, this species did not feature in the discussion. Furthermore, in the majority of the consulted literature, rays and sharks were often grouped together. Consequently, the rays featured in Table 1 also do not form part of the discussion as a separate group.

TELEOSTS

Groupers

Groupers are amongst the most commercially important of all marine teleosts and are highly valued in the world. They are being increasingly targeted globally for human consumption in both domestic and international trade, for food and as marine ornamentals (Howlett *et al.*, 2016; Tupper, 2007). They are classified in 14 genera of the family Serranidae and subfamily Epinephelinae, comprising of at least approximately 449 species. To note that the six most common species of grouper in Seychelles are as follows: the red mouth (*Aethaloperca rogaa*), slender (*Anyperodon leucogrammicus*), peacock (*Cephalopholis argus*), coral hind (*Cephalopholis miniata*), blacktip (*Epinephelus fasciatus*) and blackfin (*Cephalopholis nigripinnis*) (Howlett *et al.*, 2016). Consequently, research often focused on these species, as opposed to the less common ones.

In relevance to our species list, the giant grouper *Epinephelus lanceolatus* and the blacksaddled coral grouper *Plectropomus laevis*, although present in Seychelles waters, are now less common and are also present on the ICUN red list of threatened species. Early literature addressing groupers in Seychelles fisheries recorded 43 giant groupers caught at Aldabra, making up 16% of catch there (Wheeler, 1956). Records from later in 1988 indicated that groupers were the most abundant catch on the Amirantes plateau (Lablache *et al.*, 1988).

As it can be deduced from *The Mauritius-Seychelles fisheries* survey in 1953, Wheeler accounts, research focused mostly on the most common groupers. Although no distinctions between species were made in the recorded catches, the importance and occurrence of groupers in artisanal fishery was clearly illustrated.

Findings on a interview-based surveys of artisanal fishers suggest that several spawning aggregations are targeted by fishers on a regular basis (Robinson *et al.*, 2004)

Sudies conducted in the Carrabean suggested that the overfishing of groupers spawning aggregations contributed to the collaps of commercial fish stock (Sadovy & Eklund, 1999, cited in Robinson *et al.*, 2004), Concerns over the status of spawning aggregations in the Seychelles have increased over recent years, mainly as a response to reports of heavy exploitation at several sites (Robinson *et al.*, 2004). Live Reef Fish Food Trade trials at a number of atolls in 1998/ 1999 (Bentley & Aumeeruddy, 1999, cited in Robinson *et al.*, 2004) possibly targeted groupers' spawning aggregations.

By 1990 and 1991, the SFA recorded karang (trevallies) as the most dominant species group in artisanal fishery while groupers made up a total of only 6% of the overall catch in both years (SFA Annual reports, 1990a; 1991b). By the year 2004, groupers represented only 2.3% of total catch. This average range fluctuated between 1.3 % and 2.7 % from 2004 until 2009. However, from 2010 up to 2015 the average rose from 3.9 and 3.4 %. (SFA Annual Reports 2000–2009). To note that it has never reached the levels of previous years of the 1990s. In essence, this presents a different picture from the account of late 1920's where groupers dominated artisanal fishery. Hence, one could argue that there has been a steady decline in groupers over the past few decades and that the groupers featured in Table 1 experienced the same rapid decline in population, if not more drastic than the other groupers.

Wrasse and parrot fish

Documentation on parrotfish in the Seychelles artisanal fishery is equally elusive. In his account, Wheeler (1956) also makes reference to *'very few parrot fish being caught off Moyenne Island',* but again there were no specific mention of the species caught. Earlier accounts from Hornelll in 1927 briefly stated that the *Bolbometopon muricatum (*green humphead parrotfish) and the Napoleon wrasse (*Cheilinus undulatus)* were, at one point, amongst the most numerous individuals in abundance. However, there is lack of empirical evidence denoting the degree of abundance of this species. Fisheries report from 1988 also indicated that parrot fish was amongst the species caught in traps amounting to 153 tons in 1979 and dropping to 86 tons in 1984 in total catch (Lablache *et al.*, 1988). Again, based on the reported abundance of these species from earlier accounts, it can only be assumed that both the Napoleon wrasse and the green humphead parrotfish have also declined heavily over the past decades.

Sharks

Shark fishery has a long history in Seychelles and the local sharks stock represents an important socio-economic resource. The Seychelles stock, like others around the world, has been facing increasing pressures from high levels of exploitation and climate change related factors. Early accounts on the occurrence and abundance of sharks in Seychelles are descriptive and indicate very large populations of aggressive sharks (Table 2), however, they are rarely quantified.

Table 2: References to shark populations from the late 18th and early 19th centuries.
Note: Reprinted from Seychelles National Plan of Action for conservation and management of sharks, 2007.

DATE	REFERENCE
1768	*"the turtle populations of the islands are heavily predated by the sharks that populate the waters in prodigious numbers"* Mr Duchemin [32]
1770	*"Silhouette island is surrounded by prodigious numbers of sharks and crocodiles. The former are so aggressive as to impede the work of the oarsmen by their repeated biting of the oars"* Du Roslan [33].
1800	The Corsair Hodoul described how, while his ship lay at anchor close to the island of St Anne, one of his boats putting off to go ashore was overturned by a school of sharks leaving the crew on the ship to watch helplessly as their shipmates were torn apart. [34]
1805	*"But no [other] part [of the world] I have visited is so infested with sharks – the blue, the white, the tiger, the hammer-headed and indeed most of the varieties of that voracious tribe."* Captain Philip Beaver, [35]

Records suggest that shark populations stagnated at high levels through the 19th and first half of the 20th century and the occurrence of large specimens inshore was common (Hornell 1927, cited in Nevill *et al.*, 2007). Previously in 1926, Hornell himself strongly recommended to facilitate the development of the shark fishery, "...seeing how sharks swarm in the sea surrounding the island[s]"

Earlier in 1953, Wheeler also described "that sharks abound on the banks" and recorded sharks being caught but made no specific mention of how many or what species the catch consisted of; he merely mentioned that the white tipped shark was the most prevalent. In his 1948 and 1949 fisheries survey, he concluded that the standing biomass of sharks on the Seychelles banks exceeded that of demersal fish. He pointed out that Fortune Bank in particular was found to have very dense shark populations yielding a catch ratio of shark: fish of 16:1 (Table 3).

Table 3: Estimates of the standing biomass of shark and fish on the Seychelles banks (Wheeler, 1946).
Note: Reprinted from Seychelles National Plan of Action for conservation and management of sharks, 2007

	Standing Biomass (metric tonnes)		Shark : Fish biomass ratio
	Shark	Fish	
Mahe Plateau	56,100	46,500	1.2 : 1
Fortune Bank	10,622	655	16 : 1
Constant Bank	8,300	1,760	4.7 : 1
Amirantes Plateau	15,168	17,024	1 : 1.1
Total	90,190	65,939	1.4 : 1

Literature also recounts the inshore sightings of the larger specimens and most feared species of sharks as 'common' along the coasts of the inner granite islands. Great white sharks (*Carcharodon carcharias*) were sighted around Port Victoria, and tiger sharks (*Galeocerdo cuvier*) and, more importantly relevant to this review, large hammerheads (*Sphyrna* spp.), seen inshore along the bays, beaches and reefs, were not out of the ordinary (Ommaney, 1965 cited in Nevill *et al.*, 2007). However, by the late 1950s, populations were noted as being in decline and the sighting of large specimens around the central islands and latter on the banks was becoming rare. This trend continued well into the end of 1960s whereby sightings of large sharks around the main island were now a rarity (*Travis, 1961*). Nonetheless, smaller sharks were still considered common on the more distant banks (Smith and Smith, 1969; cited in Nevill *et al.*, 2007). It is important to point out that these accounts do not pay particular attention to species. They have, however, been corroborated by contemporary interviews of former shark fishers involved in the fishery during the 1950s (Nevill, 2005). Literature suggests that sharks have been caught in the Seychelles waters for centuries to such an extent that populations were already considered as over-exploited by the end of the 1950s (Marshall, 1997, as cited in Nevill *et al.*, 2007). Once again, no empirical data could be located for the purpose of this review.

To that end, Nevill *et al.* (2007) argued that the importance of sharks with regard to the total artisanal fisheries catch has declined substantially since the early 20th century (Figure 1). In comparison to the 1930s, the data from the 1970s onwards is composed of shark and ray landings combined. Based on both related recent research and the history of shark fishery development, evidence indicates a significant decline in shark stocks during the second half of the 20th century.
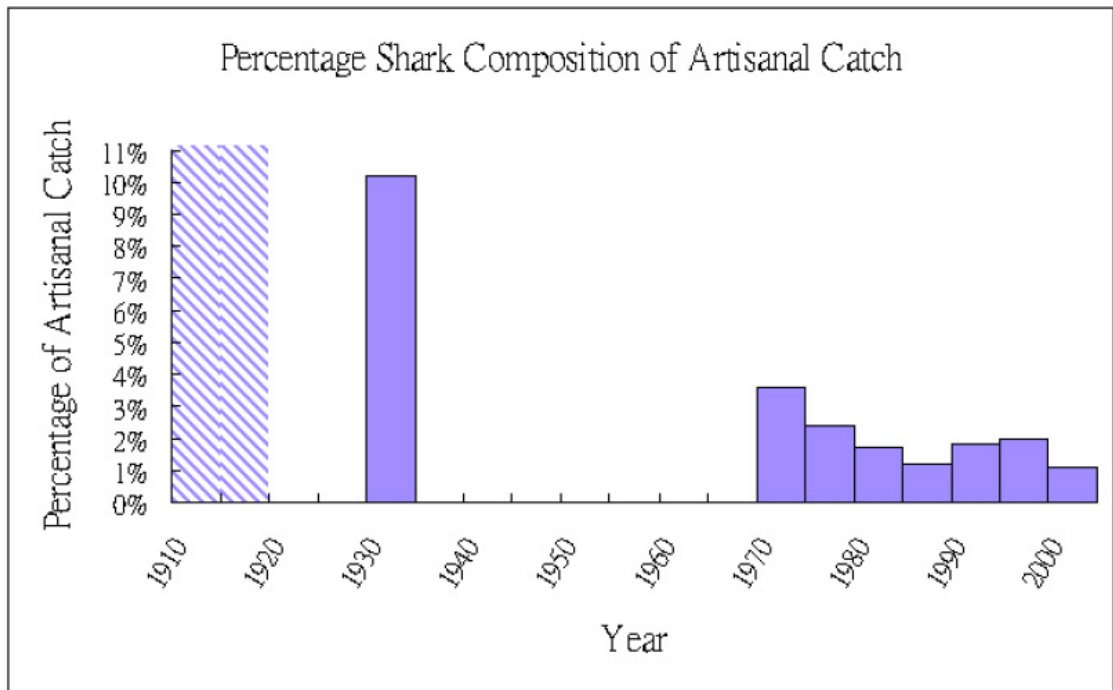
Figure 1. Percentage shark composition (5-year means) of artisanal catches (Nevill 2005)
Note: Reprinted from Seychelles National Plan of Action for conservation and management of sharks, 2007.

Despite a lack of data over much of the period, a clear trend of declining importance is only temporarily broken by the increasing price of fin, and related increase in catch and effort, in the 1990s and early 2000s (Nevill *et al.*, 2007). This particular period saw fleet of longliners shifting their target from tuna and swordfish to sharks, due to a European ban caused by high levels of cadmium (SFA 2005). Sharks were canned for the Asian market and carcasses were mostly discarded at sea due to the low value of the meat at local markets (SFA 2007). The EU removed the ban on tuna and swordfish imports in 2005, but longliners continued to target shark fins up until 2009. By then, the overall catch was 13% lower than 2005. Blue sharks, oceanic whitetip sharks, silky sharks, mako sharks and tiger sharks were the main target species (SFA 2012b). There are no indications that the shark species featured in Table 1 were targeted for their fins. Once again, it can only be assumed that they endured the same fate in the process as by-catch.

In the 2007 report, Nevill *et al.* stated that the best current information available regarding the species composition of contemporary stocks of sharks is restricted to an interview-based stakeholder survey undertaken in 2005. Figure 2 illustrates the species most commonly caught by both artisanal and semi-industrial shark fishers whilst Figure 3 illustrates a weighted index of species most commonly seen by divers (Nevill, 2005).
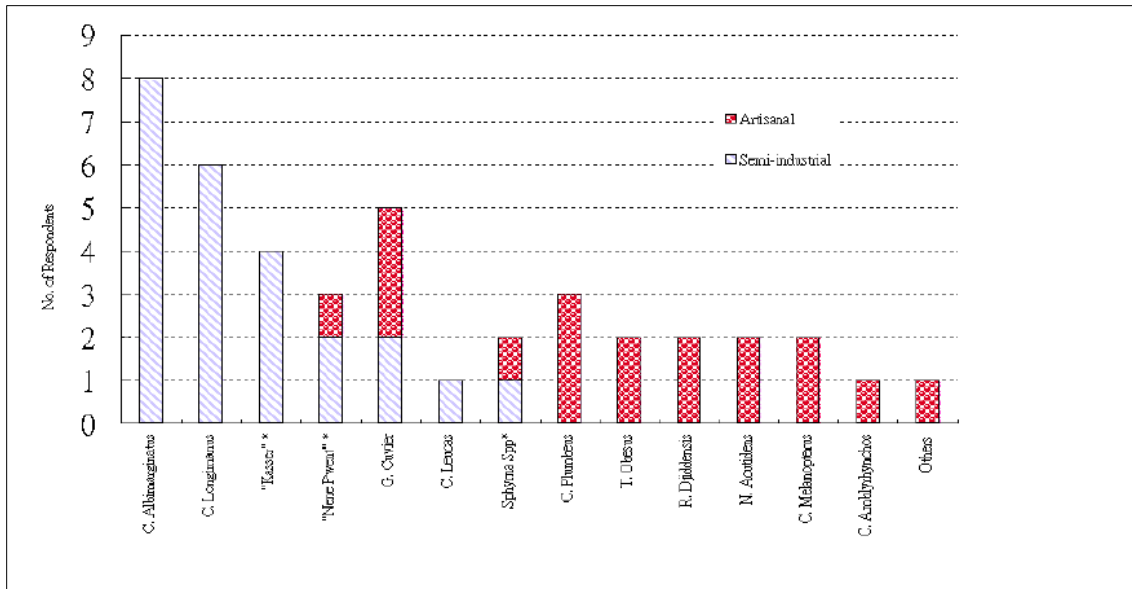
Figure 2. Shark species most frequently caught
Note: Reprinted from Seychelles National Plan of Action for conservation and management of sharks, 2007.
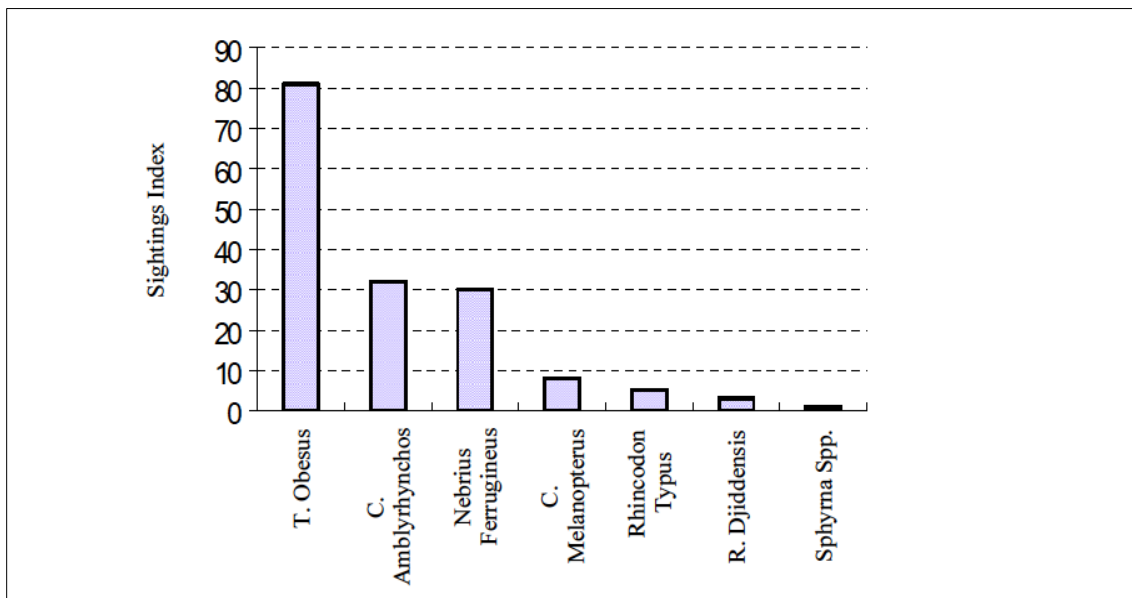

Figure 3. Shark species most frequently seen by divers.
Note: Reprinted from Seychelles National Plan of Action for conservation and management of sharks, 2007.

Figure 3 shows that there is diversity of shark species still commonly caught. With regards to the threatened species from Table 1, it appears that *Carcharhinus albimarginatus* is caught mostly by semi-industrial rather than artisanal fishers. The hammerhead species (*Sphyrna* spp.) are caught by both types of fishery but of

hammerheads were recorded less sighting by divers (Figure 3). As for *Carcharhinus plumbeus* (sandbar shark) and *Negaprion acutidens* (sicklefin lemon shark), they were being caught by the artisanal fishers. It must be noted that in that particular study fishers were asked to name the three species they caught most frequently. Nonetheless, the study highlights that the artisanal and semi-industrial fisheries are in general targeting different species components of the overall shark stock, reflecting their different areas, depths and methods of activity (Nevill *et al.*, 2007). Figure 3, however, suggests that there is a reduced diversity of sharks in near shore waters with only 3 species being seen much and one (*T. obesus*) dominating sightings (Nevill *et al.*, 2007). Apart from the *Sphyrna* spp., the other sharks listed in Table 1 did not feature in Figure 3, further accentuating low abundance and occurrence.

Species based information on stock status is chronically lacking as echoed by Nevill *et al.*, 2007. The historical data available (fin export and catch data) pertains to biomass caught predominantly on the Mahé plateau and surrounding drop-off, though there is significant anecdotal information that the Amirantes shark stock has been severely depleted (Nevill, 2005). Nevill strongly argues that shark abundance cannot be directly inferred from the decline of the importance of shark in the artisanal fishery (Figure 2). However, when coupled with the large increase in effort in the fishery, the historical accounts of abundance and decline points to a significant decline in shark stocks.

The report by Nevill also pointed out that another important issue in the official statistics is the lack of accounting of shark catches by the semi-industrial fleet of longliners. Whereas official reports state that sharks have been increasingly targeted for their fins after the 2003 European ban on exports, official statistics show almost no shark catches at all. This clearly underscores the difficulty in collecting catch data, let alone specific species records (Nevill *et al.*, 2007).

Types of Gear Employed

The artisanal fishery in Seychelles is characterized by a wide variety of boats using different gears and targeting various species. For example traditional wooden pirogues targeted the shallow inshore fishing grounds until the 1950s, followed by the introduction of traditional whalers powered by sails (Salm, 1978). The whalers extended fishing areas to the more productive bank fishing ground of the Mahé Plateau and by the mid 1960 were able to operate further around the periphery of the Mahé Plateau due to introduction of inboard engines on these vessels (SFA, Official Website, 2018). In the 1970s larger vessels powered by 4-cylinder engines joined the fishery starting the schooner fishery. The schooners targeted distant fishing grounds including the southern atoll groups. In the early 1980s fibreglass vessels, the mini-Mahé, join the fishery targeting inshore reef and plateau grounds with 15 nm of the main granitic islands (Salm, 1978; Lablache 1988; SFA, 2007).

Today more than 400 vessels are currently active in the artisanal fishery, whereby 75% of the fleet are outboard vessels and 20% are whalers. The principal gears used by whalers and schooners are handlines, while the small boats uses a multitude of gear combinations, including handlines, traps, encircling gill nets, beach seines and harpoons (SFA Official website , 2018).

The first account documenting the number of artisanal fishers was in 1988 where Lablache *et al.* presented findings, on behalf of SFA, that there were 1,157 fishers, possessing 446 boats in total. From an article dated as far back as 1927 by Hornell, we can deduce that the apparatus used during the days of early settlers included:

handlines, kazye/basket traps, seine nets, carlet/hoop nets, harpoons and spears. Mosquito nets were also used to catch small bait fish. At this time fishing regulations were constantly changing and all forms of fishing and boats used at first had to be licensed. This was then abolished in 1919, along with the restrictions previously put on sizes of nets allowed for fishing (Lablache *et al.*, 1988).

Over the next decades there was not much mention in change of fishing apparatus. However, in 1982 there was mention of handlines, traps and trolling lines, which brought in mainly sharks and rays. By then the most common gear in use was handlines, traps and gill nets and seines (Lablache *et al.*, 1988).

In the early months of 1991 it became apparent that Seychelles was set for a new fishing technique. The technique included the drop line method, which gave 30% improvement in the catch rates, with average catch rates of 61 kg per hour. The method consisted of a single line-up of up to 30 hooks and targeted the deep-water groupers. It was found to be the most effective at a depth of 80-150 m. However, records in species compositions for total landings from 1992 onwards did not necessarily reflect an increase in groupers landed, in spite of this new technique (See below from **Error! Reference source not found.** to Table 6). In 1998 the catch has declined drastically although there was a sharp increase of fishing effort (SFA Annual report, 1998). The catch rate for 1998 averaged 4.4 kg/man hour compared to 8.1 kg/man hour for 1997. It is interesting to note that it was mostly due to high water temperature recorded during the 1997/1998 fishing season.

Table 4: Species Composition in artisanal catch (%) from 1992 to 1998
Note: Reprinted from Seychelles Fishing Authority Annual Report 1998

Species Group									
English / Scientific	Kreol	1992	1993	1994	1995	1996	1997	1998
Trevally (Carangoides spp.)	Karang	33	30	25	30	35	38	30
Red Snapper (Lutjanus sp.)	Bourzwa, Bordomar, etc	3	3	5	13	8	5	13
Jobfish (Aprion virescens)	Zob	11	15	14	13	10	11	18
Emperors (Lethrinus spp.)	Kaptenn	10	7	6	7	7	5	8
Bonito (Euthynnus spp.)	Bonit	4	3	4	2	4	5	1
Groupers (Epinephelus sp.)	Vyey	5	4	3	4	3	3	3
Rabbitfish (Siganus spp.)	Kordonnyen	8	7	5	7	8	4	4
Mackerel (Rastrelliger spp.)	Makro dou	5	6	13	8	9	7	1
Others		21	24	26	16	16	21	22
Total Landings (MT)		5718	4923	4428	4313	4510	4095	3334

Table 5: Species Composition in artisanal catch (%) from 1994 to 1999.
Note: Reprinted from Seychelles Fishing Authority Annual Report 2000

Species Group		Annual Catches					
English / Scientific	Kreol	2000	2001	2002	2003	2004	2005
Trevally (*Carangoides* spp.)	Karang	37.0	30.0	41.6	33.6	28.2	24.9
Red Snapper (*Lutjanus* spp.)	Bourzwa, etc	8.7	14.1	10.0	11.5	17.0	22.2
Jobfish (*Aprion virescens*)	Zob	11.6	16.4	12.4	15.8	12.5	11.2
Emperors (*Lethrinus* spp.)	Kapten	8.9	11.3	6.9	6.1	6.2	5.1
Bonito (*Euthynnus* spp.)	Bonit	1.7	1.2	1.5	3.5	1.9	2.0
Groupers (*Epinephelus* spp.)	Vyey	3.2	2.5	1.5	2.4	2.3	2.1
Rabbitfish (*Siganus* spp.)	Kordonnyen	3.4	2.1	4.1	6.6	7.6	5.4
Mackerel (*Rastrelliger* spp.)	Makro Dou	6.2	6.1	7.0	5.7	11.0	15.4
Others		19.2	16.3	15.1	14.8	13.3	12.0
Total Catches (MT)		4,764	4,290	4,915	3,852	4,177	4,439

Table 6: Species Composition in artisanal catch (%) from 2000 to 2005.
Note: Reprinted from Seychelles Fishing Authority Annual Report 2006

Species Group							
English / Scientific	Kreol	1994	1995	1996	1997	1998	1999
Trevally (*Carangoides spp.*)	Karang	25	30	35	38	30	30
Red Snapper (*Lutjanus spp.*)	Bourzwa, Bordmar, etc.	5	13	8	5	13	10
Jobfish (*Aprion virescens*)	Zob	14	13	10	11	18	17
Emperors (*Lethrinus spp.*)	Kapitaine	6	7	7	5	8	6
Bonito (*Euthynnus spp.*)	Bonit	4	2	4	5	1	3
Groupers (*Epinephelus spp.*)	Vyey	3	4	3	3	3	3
Rabbitfish (*Siganus spp.*)	Kordonnyen	5	7	8	4	4	5
Mackerel (*Rastrelliger spp.*)	Makro Dou	13	8	9	7	1	7
Others		26	16	16	21	22	19
Total Landings (MT)		4,428	4,313	4,510	4,095	3,334	4,842

In mid-1990s it was reported to authorities that there were 400 known fishing boats from Mahé, Praslin and La Digue islands which in total landed 4,427 tons of fish over 1994; in 1993 and 1992 4,925 tons and 4,133 tons were landed respectively. Apparatus responsible for the above catches included handlines (75%), nets (10%) and traps (8%) (SFA Annual Report, 2006).

Gill nets, ranging from 100 m to 400 m, were set to exploit the sharks and ray species around the Mahé plateau and other offshore banks, with intensity increasing during the South East monsoon. Gill nets used in the shark fishery were banned by the Seychelles government in August 1998, due to the fact that the shark nets occasionally caught non-targeted species i.e. turtles and dolphins. Along with the ban, an introduction of a shark longline was put in place to lessen the effects of the ban on fishers (SFA, Technical Report, 2000). However, gills

nets are still in use, which means that fishers could still be catching a significant amount of sharks using this method.

In the years 1999-2004 it is evident that a large portion of artisanal catches were landed by whalers (average landings of 61.93% of total catch) and outboards (average landings 29.48% of total catch), with schooners (5.91%), pirogues (2.68%) of the landings (SFA, Technical Report, 2005).

In terms of fishing effort, from 2008 to 2010 the harpoon, handline and net fishery recorded a decrease of 62%, 29% and 28% respectively. Factors contributing toward the decline in the catch were attributed to the effect of the Somali piracy activities operating inside of the Seychelles EEZ, where fishers reduced the number and period of their fishing trips, due to fear of attacks (SFA, Technical Report, 2011).

From 2011 to 2013 catch in handline fishery, handline & trap fishery and the trap fishery recorded year-on-year increases of 114%, 18% and 16% respectively. The composition of the total artisanal catch by vessel category was whalers dominating catches, followed by outboards and schooners (SFA, Technical Report, 2013).

In terms of catch by gear categories, from 2008 to 2012, handline fishery, handline and trap fishery and the trap fishery decreased by 35%, 29% and 12% respectively whilst net fishery (net fishery fishing effort has remained more or less constant between the period 2007 to 2011 and has since then been on the increase), dropline and harpoon fishery recorded increases of 157%, 21% and 3% respectively (SFA, Technical Report, 2013).

The more recent years of 2015 and 2016 saw the number of boats to be around an average of 461 active boats per month, 75% of the fleet were outboard vessels and 20% were whalers with the remaining 5% a mix of pirogues, mini Mahé etc. Gear employed at this time by fishers included the handline fishery which dominated artisanal fisheries catches, accounting for 60% of total landings in 2016 followed by encircling gillnet (18%) and static trap (12%) (SFA, Technical Report, 2016).

In 2016, decreases in catches were detected by encircling gillnet (34%) and by 'other' gear (71%). However, catches by harpoon, active and static trap increased by 44%, 97% and 12% respectively when compared to the previous year. On the other hand, catches by handline and traps also increased by 24% from 2015. However, despite the comprehensive data on landings and fishing effort, there is very limited data on the targeted threatened species listed in Table 1 in relation to gear and fishing techniques involved (SFA, Technical Report, 2016).

It should be noted that although the primary goal of this paper is not to evaluate environmental and other indirect factors affecting total landings and catch rates, these aspects have been included in some studies. For example, the decline in catches in 1998 have been attributed to the El Nino (ENSO) (Spalding & Jarvis, 2002), while the opening of the Seychelles international airport in the 1970s resulted in an increase in tourists and demand for fish to be caught. This lead to rapid exploitation of fish stocks on some parts of the plateau (Spencer et al., 2000). However, once again, it remains unclear on what species were present in these fish stocks. It is also unclear what species were directly affected from either overfishing or from the catching of juveniles before sexual maturity is reached. It can only be assumed that the non-appearance of high volumes of those fish species today were indeed the product of these factors combined.

Conclusion

The aim of this review was of two fold: firstly to establish the historical baseline for occurrence and relative abundance of the threatened species, specifically in the artisanal fishery catches, and secondly to examine the different fishing techniques and gears employed by fishers throughout the years, with the aim of evaluating the impacts on the threatened species compositions.

Evidently limited literature on the species of interest as per Table 1 curbed the focus to genus or family groups instead. To that end, it can be deduced that groupers and sharks have indeed recorded significant decline in populations in general, but, due to limited records on the individual species, it is not possible to analyze to what degree has the selected species in Table 1 decreased in occurrence and relative abundance. It should be highlighted that groupers and sharks are more present in literature, due to the fact that populations of both groups were considered to be decreasing by local fishers and that the reported overfishing of the groupers spawning grounds contributed to a commercial fish stock collapse. Sharks, in particular, have at least been receiving considerable attention in comparison to the other threatened species. It was at least evident that some shark species of interest for this review was considered in some studies, namely *C. plumbeus*, *N. acutidens* and *Sphyrna* spp., and this provided an idea that they have indeed decreased in abundance and occurrence. However, due to the fact that groupers are still considered to be common in Seychelles, limited importance has been placed on the giant grouper and the blacksaddled coral grouper, despite how rare they have now become. Very little attention has also been given to the Napoleon wrasse and the green humphead parrot fish, with no research conducted on these two species in recent years. Additionally, analyses on rays were not possible under this review, for the simple reason that they are often grouped with sharks. On another note, guitarfish was not mentioned in any consulted literature. This therefore presents an even greater gap in the knowledge on the abundance of guitarfish and rays. To that end, relying entirely on literature to establish a historical baseline in occurrence and relative abundance of these species may not yield effective result.

Nonetheless, changes in total catches have been relatively well documented and analyzed. The SFA provides annual statistics and records on catches and types of boats and gear used, thus providing a good indication on what are the most efficient or preferred gear and method. Considering the type of fishing gear that was used over time, it was obvious that the use of handlines and nets remained the most favourable method amongst artisanal fishers. However, data is often broadly categorized and does not cater for correlations between the types of species caught verses types of gear employed. For example, even though it was suggested that the new fishing technique introduced in 1991 targeted groupers and resulted in greater fishing effort, the Table 4 to Table **6** clearly demonstrate that the amount of groupers landed did not show any increase. Conversely, the increase in gills nets did show an increase in landing in sharks and could therefore be considered for further studies to provide empirical evidence for this correlation. To this end, for the purpose of this review, it is not possible to objectively deduce which fishing method and gear resulted in an impact and in the decline of the threatened species.

It is important to note that as much as this review draws attention to the chronic lack of species-specific data in fisheries, especially for threatened species, it also highlights the importance of quality data in management approaches. Despite concerns over depleting fish stocks for certain species over the past decades, there has been limited species-specific research, whereby the most common and the more economically valuable species

have been at the fore front of the research. This can pose a danger for the threatened species in particular. Given their fragile status, should they be ignored and not duly considered in research for stock management, this lack of attention can further exacerbate their vulnerability and potentially lead to their extinction. Furthermore, the need to consider external factors such as climate change and habitat destruction is crucial in underpinning management measures in fisheries in general. At this juncture, following the lack of empirical data on the threatened species, it is highly recommended that anecdotal evidence is gathered and documented to fill in the gaps identified in this review.

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