

ARTISANAL FISHERIES IN THE WORLD'S SECOND LARGEST TUNA FISHING GROUND — RECONSTRUCTION OF THE SEYCHELLES' MARINE FISHERIES CATCH, 1950–2010*

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ABSTRACT

Total marine fisheries catches were estimated for the Seychelles for the 1950–2010 time-period using the catch reconstruction approach developed by the *Sea Around Us* and applied to coastal countries worldwide. This included catches (including dead discards) of the industrial, artisanal, and recreational fishing sectors. The total reconstructed catch for domestic sectors (i.e., excluding the foreign-owned but Seychelles-flagged vessels) for the 1950–2010 time-period reached almost 290 000 t. This figure is 1.3 times the catch officially reported to the Food and Agriculture Organization of the United Nations. Major taxa in catches were jacks and pompanos (Carangidae; 26.5%), snappers (Lutjanidae; 18.7%), Indian mackerels (*Rastrelliger kanagurta*; 6.4%), emperors (Lethrinidae; 6.2%), kawakawa (*Euthynnus affinis*; 4.0%), and groupers (Serranidae; 3.5%). The artisanal sector accounted for the vast majority of the catch, with 95.2% overall.

INTRODUCTION

The Republic of the Seychelles (referred throughout as 'the Seychelles') is the least populated country in Africa, with a population of around 90,000 inhabitants. It is an archipelago located north of Madagascar that is composed of 115 islands, 42 of which are granitic mountainous islands of continental origin, and the others which are flat and of coralline origin (Figure 1). Although discovered by the Arabs in the 9th century, it is only in 1756 that France set its flag in the Seychelles and inhabited it since 1770 (Filliot 1983; Doumenge 1987).¹ Half a century later, the Seychelles were ruled by the United Kingdom, and this until their independence in 1976 (Doumenge 1987). Nowadays, most of its inhabitants live on the island of Mahé, mainly in the capital city of Victoria.

Victoria hosts the largest tuna hub in the Indian Ocean, with around 80% of the tuna caught in the region transiting every year through its infrastructures, which include the Indian Ocean Tuna (IOT) cannery (Martín 2011).² Canned tuna is the main good exported by the Seychelles (primarily for the European market), although there are also substantial exports of fish meal/oil, as well as dried holothurians and shark fins³ to Asia (Marshall 1997; Robinson *et al.* 2006; SFA 2014). With between 5,000–6,000 direct and indirect jobs, i.e., 15% of the total of formal jobs in the Seychelles, the fisheries sector is the main pillar of the national economy, along with the tourism industry. Activities linked to the industrial tuna fisheries are the most important foreign exchange earners, with revenues generated by goods and expenditures (e.g., processing at the cannery, and goods and services procured by purse-seiners in Port Victoria; see Robinson *et al.* 2010), and

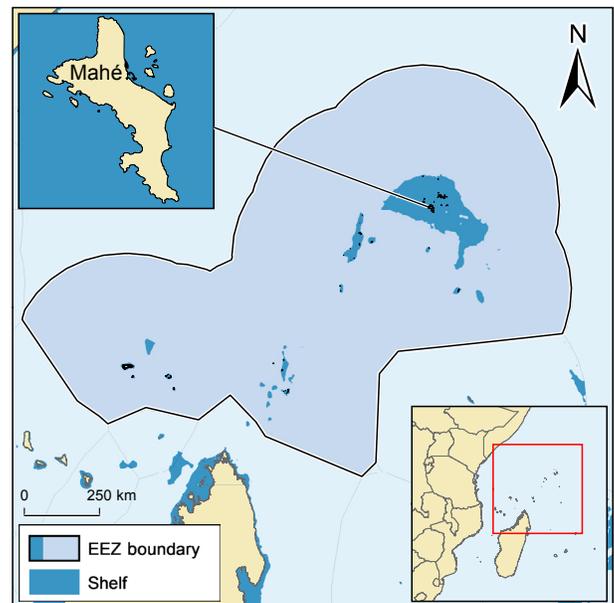


Figure 1. Extent of the Seychelles EEZ, as well as its Inshore Fishing Area (IFA; i.e., the 'shelf').

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¹ Several expeditions from Portugal, the United Kingdom, or France set foot on the various islands prior to 1756 (Filliot 1983; Doumenge 1987).

² This is one of the largest canneries in the world, with over 90,000 t of tuna processed for canning every year. It is known as a highly efficient one with regards to water use and production by employees (Michaud 2003; Martín 2011).

³ 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; Nevill *et al.* 2007).

licensing fees playing the most prominent roles (Ghosh 1990; Parks 1991; Robinson *et al.* 2006). Around half of these 5,000–6,000 jobs happen to be at the national cannery, while approximately 1,500 of them consist of active fishers (Robinson *et al.* 2006; SFA 2013, 2014).⁴ Historically, however, copra, cinnamon, and vanilla used to be the most important drivers of the economy, while the tourism industry took off only in 1971, after the inauguration of the international airport (Doumenge 1987; Kimani 1995; Ellis 1996). The industrial fisheries sector only started to develop in the mid-1980s with the arrival of European and Japanese funds linked to fishing access agreements. These funds were used to develop tuna-related infrastructures, such as the port and the cannery in Victoria, as well as infrastructure and fleets for semi-industrial⁵ and artisanal fisheries (Michaud 1991, 2003; Robinson and Shroff 2004; Alexis and Chang-Sam 2006; Martín 2011).

Thanks to these two recent, yet thriving industries, the Seychelles have become an exception in the region (notwithstanding Mauritius), with high social and economic indexes. However, its status of middle income country limits international aid, and that issue was reinforced during the global financial crisis of 2007–08, due to a high external debt (Anon. 2004a). Also, the Seychelles are beset by strong socio-economic inequalities, with a substantial part of the population having very low incomes (Doumenge 1987; Khan 1994), although not as pronounced as comparable countries (Republic of the Seychelles 2013).

The Seychelles' EEZ (declared in 1978; Republic of the Seychelles 1978) extends over almost 1.4 million km², which is the largest in the Western Indian Ocean (www.seararoundus.org). Coral reefs are well developed around the main group of granitic islands located on the Mahé plateau, as well as around the satellite coral islands, with a total cover of 1,700 km² (Spalding *et al.* 2001).⁶ Due to the high population density and reliance on the coastal environment for development, tourism, transport and fisheries, coral reefs around the main granitic islands are under high pressure, whereas those farther from these heavily populated areas are relatively well preserved (Spalding *et al.* 2001). Consequently, remote stocks appear to be under-exploited (Anon. 2004a), while inshore fisheries around the main islands and some Mahé Plateau fisheries are fully exploited or over-exploited (Mees *et al.* 1998; Wakeford 2001; Grandcourt and Cesar 2003; Robinson and Shroff 2004). Historically, fisheries were mostly restricted to inshore areas around the main islands, but were expanded to the plateau and outer islands as motorized fleets developed in the 1960s (Wakeford 2001). Fisheries fleets in the Seychelles consist of three main types:

- A fleet of small and large (5–13 m LOA) outboard- or inboard-powered boats targeting demersal and pelagic species on or near shallow waters (typically 0–60 m) of the banks and reefs. Most catches of this artisanal fisheries sub-sector are consumed locally (Ghosh 1990; Alexis and Chang-Sam 2006);
- A semi-industrial fleet of small longliners targeting large pelagics (mostly swordfish and tuna) further offshore (Wendling *et al.* 2003; Kolody *et al.* 2011). This fleet started to develop in 1995 (Wendling *et al.* 2003);
- An industrial fleet of foreign-owned and foreign or Seychelles-flagged purse-seiners and longliners targeting large pelagics throughout the region. This fleet developed in the mid-1980s.

In an effort to preserve marine habitats and resources from degradation and overexploitation, the Government of the Seychelles adopted a number of precautionary fisheries management measures in the early stages of fisheries development. Licenses are required for all vessels longer than seven meters and for smaller vessels with engines or those that target sensitive species such as holothurians (Michaud 1995; Martín 2011).⁷ Also, demersal trawling and spearfishing are forbidden in the entire EEZ, and there are limits on the total number of licenses allocated every year for the holothurian and lobster fisheries (Michaud 1995). Also, Seychelles-flagged and foreign industrial fleets are excluded from the shallow banks and reefs, and exploitation of all species except large pelagics is reserved for nationals. Last but not least, there was a network of 17 marine protected areas as of 2008 (UNEP 2008), including the Natural World Heritage Site of Aldabra Atoll (enlisted in 1982; whc.unesco.org/en/list/185).

Catch assessment surveys were first implemented in 1985 following the establishment of the Seychelles Fishing Authorities (SFA; Robinson and Shroff 2004). However, SFA noted in its 2012 report that lower catch data might result from a lack of coverage of landing sites (SFA 2014). Although there have been significant improvements in the last couple of decades (for example thanks to the implementation of logbooks on both purse-seiners and longliners), effective monitoring, control and surveillance of this large EEZ is still lacking (Michaud 1995; Wakeford 2001; Anon. 2004a; SFA 2014), with only two long-range patrol vessels (which spent between seven and 107 days at sea annually in recent years) and marginal aircraft surveillance (3.2–216 hours per year; Anon. 2004a; SFA 2014). However, the coverage by vessel monitoring system is high (SFA 2014).

In this report, we apply to the Seychelles the reconstruction methods developed around principles in Pauly (1998), described in Zeller *et al.* (2007) and applied worldwide by the *Sea Around Us* (see, e.g., Harper and Zeller 2012; Harper *et al.* 2012; Zeller and Harper 2009; Zeller and Pauly 2007). We aim to improve the overall quality of fisheries statistics by thoroughly reviewing the available literature and re-estimating the total extraction of marine fish since 1950.

⁴ Noteworthy, 30% of the artisanal fleet was damaged by the December 2004 tsunami, but the sector quickly recovered (SFA 2007).

⁵ In the *Sea Around Us* database, this 'semi-industrial' sector is labeled as 'industrial', in order to allow the data to be spatially allocated to the entire EEZ, rather than solely to the inshore fishing area.

⁶ These coral reefs, like all those of the region, were highly impacted by the 1997–98 El Niño event, with a 50–90% mortality rate (Spalding *et al.* 2001; Spalding and Jarvis 2002). This El Niño event also resulted in decreases in fish abundance, even in protected areas (Pistorius and Taylor 2009). The Seychelles also host a marginal mangrove forest, as well as small seagrass beds (Spalding *et al.* 2001).

⁷ Interestingly, fishers must also apply for a special license to fish outside the EEZ (Martín 2011).

MATERIAL AND METHODS

The fisheries statistics software of the Food and Agriculture Organization of the United Nations (FAO), FishStat (FAO 2013), includes catch data for up to 35 taxa (in 2009) in five FAO Areas. Based on a preliminary review of the literature, it appeared that catch data reported by FAO on behalf of the Seychelles include catches by foreign-owned vessels that are Seychelles-flagged. The first step of the reconstruction was therefore to separate the truly domestically owned catch from the foreign owned catch.

'Domestic' vs. 'Foreign' catch

Of the 46 taxa reported by FAO, eight are exclusively caught in FAO Areas other than Area 51 (Western Indian Ocean), to which the Seychelles belong (i.e., *Merluccius hubbsi* [Argentine hake], *Thunnus thynnus* [Atlantic bluefin tuna], *Macruronus magellanicus* [Patagonian grenadier], *Loligo gahi* [Patagonian squid], *Dissostichus eleginoides* [Patagonian toothfish], *Genypterus blacodes* [pink cusk-eel], Rajiformes [rays, stingrays, mantas nei], and *Salilota australis* [tadpole codling]). Since there is no distant-water fishing by Seychellois vessels, the entire catch of these eight taxa were not treated here but rather considered as if the Seychelles was acting as a flag of convenience (unknown beneficiary).

Of the remaining 38 taxa reported to be caught in the Western Indian Ocean, 19 were species of large pelagics. The catch for these 19 large pelagic taxa is virtually identical to the data published by the Indian Ocean Tuna Commission (IOTC) for the Seychelles in the Western Indian Ocean, as part of its nominal database (which contains information regarding gears; IOTC 2014). Therefore, it was possible to re-allocate the FAO catch of these taxa to various gears. To do this, we applied the gear breakdown published by IOTC to the FAO data. Once this step was performed, it was possible to determine whether a gear was used by the artisanal or semi-industrial domestic fleets, or the large-scale industrial foreign fleet. For this, we deemed both 'purse seine' and industrial 'longline' gears to belong to foreign fleets, whereas the other gears were automatically considered to be part of the domestic fleets (the rest of the FAO data – consisting of taxa not accounted for by IOTC – was automatically allocated to the domestic fleet). This re-allocation was motivated by the fact that both industrial purse-seiners and longliners, although flagged in the Seychelles, are owned by foreign interests. In 2012, there were six Spanish-owned purse-seiners and 23 Japanese- and Taiwanese-owned longliners (SFA 2012a).

This re-allocation allowed us to distinguish the different components of the reported data based on the ownership of the catch and vessel: only the catch whose ownership was from the Seychelles was treated here. The catch whose ownership was foreign (industrial purse-seine and longline fleets owned by European and Asian firms, but flagged in the Seychelles) represented 79.1% of the total FAO catch and was dealt with as part of the global tuna atlas produced by the *Sea Around Us* (Le Manach *et al.* in press).

This methodology produced data that formed the basis for the reconstruction presented in this report. This baseline is compatible with first-hand data published by the Seychelles Fishing Authority from 1985 to 2005 ($r^2 = 0.89$; de Moussac 1987a,b, 1988; SFA 1989, 1990a, 1991–2003, 2005–2008, 2012b), and 50% higher but with a similar trend from 2005 onward.

Artisanal fisheries

Composition and evolution of the fleet

The artisanal fleet is the only historical fishing sector in the Seychelles, and is of paramount importance to the population of the Seychelles, notably with regards to its daily animal protein needs.

Historically, this fleet essentially consisted of *pirogues*, which were increasingly replaced by other types of boats called whalers and schooners (the latter being introduced in 1974; Payet 1996), which are usually equipped with freezers and inboard motors. Furthermore, plastic and fiber-glass hull outboards equipped with motors were introduced in the early 1970s, and considerably changed the structure of the fleet (Bach 1992; Payet 1996). This shift in the fleet composition allowed local fishers to expand their fishing grounds by going farther offshore (Bach 1988; de Moussac and Bach 1988).

Despite precise number regarding the composition of the fleet since the mid-1980s, there is no time-series covering the entire 1950–2010 period. As a first step in the reconstruction process, we re-estimated the number of boats by type since 1950 (Figure 2), following a series of simple assumptions:

- Based on Bach (1992) and Payet (1996), we set the number of schooners at zero in 1973. To reflect an important increase in the number of boats during the first few years of a fishery, we then assumed that their number reached half of the first anchor point found in the literature (26 in 1985, but assumed similar in 1983–84; de Moussac 1987a; Payet 1996) five years later (i.e., 13 schooners in 1978). The rest of the time-series was provided in other reports (Payet 1996; SFA 1999, 2002, 2005–2008, 2012b);⁸

⁸ SFA (1990a) reported somewhat different numbers for 1989, but we chose to use the updated numbers reported by SFA (2002), as they may have included corrections.

- For whalers, we set their number at zero in 1957 based on Wakeford (2001). Similarly to schooners, we then assumed that their number reached half of the first anchor point found in the literature (37 in 1985 and 53 in 1986; de Moussac 1987a; SFA 2002), i.e., 18.5 whalers in 1962. The rest of the time-series was provided in other reports (Payet 1996; SFA 1999, 2002, 2005–2008, 2012b);
- Based on Wakeford (2001), we set the number of outboards at zero in 1980. Given that the first anchor point found in the literature (222 in 1985, but assumed similar in 1983–84; Payet 1996; 171 in 1989; SFA 2002) was only 3 years later, we simply interpolated their number between 1980 and 1983. The rest of the time-series was provided in other reports (Payet 1996; SFA 1999, 2002, 2005–2008, 2012b);
- Finally, going backward from the first anchor point found in the literature (125 in 1985; de Moussac 1987a; Payet 1996), we assumed that the number of *pirogues* declined by 12.5% since the introduction of whalers (in 1983), another 12.5% between the introduction of schooners (in 1974) and whalers, and another 12.5% between the introduction of outboards (in 1971) and schooners. Between 1950 and 1970, the ratio of the number of *pirogues* to the total population in 1971 was applied throughout (i.e., one *pirogue* for 307 inhabitants).⁹ The rest of the time-series was provided in other reports (Payet 1996; SFA 1999, 2002, 2005–2008, 2012b).

The resulting time-series (Figure 2) was used in the next section to re-estimate the catch of the Seychelles artisanal fleet prior to the establishment of SFA in 1984 and the implementation of a proper catch survey.

Catches and reconstruction

The artisanal fleet mostly uses handlines and traps (traps are essentially used by small boats, whereas whalers and schooners virtually use only handlines; Alexis and Chang-Sam 2006; Bach 1988, 1992; Bach and Lablache-Carrara 1991; de Moussac and Bach 1988; Martín 2011; SFA 2002; SFA 2003). The target species are snappers, jobfishes, groupers, threadfins, emperors (mainly *Lethrinus variegatus*), rabbitfishes, various species of crustaceans (such as *Ranina ranina* [Kona crab]),¹⁰ and medium pelagics such as jacks and small tunas. Except Carangidae, which are actively targeted at times, large pelagics are mostly caught by troll when moving between fishing areas (Bach 1992). A commercial fishery for deep-water snappers started in the late 1980s (Intes and Bach 1989), with electronic reels, drop lines, sonars and GPS (dropline boats are included in the 'schooners and other types of boats' category in Figure 2; Mees and Rousseau 1997). A fishery for live reef food fish trialed in 1998 and 1999, after which it was closed and later prohibited by law (in 2005) due to concerns of over-exploitation and lack of technical means to carry out this fishery properly (Aumeeruddy and Robinson 2006).

In addition to these 'regular' reef and medium pelagics components of the artisanal fleet, there are two distinct sub-fisheries:

- A spiny lobster fishery, which is active 3–4 months per year around the months of December and January. The main targeted species are *Panulirus penicillatus*, *P. longipes*, *P. versicolor*, and *P. ornatus*, which are mostly caught at night by snorkelers and divers (Martín 2011). This fishery is very lucrative despite low catches and overfishing has probably occurred recently (SFA 2012b, 2014). For this reason, the number of licenses is controlled, sizes are regulated, and the fishery is closed most of the year (and sometimes the full year; Michaud 1995; SFA 2012b, 2014);
- A small holothurian (*bêche-de-mer*) fishery has been present since colonization, but catches increased rapidly in the 1990s due to rising demand by Asia and subsequent high prices (Aumeeruddy and Conand 2007, 2008; Pinault and Conand 2007; SFA 2013). There has been signs of over-exploitation (typical for these 'boom and bust' fisheries; Anderson *et al.* 2010), as divers now fish in deeper waters, similar to Madagascar (Le Manach *et al.* 2011, 2012). This fishery has been regulated since 1999 (i.e., poorly reported before; Pinault and Conand 2007; Aumeeruddy and Conand 2008), and there are currently around 25 licenses distributed annually (SFA 2014).

Given that the catch assessment surveys implemented in 1985 are considered to be accurate, the reconstruction of the artisanal sector only focused on the 1950–1984 period. For each type of vessels, we extracted from these surveys the information on the contribution of each gear towards the total catch (three anchor points in 1985–87 and one anchor point in 2002 for each series; de Moussac 1987a,b, 1988; SFA 2002, 2003). We then calculated an average

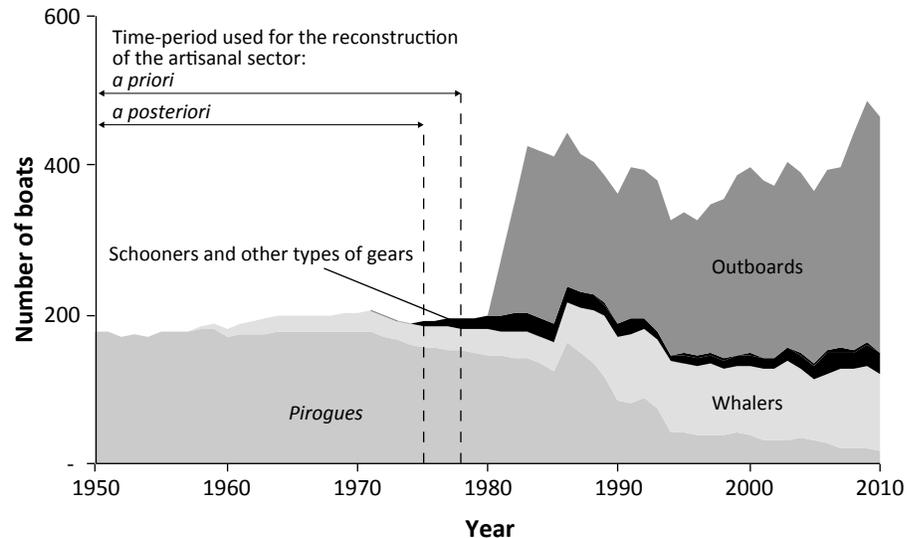


Figure 2. Reconstructed time-series of the number of artisanal boats by type, 1950–2010. This time-series was only used from 1950 to 1975 to reconstruct artisanal catches.

⁹ The population time-series was extracted from the UN's demographic yearbook series from 1950 to 1959 (United Nations 1953–1959), and from the Seychelles' National Bureau of Statistics (www.nsb.gov.sc/statistics/demography) from 1960 onward.

¹⁰ The Kona crab fishery only started in the mid-1980s, thanks to European funds (de Moussac and de San 1987).

contribution for each series and applied it back to the first year each type of vessel existed (see Figure 2). We also extracted CPUEs for each of these series from the catch assessment surveys,¹¹ and estimated them for missing years using different methods depending on the available data:

- For outboards, we used the 1986–87 average throughout back to 1981;
- For handlines used on whalers (traps were disregarded due to lack of data), we used the 2001–02 average CPUE throughout since their introduction in 1958. We also considered that there was an average of 6.5 crew members per boat (Bach 1988);
- For schooners, we used the 2001 CPUE throughout since their introduction in 1974. The average crew was assumed to be consisting of 6 members per boat (Bach 1988; Payet 1996).
- For *pirogues*, we considered that the CPUE of handlines in 1950 was 25% lower than in 1985. For traps and nets, we used the 1986–87 average throughout.

Finally, we assumed that all gears were active on average five days a week throughout the year, as fishers usually go out most days, except during the monsoon season. By multiplying the contribution of each gear by its CPUE, as well as the corresponding number of boats (and seamen if needed) and days at sea, the total catch of the artisanal fleet was reconstructed. This reconstructed time-series happen to almost match the FAO time-series in 1975, i.e., just a few years before the implementation of catch surveys by SFA. Therefore, we only replaced the FAO time-series by our reconstructed series from 1950 to 1974 (not 1984, as originally planned), and then used the data as provided by FAO.

However, it is fairly well accepted that poaching still occurs in most MPAs (Jennings *et al.* 1996; Wood 2004), but also that some components have been historically under-estimated (e.g., schooners and whalers until 1990; SFA 1991). Furthermore, although fisheries based on other islands are thought to be rather small (Bach 1988; de Moussac and Bach 1988), the catch survey implemented by SFA in the mid-1980s only accounts for the main three islands (SFA 1990b). Consequently, due to improving yet lacking monitoring capacities (Michaud 1995; Wakeford 2001; Anon. 2004a; SFA 2014), SFA still recently noted that a lack of coverage of landing sites and landing times likely resulted in under-estimated catches (SFA 2014). Therefore, we assumed that unreported catches decreased from 30% in 1978 (which is in line with the proportion of unreported catches in 1975–77 estimated above) to 15% in 1995 and then stabilized at that level.

With regards to the taxonomic breakdown, we applied the 1978–1982 proportions to both the unreported and reported components prior to 1978, and for 1978–2010, the annual FAO breakdown was applied to the unreported component.

Semi-industrial fleet

A fleet of semi-industrial longliners was created in 1995, with the aim to target large pelagics.¹² It is the only industrial sector in the Seychelles that is truly domestic.¹³ The number of active vessels increased from two in 1995 to 10 in 2001 (Wendling *et al.* 2003; Anon. 2004b). The number of vessels then dropped to four in 2004, increased again to reach ten by 2009–10, and decreased to four in 2011 and seven in 2012 (SFA 2014). These longliners target tuna and swordfish around the Mahé plateau and in the northeastern part of the EEZ (Kolody *et al.* 2011), and usually catch between 200 and 300 tonnes annually (SFA 2014). Noteworthy, it is reported that there is a high depredation by false killer whales and sharks (Alexis and Chang-Sam 2006), similarly to La Réunion (Le Manach *et al.* this volume).

In the early 2000s, this fleet of longliners shifted to target sharks rather than tuna and swordfish, due to a European ban caused by high levels of cadmium (SFA 2005).¹⁴ Sharks were finned 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 circa 2009. Blue sharks, oceanic whitetip sharks, silky sharks, mako sharks, and tiger sharks were the main target species (SFA 2012b).

For this sector, we assumed that the landings were correctly reported. However, based on information reported on depredation by cetaceans, we considered that discards were making 26%, 19%, 30%, 22%, 15%, and 11% of the total catch from 1995 to 2000, respectively (SFA 1996–1998, 2000, 2001). From 2001 to 2010, we used the average discard rate from 1999–2000 as real estimates are not available due to piracy in the area (SFA 2012b). We also assumed that half of the discarded sharks were unreported from 1995–2000. From 2001 to 2005 (i.e., during the EU ban of tuna and swordfish) we estimated shark discards using a linear regression of the decreasing discard rates between 1995 and 2000. As no longliners were engaged in shark finning in 2010 we estimated these discards as the average from the 1995–2000 period. Discards from 2006 to 2009 were linearly interpolated.

¹¹ Some of the CPUEs provided in de Moussac (1987a,b, 1988) and SFA (2002, 2003) seemed very different than other values in the time-series, so we did not use them. This was the case for the CPUEs of handlines and traps used on *pirogues*, in 2001 and 2002, respectively.

¹² Catches by longliners targeting swordfish were reported prior to 1994. Given the lack of information regarding this catch, we accepted as is.

¹³ A bait fishery for *Decapterus* spp. was tested in the early 1980s to develop a pole-and-line fishery (Hallier 1989), but has not continued..

¹⁴ This ban was criticized for its lack of coherence, as European vessels were still allowed to catch and land the same fish (Lahnalampi 2009).

Recreational fishery

Until 2002, annual SFA reports included estimates of catch by recreational fishers. The number of boats was low in the 1980s, ranging from 4–7 (Payet 1996).¹⁵ During the 1990s, their number steeply increased, to reach 40 by 2000 (SFA 2005). Since 2003, logbooks are poorly transmitted, precluding catch data from being estimated and included in national data (SFA 2006–2008, 2012b). To date, there are no real estimates with regards to the number of vessels participating in this activity (SFA 2013, 2014).

For the purpose of this reconstruction, and in order to produce a time-series reflecting the aforementioned trends in this sector, we assumed that recreational fisheries started in 1971 (opening of the airport; i.e., no catch in 1970), reached 10% of the unreported artisanal fleet catches by 1990, and 25% by 2010 (proportion held constant afterward). We reallocated part of the unreported artisanal fleet catches rather than adding a whole new sector in order to avoid double-counting, as a portion of the recreational fishery's catch might have been included in official statistics, at least prior to 2003.

RESULTS AND DISCUSSION

Overall,¹⁶ the reconstructed domestic catch totalled nearly 320,000 t from 1950 to 2010 (of which 30% were unreported), and averaged 4,000 t annually until 1970 and then steeply increased with the introduction of outboards and schooners to reach almost 8,000 tonnes by the early 1980s. Since then, catches have been fluctuating, mostly between 4,500 and 8,000 t per year (Figure 3). The proportion of unreported catch decreased from slightly less than 80% of the total catch in 1950 to 15% by 2010. Discards have only existed since the mid-1990s and the inception of the domestic longline fleet, but they are marginal.

The artisanal has dominated the total catch, with an overwhelming 95.6% since 1950. The recreational sector, however, has increased its share (around 3.5% in 2010), similarly to the semi-industrial longline fleet, which made up on average 8.5% of the annual catch (Figure 3).

Jacks and pompanos (Carangidae) are the most widespread species, with 26.5% of the catch since 1950, followed by snappers (Lutjanidae), Indian mackerel (*Rastrelliger kanagurta*), emperors (Lethrinidae), kawakawa (*Euthynnus affinis*), and groupers (Serranidae), with 18.7%, 6.4%, 6.2%, 4.0%, and 3.5%, respectively (Figure 4).

The reconstructed time-series discussed here provides a more credible estimate of early catches, in contrast with the step-like increases in FAO data. However, the situation steeply increased in the early 1980s with the implementation of catch surveys, but also with the increasing enforcement and monitoring of

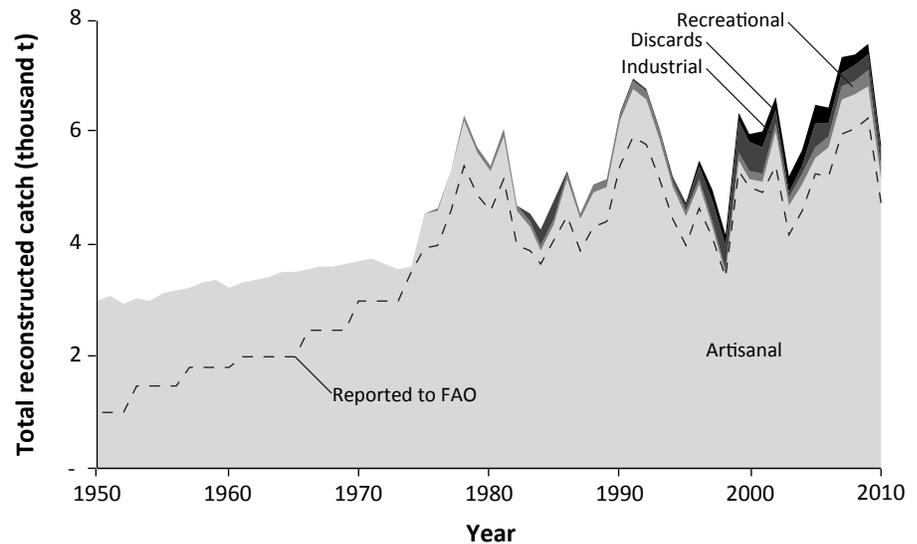


Figure 3. Total reconstructed catch by sector, compared to the data reported to FAO from 1950 to 2010 (dashed line). See Appendix Table A1 for details.

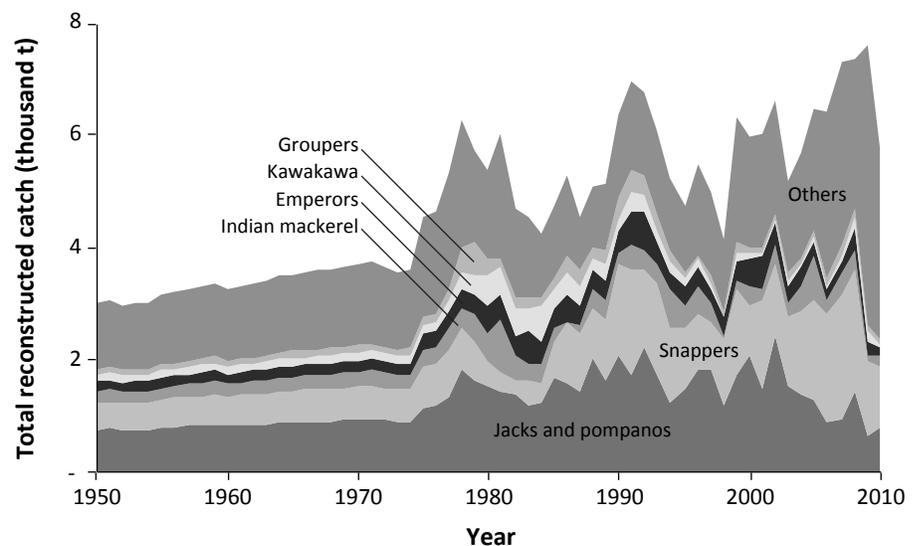


Figure 4. Total reconstructed catch by taxon, 1950–2010. See Appendix Table A2 for details.

¹⁵ This figure may, however, be an under-estimate, as the original catch assessment survey reported 17 sport fishing boats (SFA 1990b). This report also notes that the survey does not include catches on Sundays and public holidays (SFA 1990b), nor catches made by pleasure boats (which were estimated to be 50 in 1989; SFA 1990a).

¹⁶ Only including the truly domestic catches, i.e., not including catches of the Seychelles-flagged vessels targeting tuna in the region, or other species in other oceans.

fishing activities. After the early 1980s, the increased reconstructed catches mostly account for poaching and under-reporting by artisanal and recreational sectors, but the situation is improving due to stricter enforcement.

We hope this improved time-series highlights some fundamental biases in official catch statistics, and will encourage improved data collection for fisheries operating in Seychelles' waters. For example, we believe that our recreational catch estimates are conservative, given the number of boats and economic opportunities associated with this sector. Therefore, real catches are probably higher, but difficult to record as they are likely landed outside official landing sites, or consumed by tourists without being declared. Further research would provide a better assessment of the recreational fishery, including its contribution to the national economy and implications for target species' stocks (see, e.g., reconstruction for La Réunion Island; Le Manach *et al.* this volume). 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. Our reconstructed time-series proposes an alternative catch for this group of vulnerable species, but better accounting would be needed.

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Appendix Table A1. Total reconstructed catch by sector compared to the data reported to FAO, as well as total catch by Seychelles-flagged but foreign-owned vessels as reported to FAO.

Year	Domestic catch					Foreign-owned catch			
	Reconstructed catch				Total	Reported to FAO			
	Artisanal	Industrial	Discards	Recreational		Asia	Flag of convenience	Spain	
1950	3,018	-	-	-	3,018	1,000	-	-	-
1951	3,081	-	-	-	3,081	1,000	-	-	-
1952	2,977	-	-	-	2,977	1,000	-	-	-
1953	3,038	-	-	-	3,038	1,500	-	-	-
1954	3,015	-	-	-	3,015	1,500	-	-	-
1955	3,153	-	-	-	3,153	1,500	-	-	-
1956	3,207	-	-	-	3,207	1,500	-	-	-
1957	3,258	-	-	-	3,258	1,800	-	-	-
1958	3,322	-	-	-	3,322	1,800	-	-	-
1959	3,383	-	-	-	3,383	1,800	-	-	-
1960	3,260	-	-	-	3,260	1,800	-	-	-
1961	3,339	-	-	-	3,339	2,000	-	-	-
1962	3,379	-	-	-	3,379	2,000	-	-	-
1963	3,442	-	-	-	3,442	2,000	-	-	-
1964	3,511	-	-	-	3,511	2,000	-	-	-
1965	3,542	-	-	-	3,542	2,000	-	-	-
1966	3,568	-	-	-	3,568	2,500	-	-	-
1967	3,597	-	-	-	3,597	2,500	-	-	-
1968	3,632	-	-	-	3,632	2,500	-	-	-
1969	3,674	-	-	-	3,674	2,500	-	-	-
1970	3,726	-	-	-	3,726	3,001	-	-	-
1971	3,767	-	-	7	3,774	3,001	-	-	-
1972	3,662	-	-	16	3,678	3,001	-	-	-
1973	3,555	-	-	26	3,581	3,000	-	-	-
1974	3,600	-	-	28	3,628	3,500	-	-	-
1975	4,543	-	-	31	4,573	3,950	-	-	-
1976	4,612	-	-	43	4,655	4,010	-	-	-
1977	5,290	-	-	39	5,329	4,600	-	-	-
1978	6,210	-	-	93	6,303	5,400	-	-	-
1979	5,641	-	-	91	5,731	4,905	-	-	-
1980	5,318	-	-	91	5,409	4,624	-	-	-
1981	5,944	-	-	107	6,051	5,169	-	-	-
1982	4,592	-	-	86	4,678	3,993	-	-	-
1983	4,335	117	-	84	4,536	3,886	-	-	-
1984	3,912	283	-	78	4,273	3,684	-	-	-
1985	4,392	290	-	90	4,771	4,108	-	-	0
1986	5,178	30	-	107	5,315	4,532	-	-	0
1987	4,450	21	-	93	4,564	3,890	-	-	0
1988	4,956	24	-	104	5,084	4,333	-	-	0
1989	5,042	18	-	106	5,166	4,402	-	-	0
1990	6,192	43	-	130	6,364	5,427	-	-	0
1991	6,757	47	-	144	6,947	5,922	-	-	2,218
1992	6,581	66	-	141	6,788	5,788	-	-	875
1993	5,896	51	-	127	6,074	5,178	-	-	-
1994	5,028	88	-	107	5,222	4,459	-	-	-
1995	4,495	94	71	95	4,755	4,003	-	-	5
1996	5,055	245	90	112	5,502	4,641	-	-	66
1997	4,308	377	194	101	4,979	4,122	6	2,302	7,613
1998	3,483	414	190	86	4,172	3,442	103	3,886	16,455
1999	5,514	538	150	142	6,343	5,333	438	22	28,432
2000	5,155	534	155	138	5,982	5,016	1,342	320	26,100
2001	5,119	472	281	143	6,015	4,924	2,514	4,168	41,986
2002	6,006	203	244	175	6,628	5,425	5,007	3,475	49,476
2003	4,684	116	266	142	5,209	4,190	12,496	732	68,604
2004	5,086	178	283	160	5,707	4,601	13,289	623	82,158
2005	5,550	423	340	181	6,494	5,249	12,798	155	90,478
2006	5,732	235	288	194	6,448	5,219	5,710	288	81,522
2007	6,602	238	253	230	7,324	5,979	7,118	712	51,705
2008	6,690	252	185	241	7,368	6,069	5,044	1,702	56,385
2009	6,838	298	202	254	7,593	6,244	5,241	1,875	67,737
2010	5,155	277	177	198	5,806	4,760	5,623	1,502	75,224

Appendix Table A2. Total reconstructed catch by taxon, 1950–2010.

Year	Jacks and pompanos	Snappers	Indian mackerel	Emperors	Kawakawa	Sea basses and groupers	Others
1950	773	475	208	172	116	100	1,173
1951	789	485	213	176	118	102	1,198
1952	762	469	205	170	114	99	1,158
1953	778	479	210	173	117	101	1,181
1954	772	475	208	172	116	100	1,172
1955	807	497	218	180	121	105	1,226
1956	821	505	221	183	123	106	1,247
1957	834	513	225	186	125	108	1,267
1958	851	523	229	189	127	110	1,292
1959	866	533	233	193	130	112	1,315
1960	835	514	225	186	125	108	1,268
1961	855	526	230	190	128	111	1,298
1962	865	532	233	193	130	112	1,314
1963	881	542	238	196	132	114	1,338
1964	899	553	242	200	135	117	1,365
1965	907	558	244	202	136	118	1,377
1966	914	562	246	203	137	118	1,387
1967	921	567	248	205	138	119	1,399
1968	930	572	251	207	139	121	1,412
1969	941	579	254	209	141	122	1,428
1970	954	587	257	212	143	124	1,449
1971	966	595	260	215	145	125	1,467
1972	942	579	254	210	141	122	1,430
1973	917	564	247	204	137	119	1,392
1974	929	572	250	207	139	120	1,410
1975	1,171	721	316	261	175	152	1,778
1976	1,192	733	321	265	179	154	1,810
1977	1,364	839	368	304	204	177	2,072
1978	1,867	700	350	350	292	467	2,276
1979	1,637	677	526	347	347	573	1,625
1980	1,545	434	501	499	554	275	1,600
1981	1,447	369	926	446	480	172	2,211
1982	1,379	252	469	318	525	173	1,563
1983	1,204	438	283	612	368	203	1,428
1984	1,261	357	318	386	638	151	1,162
1985	1,677	657	232	345	383	156	1,321
1986	1,595	1,066	41	466	379	335	1,433
1987	1,456	1,044	129	362	322	290	962
1988	2,042	876	352	353	180	217	1,064
1989	1,649	1,073	346	363	272	275	1,188
1990	2,068	1,625	238	359	221	404	1,450
1991	1,765	1,842	476	583	344	386	1,552
1992	2,261	1,356	362	657	308	336	1,509
1993	1,753	1,595	357	417	191	292	1,468
1994	1,252	1,311	688	335	200	156	1,281
1995	1,508	1,092	378	345	147	83	1,202
1996	1,843	996	500	347	109	78	1,630
1997	1,838	831	351	259	114	146	1,440
1998	1,188	1,209	29	330	48	53	1,315
1999	1,739	1,550	119	336	186	169	2,244
2000	2,083	903	348	500	89	66	1,993
2001	1,519	1,543	215	571	57	126	1,984
2002	2,417	1,303	333	398	69	88	2,022
2003	1,532	1,245	244	277	140	109	1,661
2004	1,396	1,460	486	306	76	114	1,869
2005	1,310	1,768	772	270	84	110	2,180
2006	912	1,931	219	200	74	145	2,969
2007	935	2,224	393	225	90	176	3,280
2008	1,470	2,152	348	405	156	185	2,652
2009	645	1,344	107	260	161	98	4,977
2010	811	1,093	208	116	45	93	3,441