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Rich fisheries and poor data: a catch reconstruction for Angola, 1950-2010, an update of Belhabib and Divovich (2014)

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Abstract

This is an update of the Angola catch reconstruction done by Belhabib and Divovich (2014). Angola's coast lies within the highly productive Benguela Current Large Marine Ecosystem, which leads to abundant and attractive fisheries, notably to foreign fleets. However, the data upon which any fisheries management plan would depend on are often unreliable or nonexistent, and the only two sectors that are covered by official statistics, at least partially, are industrial and artisanal fisheries. Angola's situation became worse after independence from Portuguese rule in 1975, as monitoring was absent for over 30 years due to a tumultuous civil war. Catches for Angola were reconstructed at 181,700 t in 1950, at a peak of 683,200 t in 1972, thereafter collapsed to 131,000 t in 1976 with the departure of the Portuguese fleet and then increased steadily, while remaining at low levels during the civil war, to 516,000 t in 2007. Domestic catches were 50% higher than the catch data reported to the FAO. Although this may seem low compared to other West African countries, under-reporting increased since the departure of the Portuguese but decreased slightly after the civil war. Foreign catches represented a third to a half of total removals from Angolan waters, most of which were never reported to Angola. Around 65% of industrial catches are species that are also caught by artisanal fisheries. This overlap illustrates the importance of tackling the issue of under-reporting and illegal fishing in Angolan waters.

Introduction

Angola is located in Southwest Africa (capital city: Luanda 12°30′S 18°30′E). Its mainland is located between Namibia in the South and the Democratic Republic of the Congo in the North, and with Zambia in the East and the Benguela Large Marine Ecosystem in the West. Cabinda, an Angolan exclave, is located between the Democratic Republic of the Congo and the Congo (Figure 1). Cabinda was a Portuguese colony called the 'Portuguese Congo', and is known today for its offshore oil fields, some of the largest in the world.

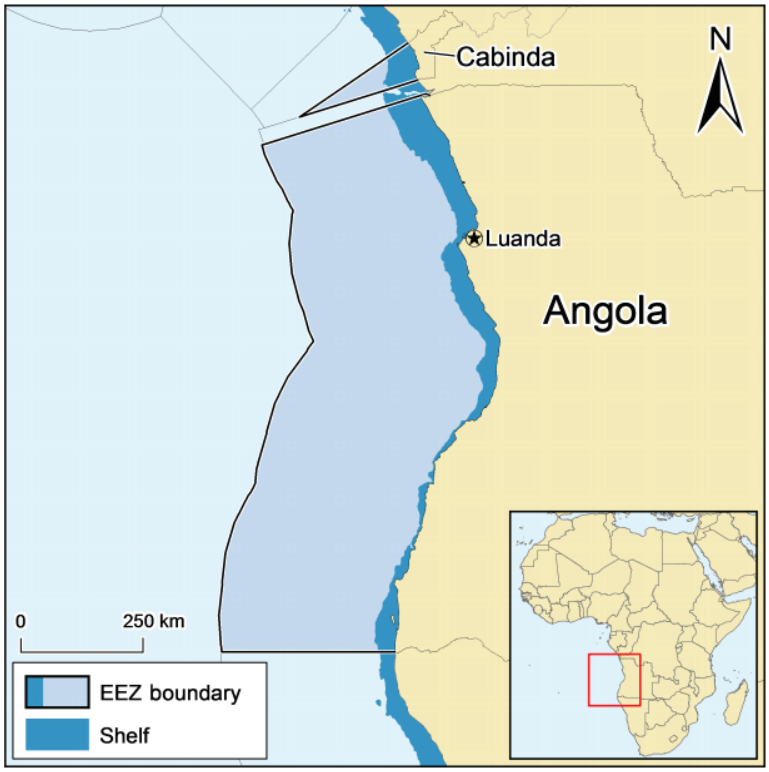

Figure 1. The Exclusive Economic Zone (EEZ) and shelf waters up to 200m depth of Angola.

The location of Angola in the northern part of the Benguela Large Marine Ecosystem, where the cold, northward Benguela current meets the warm Angola current to create a strong upwelling, is the reason why Angola's fish resources are abundant (FAO 2007b; Du Preez 2009). However, fisheries, like other sectors of the Angola's economy, have been strongly impacted by the painful history and particularly the socio-political turmoil that beset the country since independence.

When the first permanent settlement of Luanda was founded in 1576 by the Portuguese, this began the colonization that would last until Angola's independence in 1975 (Anon. 2003). The first colonial period, marked by the international slave and ivory trade, was ended by the abolition of slavery in 1876 (Valério and Fontoura 1994). However, control of lands and trading posts by a few thousands of European settlers over almost half a million indigenous people had only contributed to worsening the economic situation of the latter, and benefits driven from sectors like fisheries remained particularly restricted to settlers (Valério and Fontoura 1994).

The year 1876 also marked the beginning of the 'second colonial period' known for the development of a prosperous national economy, as it opened to world international markets particularly after World War II (Valério and Fontoura 1994). This period lasted until 1975, when Angola's war for independence ended and Angola became one of the fronts of the Cold War, in form of a vicious civil war by proxy, which lasted 30 years and devastated the country.

Notably, half a million people were killed and over a million were displaced (McGrath 1993; BBC 2013). At the end of the civil war in 2002, the country invested in rebuilding its economy. Angola experienced then the fastest growing GDP in the world. Currently, Angola is the second largest oil producer in Africa and the world's fourth largest producer of diamonds. Despite this wealth, Angola is still ranked 148th out of 186 countries on the Human Development Index, with two thirds of its population living under the poverty line, thanks to the sequels of colonialism and civil war, aggravated by corruption and poor governance.

Conflicts driving people to the coast (Medeiros 1982), poor economic conditions and droughts (Anon. 2013) limiting agricultural opportunities for people, certainly contributed to making fisheries one of the few choices Angolans have for their livelihoods, despite often difficult working conditions. Indeed, the fishing sector is a major source of employment for many Angolans, contributing 126,000 jobs (Stop Illegal Fishing 2006). Two sectors are officially reported in Angola: the industrial (and semi-industrial) sector, mainly operated by the domestic reflagged fleet and the foreign fleet (currently operating as joint ventures) and the artisanal sector operated by boats of up to 14 m (Du Preez 2009). Other fisheries sectors exist, however, they are not officially monitored, i.e., subsistence and recreational fisheries (Du Preez 2009). Although, official data show a drastic decline in marine fisheries catches due to the turmoil of the independence and civil wars, the present decrease in the size of the fish caught and their catches point to overfishing (Lankester 2002; Embaixada da República de Angola em Portugal 2014), likely initiated by foreign fleets that operated off the coast of Angola during the 1980s and continued into the 2000s, to a lesser extent. These catches, along with those of small-scale fisheries are uncertain (FAO 2007b), but are needed to support any development strategy and to ensure food security of coastal populations of Angola, as fish constitutes a large part of the animal protein intake of Angolans.

Herein, we attempt to reconstruct coherent time series of catches from the Angolan Exclusive Economic Zone (EEZ) between 1950 and 2010, which take these foreign fleets into accounts.

Methods

Total and coastal population

Total population was extracted from the World Bank database (www.worldbank.org) between 1960 and 2010 and supplemented by the data from PopulStat (www.populstat.com). Estimates for rural coastal population living within 10 km from the coast were available through (CIESIN 2012) for 1990, 2000 and 2010. We converted the latter to percentages, extrapolated the trend back, and estimated that in 1950, 1.3% of the total population of Angola was living in coastal rural areas. We interpolated linearly between these percentages from 1950 to 1990 and then multiplied them by the total population of Angola. Finally, we completed the coastal population time series by performing a series of linear interpolations (Figure 2).

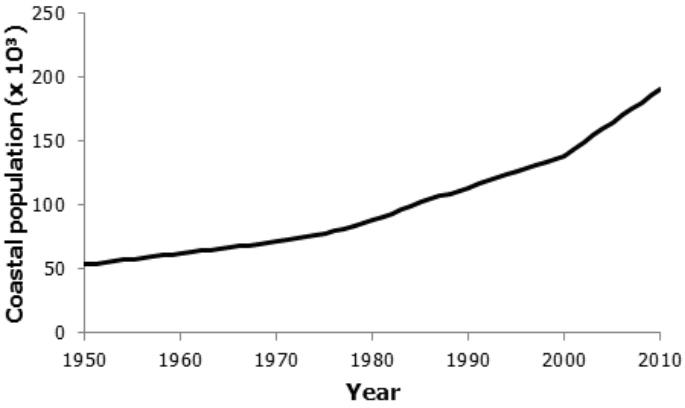

Figure 2. Estimated coastal population of Angola, 1950-2010.

Industrial catches

Industrial fisheries in Angola were dominated by foreign fleets whose catches are mostly unknown and while domestic fleets[1] are responsible for supplying catch data to authorities (Agostinho *et al.* 2005), this often results in catch under-reporting. Reported landings between 1953 and 1974 were all industrial (de Matos 1984). Likewise, the data reported by Lankester (2002) for industrial fisheries appear to overlap with the data reported to FAO between 1950 and 1999, i.e., the data reported to FAO for this time period included only industrial catches. Thereafter, the industrial reported catch was accepted as the difference between the data reported to FAO and the artisanal reported landings available between 2000 and 2004 (Norfolk *et al.* 2006), and 60% of the data reported to FAO between 2005 and 2010 correspond to the percentage of industrial landings over the total landings for 2003 and 2004. Industrial catches were reported fairly rigorously until 1957 (Coelho and Stobberup 2001). Lankester (2002) gathered what was referred to as unreported catches, taken mostly by foreign fleets, notably Russian vessels prior to the collapse of the Soviet Union between 1975 and 1994; for the latter year, unreported catches were 112% of the reported catch. We carried on this trend until the end of the civil war given the absence of any monitoring, and assumed it declined linearly by half in 2010. We applied the resulting under-reporting rates to the reported landings between 1995 and 2010. We also interpolated linearly between zero unreported catches in 1957 (Coelho and Stobberup 2001) to the unreported catch in 1975 (Lankester 2002).

[1] The Portuguese fleets operating in Angola that were based in Angola prior to Independence are considered domestic herein.

Reported catches were assumed to be Angolan, although in reality, they were mostly Portuguese and foreign during Portuguese rule (Agostinho *et al.* 2005). Subsequently after 2004, under joint venture, catches were Angolan, Russian (pelagic fisheries) and Chinese (demersal fisheries). The unreported component represented catches that were taken by foreign fleets; the majority taken by Russian fleets (50%; Lankester 2002). Before the withdrawal of the EU from Angola, 30% of the unreported catch were taken by Spain, Italy and Portugal (Preez 2009) and the remaining 20% were divided evenly between Ukraine, Nigeria, Lithuania, Japan and Angola from 1950 to 2004 (Agostinho *et al.* 2005) and China, Russia and Angola from 2004 to 2010 (Preez 2009).

We used the species disaggregation found in the FAO dataset for the most recent years (which provides the best taxonomic resolution) to disaggregate unreported catches, accounting for the fact that foreign fleets used midwater trawls for catching pelagic and bottom trawls for demersal species (Norfolk *et al.* 2006; Stop Illegal Fishing 2006).

Illegal catches

In Angola, like elsewhere in Africa, "illegal fishing is causing the depletion of marine resources", [i.e.,] "foreign trawlers have hammered patches of coastline so hard that fish have become locally scarce—a blow to a nation where a million people rely on UN food aid" (Salopek 2004; Agnonotícias 2013). Furthermore, illegal fishing in Angola is increasing due to the almost complete absence of monitoring capacity (Lankester 2002; Agnonotícias 2013). The sea patrol units acquired recently (Angodenúncias 2014) lack the capacity of covering a large range of the Angolan EEZ, notably due to lack of fuel (Salopek 2004). This lack of capacity is easily illustrated by daily incursions of industrial fishing vessels into artisanal fishing areas (Ojukwu *et al.* 2013). Illegal fishing activities include fishing in closed areas, illegal fishing gear, illegal mesh size, and fishing without a license, the latter commonly recurrent in Angolan waters (Stop Illegal Fishing 2006). Examples of illegal fishing in Angola often involve Chinese vessels with African crew (ANGOP 2013), with a number of vessels arrested in very short time periods in the 2000s (ANGOP 2009; DN 2012; O País 2014). The above-mentioned illegal fishing activities are not limited to Chinese trawlers and longliners flying with Flags of Convenience (FoC; (Gianni and Simpson 2005; MRAG 2005) ; other fleets, from Korea, Spain, Namibia, Japan and Russia, are also involved in illegal fishing activities (Salopek 2004).

The overwhelming evidence illustrates that China is the major contributor to illegal fishing activities in Angola (Salopek 2004). Often, these activities are related to other illegality, such as loss of life. Thus the quote (Salopek 2004): "at least two Angolan inspectors have vanished mysteriously while on observer duty aboard large industrial trawlers–suicides, assert the foreign skippers, pushed overboard, the fisheries police insist". Also, politicians "are using the oceans as a bank account" (Salopek 2004). Along with Chinese illegal trawlers which can catch 320 $t \cdot boat^{-1} \cdot year^{-1}$ assuming 4 fishing trips and 80 $t \cdot boat^{-1} \cdot trip^{-1}$ (Salopek 2004),[2] Korean mother-ships carry Senegalese pirogues onboard to fish in Angolan waters. This activity exploded in the 1990s and in 1998 when 100 Senegalese pirogues were confiscated (Sall *et al.* 2002).

We conservatively assumed the number of Senegalese pirogues arrested represented the total number of pirogues involved in illegal fishing in 1998 and then assumed a linear increase of 10% between then and 2010. We interpolated linearly between 0 in 1990, 100 in 1998 and 110 in 2010, and then multiplied the resulting effort by a CPUE of 125 $t \cdot pirogue^{-1} \cdot year^{-1}$ (Belhabib *et al.* 2014a). We performed the catch disaggregation by filtering out species that were caught by Korea in FAO area 47, i.e., species of interest to Korea, which were also caught by the artisanal fleet.

In 2004, over 25 days of aerial surveillance, 199 vessels were spotted, 29 of them were committing serious infringement, 13% of these were fishing with no licenses (MRAG 2005), i.e., around 4 vessels every 25 days, translating into 55 vessels per year in 2004. In 2009, 7 vessels were arrested for illegal fishing during a campaign of 2 weeks (ANGOP 2009), which translates into 170 vessels fishing illegally in 2009. We interpolated the number of illegal fishing boats linearly between 0 in 1982, when Angola declared its EEZ to the anchor points estimated above. We assumed the CPUE was 320 $t \cdot boat^{-1} \cdot year^{-1}$ across all fleets for 2004, which is a very conservative estimate compared to that of 9,000 $t \cdot boat^{-1} \cdot year^{-1}$ estimated using effort and catch data by MRAG (2005) which included illegal, unregulated and unreported catches. We assumed the CPUE was 10% higher in 1982 and was 10% lower in 2010 and interpolated linearly. We multiplied the effort by the estimated CPUE and then assumed 80% of these catches were taken by Chinese vessels, while the remaining are equally allocated to Japan, Russia, Namibia and Spain.

Discards

A report states that during a typical fishing operation by Chinese trawlers "two basketfuls of prized sole, bream and skates, the rest of the dead and dying catch is scraped over the side of the giant Chinese trawler, full to the knees of marine life" (Salopek 2004). These fish are called "wrong fish" by the crew (Salopek 2004). Discards are not limited to Chinese vessels, as overall demersal finfish and shrimp trawl fisheries in Angola are understood to generate significant discards (COFREPECHE 2013). However, the small-pelagic purse-seine and artisanal fisheries appear to have generated less discards of low value species (Kelleher 2004). Discards of the shrimp fishery were estimated at 70% of the total catch, i.e. for every 1 kg of shrimp caught, 2.33 kg of marine life are discarded (Kelleher 2004; COFREPECHE 2013). Similarly, demersal finfish fisheries discard around 40% of total catches, and purse-seine and artisanal fisheries generate discards of 5% and 1%, respectively (Kelleher 2004). We applied these percentages to shrimp trawl, demersal trawl, purse-seine and artisanal fisheries catches per fishing country and obtained total discards between 1950 and 2010.

Since no species breakdown for discards was available, we used the species breakdown provided in (Belhabib *et al.* 2014b) and assumed that purse-seiners discarded clupeids as they do in Namibia (Belhabib *et al.* 2014c).

[2] These CPUE values are much lower than the values estimated in Pauly et al. (2013).

Artisanal catches

Artisanal fisheries constitute the main livelihood of Angolan coastal communities (Anon. 2003). Fishers use boats called piroga, chata and the catronga, either canoes made of wood or fiber, and more sophisticated small-planked open boats or boats with an inboard engine (IPA 2002). Furthermore, beach-seining occurs in 47 out of the 102 fishing communities (IPA 2002) and employs 100,000 fishers in addition to the 35,000 using boats (Sowman and Cardoso 2010). Historically, Angolans were excluded from the artisanal fishing sector by the Portuguese until their rule ended in 1975 (Sowman and Cardoso 2010). With the civil war, a large number of people migrated towards the coastal zones where fishing became an alternative livelihood (Sowman and Cardoso 2010).

Anchor points on the number of fishers were reported for 1979 (Guerra 1979) and for the number of fishers and boats for 1991 (fishers only), 1995, 1998, 2000, 2001 (IPA 2002) and 2010 (Sowman and Cardoso 2010). The number of fishers declined between 1970 and 1979 (Guerra 1979), and we assume this decline was by 80% (Table 1). We estimated the number of fishers for 1950 by assuming the percentage of fishers in the coastal population was constant between 1950 and 1970 during the colonial period and then multiplied this percentage by the coastal population for 1950 (Figure 2) to obtain the number of fishers for 1950 (Table 1). Since artisanal fisheries did not change substantially over time (O País 2012), we assumed the number of fishers per boat remained constant between 1950 and 1995, i.e., 5 fishers per boat (Krantz 1984; Agostinho *et al.* 2005). We obtained the number of boats by dividing the total number of fishers by the number of fishers per boat for 1950, 1970, 1979 and 1991 and then completed the time series for the number of boats by performing a series of linear interpolations.

In the early 1980s, artisanal fishing boats were given by Sweden to Angolan in the context of a development project (Krantz 1984). The purpose of the study by Krantz (1984) was to evaluate whether this project achieved its aims, as well as to give an in-depth socio-economic analysis of numerous artisanal fisheries in Angola (Krantz 1984). Additionally, this study derived catches per boat for several fisheries, which enabled calculating the CPUE for boats in Luanda, Barra do Dande, Ambriz, Soyo and Cabinda.

Table 1. Number of artisanal boats and fishers

Year	Number of boats[1]	Source	Number of fishers[2]	Source
1950	771		3,754	
1951	*784*			
1952	*797*			
1953	*809*			
1954	*822*			
1955	*835*			
1956	*848*			
1957	*860*			
1958	*873*			
1959	*886*			
1960	*899*			
1961	*912*			
1962	*924*			
1963	*937*			
1964	*950*			
1965	*963*			
1966	*976*			
1967	*988*			
1968	*1,001*			
1969	*1,014*			
1970	1,027		5,000	Guerra 1979
1971	*1,004*			
1972	*981*			
1973	*958*			
1974	*936*			
1975	*913*			
1976	*890*			
1977	*867*			
1978	*844*			
1979	821		4,000	Guerra 1979
1980	*1,012*			
1981	*1,202*			
1982	*1,392*			
1983	*1,582*			
1984	*1,772*			
1985	*1,963*			
1986	*2,153*			
1987	*2,343*			
1988	*2,533*			
1989	*2,723*			
1990	*2,914*			
1991	3,104		15,114	Agostinho 2005
1992	*3,527*			
1993	*3,951*			
1994	*4,374*			
1995	4,798	Agostinho 2005	23,364	Agostinho 2005
1996	*5,185*			
1997	*5,573*			
1998	5,960	Agostinho 2005	21,573	Agostinho 2005
1999	*5,960*			
2000	5,960	Anon. 2003	21,573	Anon. 2003
2001	6,173	Agostinho 2005	20,131	Agostinho 2005
2002	6,500	Anon. 2003		
2003	5,171	Agostinho 2005	17,131	Agostinho 2005
2004	*5,375*			
2005	*5,579*			
2006	*5,783*			
2007	*5,988*			
2008	*6,192*			
2009	*6,396*			
2010	6,600	Sowman and Cardoso 2010	35,000	Sowman and Cardoso 2010

[1] Italicized numbers have been interpolated
[2] Excludes the fishers operating with beach seine

In the context of the study (Krantz 1984), catches, number of fishing days and number of landing occasions allowed the estimation of the CPUE, by dividing the catch per pirogue by the number of fishing days in Luanda, i.e. 64 ± 9 kg·boat^{-1}·day^{-1}. It is worth mentioning that the black market that exists in Luanda hides some unreported catches as the CPUE estimate is based on what has been reported to the fishing association (Krantz 1984). Barra do Dande fishers have always been involved in the sea, and the fact that this market is adjacent to the river as opposed to Luanda, makes the fishery relatively more successful than in Luanda even with smaller boats. As there is no fishing authority or a fishers association, there is no control of prices and no official statistics system (Krantz 1984). By taking the average monthly CPUE (Krantz 1984) and applying it to the entire year, provides a CPUE estimate of 21,525 ± 1,872 kg·boat^{-1}·year^{-1}. In Ambriz, there appears to be no black market and fishers appear more reliable and transparent in terms of reporting their catches (Krantz 1984). We estimated the CPUE using the same method as previously stated at 8,288 ± 3,181 kg·boat^{-1}·year^{-1}. There is an association in Soyo which supplies the fishers with all of their needs (Krantz 1984). However, it differs in that Luanda does not have any external support and thus very limited resources to offer their members, while Soyo is directly aided by the Swedish support sector and therefore can fulfill many needs (Krantz 1984). The author provided monthly catches per boat, which we averaged and expanded annually to estimate an average CPUE of 6,804 ± 1,816 kg·boat^{-1}·year^{-1}. A fair but limited amount of fish is sold in the black market. Cabinda is an isolated patch of Angola as it is more economically tied to its surrounding regions of the Democratic Republic of the Congo and Congo Brazzaville. Most of the fish that was eaten in this period was landed by Soviet trawlers (Krantz 1984). Following the previous approach using the data provided by Krantz (1984), we estimated the average annual CPUE at 12,934 ± 6,188 kg·boat^{-1}·day^{-1}. Therefore the average artisanal CPUE for all locations was estimated at 13.1 t·boat^{-1}·year^{-1} for 1984. Similarly, we estimated the CPUE for 2002 by dividing the catch estimate provided by Norfolk *et al.* (2006) by the number of boats. However, we adjusted the latter by adding a conservative 30% given that only 55 landing sites over 102 (Agostinho *et al.* 2005) were covered, and there was no evidence of extrapolation. Indeed, ArtFish, which allows these kind of geographic extrapolations based on a sample, is not used properly if used at all (Agostinho *et al.* 2005). We assumed the CPUE between 1950 and 1970 was 20% higher than the CPUE in 1983 due to technological creep (Agostinho *et al.* 2005), i.e., 15.73 t·boat^{-1}·year^{-1} for 1950-1970, and then declined by 5% between 2002 and 2010, i.e. 18.5 t·boat^{-1}·year^{-1} for 2010. We interpolated linearly CPUE estimates and multiplied the latter by the effort to estimate total artisanal catches in Angola.

The number of boats for Cabinda was provided for 1991 (22% of the total effort), 1995, 1996, 1998, 2000, 2001 and 2003 (19% of the total effort) (IPA 2002; Agostinho *et al.* 2005). We assumed the percentage of the number of boats in Cabinda over the total was constant between 1950 and 1991) and between 2003 and 2010 and estimated the number of boats for the latter years (Table 1). We interpolated linearly and then multiplied by the artisanal CPUE to estimate artisanal catches in Cabinda province (already included in total artisanal catches).

We disaggregated catches using the taxonomic breakdown provided by Agostinho *et al.* (2005).

Subsistence catches

Small-scale fisheries have traditionally been a subsistence activity developed by the population living along the coast and has been transmitted from generation to generation. In order to escape the ravages of war, many people fled from the interior zones of the country to the coastal zones for safety , i.e., to Luanda, Namibia, Benguela and Kwanza Sul (FAO 2007a). This along with the low purchasing power of Angolans and the fact that many part-time workers depended on fish, contributed to making subsistence fisheries an important source of protein for coastal populations (Urquhart 1963; de Sousa Ferreira 1985).

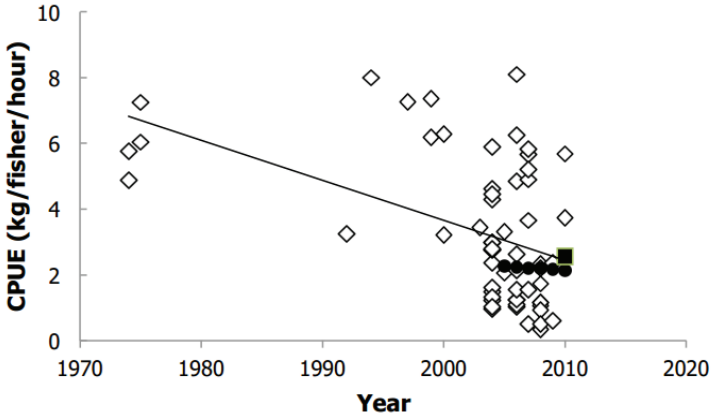

Figure 3. Observed and estimated CPUE of recreational fishers comparing various sources, diamonds (Anon. 2014), circles (Potts et al. 2009) and square (YouTube).

Subsistence fishers can catch up to 20 kg·fisher^{-1}·day^{-1} (Sowman and Cardoso 2010). The literature locates subsistence catches between 30% of total reported landings (Macauhub 2014) and the equivalent of artisanal fisheries (da Silva 2012) for 2010 as half of catches are given to the crew, while the other half is sold. Therefore, assuming the number of artisanal fishers is equivalent to the number of subsistence fishers, the total number of subsistence fishers for 2010 would be 135,000 including those operating on boats and those operating beach seines (Sowman and Cardoso 2010). We assumed subsistence fishers operated twice a month, as it is very occasional in nature, and that the CPUE in that fishery is 20 kg·fisher^{-1}·day^{-1} (Sowman and Cardoso 2010), i.e., subsistence catches were estimated at 64,800 t·year^{-1}, which is lower than literature estimates (da Silva 2012; Macauhub 2014). Krantz (1984) assessed the subsistence catch taken home by artisanal fishers; crew members are allowed to take 30 kg of fish home for their personal consumption per landing occasion, each boat has 5 crew members (Krantz 1984). Using the number of fishing days per landing occasion, we converted this estimate to take-home catch per fishing day, i.e., 33 kg·boat^{-1}·day^{-1} (we also conservatively assume that the number of fishing days was 250, equivalent to 21 fishing days per month). Crew members in Ambriz are allowed to take 5 kg for personal consumption per landing occasion (Krantz 1984); however they take much more, herein assumed 15 kg. As the author did not report the number of landing occasions, we used the ratio Subsistence: Artisanal CPUE for Luanda, i.e., for each one kg of fish landed

per boat, 0.51 kg were taken home. Therefore, for every 29 kg of fish landed in Ambriz, 15 are taken home for consumption, which is equivalent to 4,287 kg·boat^{-1}·year^{-1}. Krantz (1984) described that part of the catch in Soyo was taken home by fishers without specifying the amount. However, since a fair amount is taken home as the fishery is described to be mainly for subsistence, we assumed subsistence catches were at least equivalent to artisanal catches, which translates into 6,804 kg·boat^{-1}·year^{-1} of subsistence catch. Following the previous approach using data provided by Krantz (1984), we estimated the subsistence catch for Cabinda at 3,519 kg·boat^{-1}·year^{-1}. We averaged these CPUE rates and obtained a subsistence CPUE of 5,689 kg·boat^{-1}·year^{-1} or 1,161 kg·fisher^{-1}·year^{-1} assuming 5 fishers per boat (Krantz 1984). For the same year, we estimated the number of fishers operating in the beach seine fishery by assuming the proportion beach seine fishers:boat fishers estimated at 2.86 using data provided by Sowman and Cardoso (2010) was the same over time, i.e., 22,013 beach seine fishers in 1984. We multiplied the CPUE per boat by the number of boats and the CPUE per fisher by the number of beach seine fishers and obtained a total subsistence catch of 34,720 t·year^{-1} for 1984. Similarly for 1950, we first estimated the number of beach seine fishers applying the same method as above, but assumed the CPUE was 20% higher, i.e., 6,827 kg·boat^{-1}·year^{-1} or 1,393 kg·fisher^{-1}·year-1, given the overall over-exploitation pattern in Angola. We multiplied the CPUEs by the number of boats and the number of beach-seine fishers (9,909) respectively and estimated total subsistence catches at 18,754 t for 1950. We interpolated linearly the previous estimates to complete the time series. We extracted catches from Cabinda by using the same proportions as for artisanal fisheries and then disaggregated subsistence catches using the same species disaggregation as for artisanal fisheries.

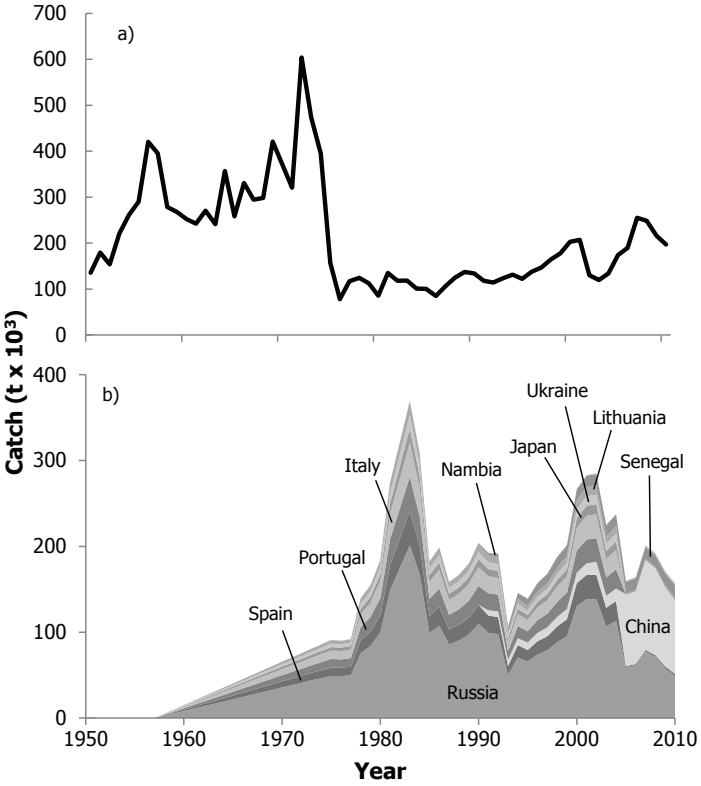

Figure 4. Reconstructed industrial fisheries catches from Angola EEZ by a) the domestic fleet and b) the foreign fleet by country, 1950-2010.

Recreational catches

Although catches and fish sizes are declining, e.g. West Coast dusky kob (*Argyrosomus coronus*) (Potts *et al.* 2011), suggesting a loss of value of recreational fisheries, there has been increasing interest in Angola's recreational fisheries, illustrated by a growing number of foreign recreational fishers in the recent years (Potts *et al.* 2009). Fishers spend 6 days fishing per visit (Potts *et al.* 2011).

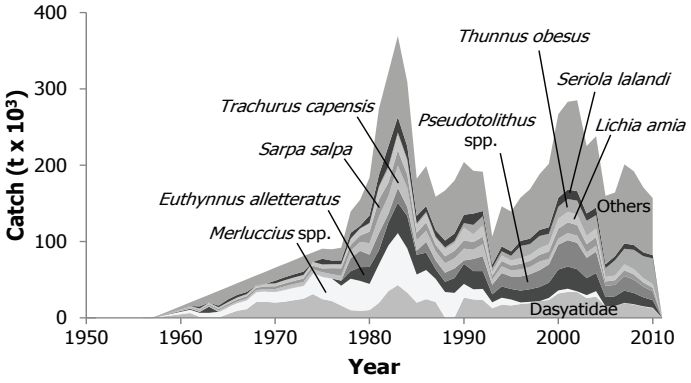

Figure 5. Reconstructed industrial fisheries catches (domestic and foreign) from Angola EEZ by major taxa, 1950-2010.

Catch per fisher data were recorded for 1974-1975 and between 1992 and 2013 (Anon. 2014) published in www.fapd.co.ao. Although these data may refer to trophy fish catches (average: 2.83 ± 1.07 kg·fisher^{-1}·hour^{-1}), these data were not significantly different from the catch per fisher data provided by Potts *et al.* (2009) between 2005 and 2010 (average: 2.2 ± 0.03 kg·fisher^{-1}·hour^{-1}). The latter provided the CPUE per species for 2005, 2006 and 2010 for West Coast kob, shad (*Pomatomus saltatrix*) and leerfish (*Lichia amia*) which constituted 87% of the total CPUE. We added 13% to these, interpolated linearly and then compared these to the data provided by Anon. (2014) for the same period (Figure 3). Similarly, recreational CPUE estimated using nine *YouTube* videos resulted in similar results (average: 2.56 ± 0.53 kg·fisher^{-1}·hour^{-1}) (Figure 3). Therefore, we derived a trend line which allowed us to obtain the annual CPUE between 1974 and 2010; we extrapolated backwards to complete the dataset for 1950-1973. For the number of fishers, the periods where records were absent corresponded to the civil war, i.e., 1975-1991, 1993, 1998, 2001-2002, which shows that the latter was directly related to foreign visits to Angola. On the other hand, the presence of records as early as 1974 reveals that there was recreational fishing during the Portuguese colonial period. There are three main lodges receiving tourists for recreational fishing, Flamingo Lodge (www.aasafaris.com), which welcomed 655 recreational fishers with an accommodation capacity of 48 rooms (Potts

et al. 2009), Kwanza Lodge, which has a capacity of 24 to 48 people per day, i.e. conservatively 328 tourists (assuming the same proportions as Flamingo Lodge) and Cunene Lodge with a capacity of 15 people per day, i.e., 195 people annually (www.aasafaris.com). This provides a total of 1,208 recreational fishers per year for 2010. We assumed the number of recreational fishers in 1950 was half of that in 2010, decreased linearly to 0 in 1975, and was 1% of the number of fishers of 2010 for the years 1992, 1999 and 2000 when records were present. The number of fishers was zero for the years 1975-1991, 1993, 1998, 2001-2002, and interpolated linearly between 2002 and 2010. Assuming 5 hours of fishing per day, and 6 days per tourist, we multiplied the CPUE by the number of fishers and obtained total recreational catches for Angola.

To disaggregate recreational catches, we calculated the percentage contribution of each documented species between the period 1974 to 2010 using the above mentioned references, interpolated linearly to fill in the gaps and assumed the species disaggregation was constant between 1950 and 1974.

Results

Industrial catches

Industrial domestic catches increased from 135,700 t in 1950 to a peak of 604,000 t before independence from Portugal and then declined drastically after the departure of the Portuguese domestic fleet to 78,000 t in 1976, their historical minimum (Figure 4a). Domestic catches remained constant at around 109,000 t·year^{-1} between then and the mid-1980s, before increasing to a peak of 255,000 t in 2007 and declining thereafter (Figure 4a). Foreign catches increased from 5,100 t in 1958 to a peak of over 369,300 t in 1983 at the height of the civil war, when monitoring was at its lowest (Figure 4b). Foreign catches subsequently decreased to around 106,400 t in 1993, then increased to a second peak of 285,000 t in 2002, before decreasing to about 156,900 t in 2010 (Figure 4b). Foreign catches were dominated by Russia (former Soviet Union) and Spain in the past, and Russia and China in the 2000s (Figure 4b).

The industrial fisheries caught and landed mostly rays (Dasyatidae; 12.2%), cape hakes (*Merluccius* spp.; 11.5%), tunas, croakers (Pseudotolithus; 7.7%) and Cape horse mackerel (*Trachurus capensis;* 5.3%). Catches of Cape hakes decreased and catches of demersal species, such as soles (*Cynoglossus* spp.; 1.2%) increased (Figure 5), due to a shift in the fishing fleet when the EU withdrew from the EU-Angola agreements negotiations. "Others" contain 135 taxonomic compositions and constitute 35.6% of total foreign industrial catches.

Illegal catches

Illegal catches by industrial fleets increased drastically from low levels in 1983 to a peak of around 63,700 t in 2010 (Figure 6a). Illegal catches taken by Senegalese pirogues transported to Angola onboard Korean mother-ships, increased from 1,400 t in 1990 when this activity began to 12,500 t in 1998 and then remained relatively constant at around 13,500 t·year^{-1} during the late 2000s (Figure 6a). China and South Korea (through Senegalese pirogues) contributed the most to illegal catches (Figure 6a).

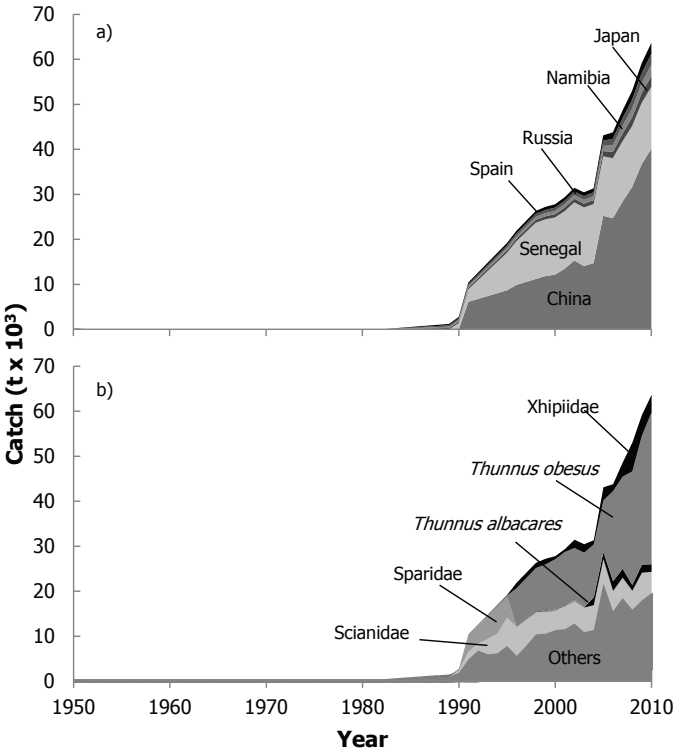

Figure 6. Reconstructed illegal catches from Angola by a) country and b) taxon, 1950-2010.

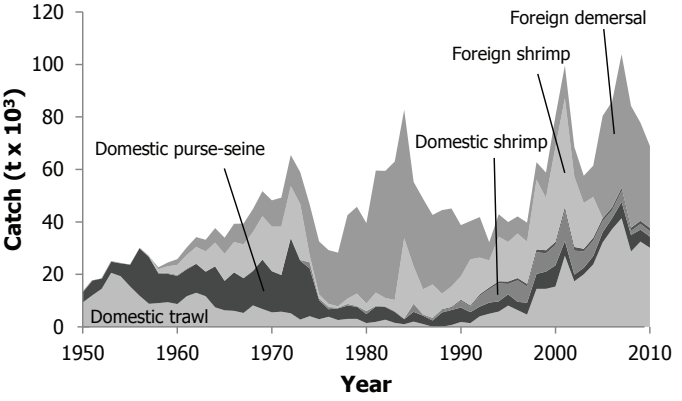

Figure 7. Reconstructed total discards by sector from Angola EEZ, 1950-2010.

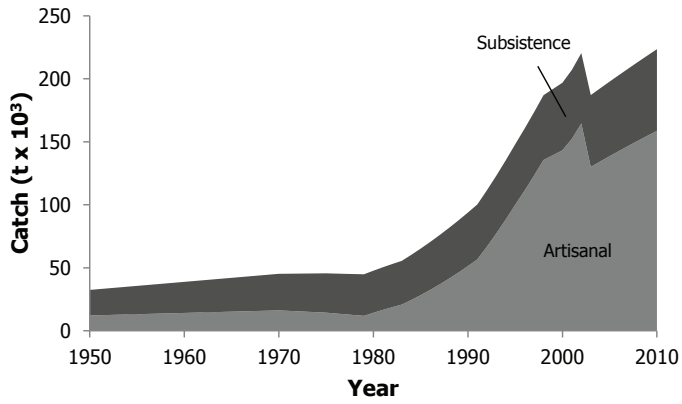

Figure 8. Reconstructed total small-scale artisanal and subsistence catches from Angola, 1950-2010.

Taxonomically, there were over 80 taxa caught by illegal fleets, however tunas (Thunnus spp.), and other large pelagics (Xiphiidae), as well as Sparidae and Sciaenidae represent over half of the latter (Figure 5b).

Discards

Discards increased from around 13,400 t in 1950 to a first peak of 65,500 t in 1972, a second peak of 82,700 t in 1984, declined to 32,200 t in 1993, and then increased to two consecutive peaks of around 99,600 t in 2001 and 103,900 t in 2007 (Figure 7). Although shrimp trawlers are known to generate the largest amount of discards in Angola in proportion, demersal finfish trawlers contributed the most to total discards in quantity between 1950 and 2010 (Figure 7).

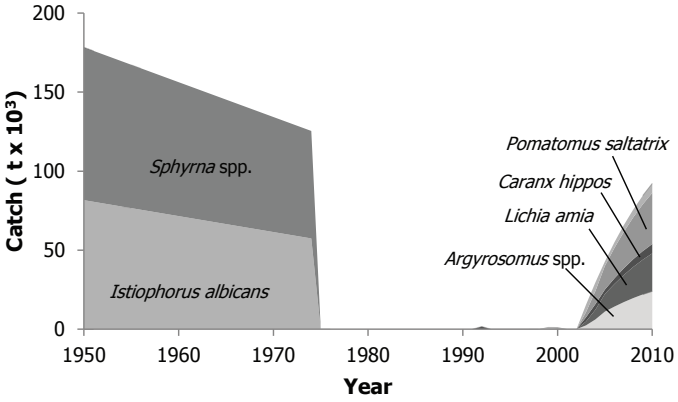

Figure 9. Reconstructed total recreational catches from Angola EEZ, 1950-2010.

Artisanal catches

Artisanal catches increased slightly from 12,100 t in 1950 to around 16,200 t in 1970, decreased slightly to 11,800 t in 1979 due to the decrease in the number of fishers and then increased rapidly to around 164,600 t in 2002. Artisanal catches decreased to approximately 130,100 t in 2003 before increasing again to about 158,700 t in 2010 (Figure 8).

Subsistence catches

Subsistence catches increased continuously, likely due to increasing migrations towards the coast during the civil war, from around 20,300 t in 1950 to 64,800 t in 2010 (Figure 8).

Recreational catches

Recreational catches were estimated at around 180 t in 1950, decreased to 0 in 1975, and generally remained at this level through the civil war, before increasing again to 92 t in 2010 (Figure 9). Taxonomically, recreational catches included sailfish and sharks before independence and shifted to leerfish, kob and shad after the civil war (Figure 9), likely due to the change in clientele from Portuguese to South Africans.

Total catches

Total removals from Angolan waters (including Angola and its exclave Cabinda) increased from around 181,700 t in 1950 to a first peak of 790,200 t in 1972, before collapsing to 242,500 t in 1976 (Figure 10). Total catches increased thereafter due to the increase in foreign industrial catches to approximately 606,500 t in 1983, declined to 384,900 t in 1993, before increasing again to 768,300 t in 2007 (Figure 10a). Domestic catches, on the other hand, increased from 181,700 t in 1950 compared to 135,700 t reported to the FAO, to a historical peak of around 683,200 t in 1972, after which they collapsed due to the departure of the Portuguese ('domestic') fleet to 131,000 t in 1976 compared to 74,142 t reported to the FAO (Figure 10a). Domestic catches increased to 458,100 t in 2010 compared to 250,000 t reported to the FAO (Figure 10a). Overall, domestic catches were 22% higher than the data supplied to the FAO prior to independence, about twice as high as the data supplied to the FAO during the civil war, and 82% higher thereafter.

Catches in Cabinda, located in the Eastern Central Atlantic area were almost completely unreported. Catches were nearly all small-scale, increased from

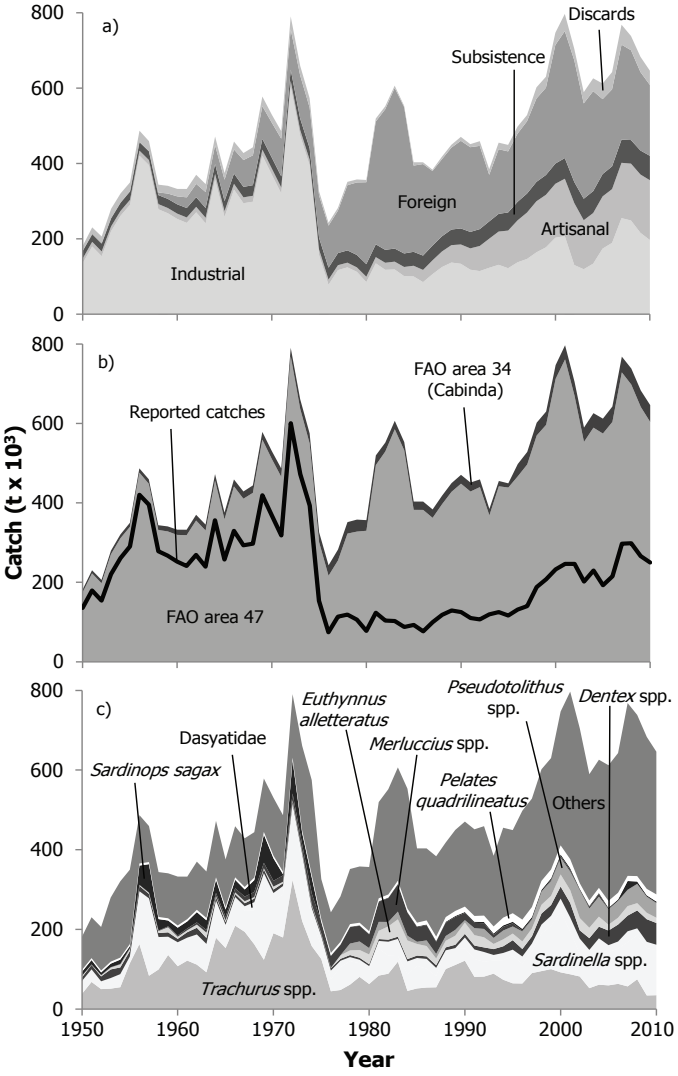

Figure 10. Reconstructed total catches from the Angolan EEZ by a) sector including domestic and foreign catches, b) area including domestic catches and c) taxon including domestic and foreign catches, 1950-2010.

around 7,300 t in 1950 compared to less than 0.5 t reported to FAO, to a peak of around 29,800 t in 1979, and then decreased, due to the decrease in the number of fishers to around 10,600 t in 1995 (as opposed to zero reported to the FAO), before increasing again to 42,400 t in 2010, with no catch reported to FAO from this area (Figure 10b).

Taxonomically, over the 180 taxa that are caught from Angolan waters. Cape horse mackerel (*Trachurus capensis*), sardinellas (*Sardinella* spp.), Cape hakes, tunas (Scombidae) and croakers (*Pseudotolithus* spp.) dominate catches (Figure 10c). Cape horse mackerel and Cape hake catches declined strongly while sardinella catches increased (Figure 10c).

Discussion

Total catches from Angolan waters were estimated herein at 181,700 t in 1950, at a peak of 790,600 t in 1972, collapsed to 242,900 t in 1976 and then increased steadily to 768,300 t in 2007. Angola is a good example that illustrates how socio-political conditions in the country could impact fisheries. For example, the under-reporting component was shown to be at its highest during the civil war, when fisheries monitoring was not a priority. Similarly, industrial domestic fisheries collapsed during independence in the mid-1970s, while foreign fisheries flourished and peaked at the height of the civil war, notably because of the lack of surveillance. While artisanal fishing opportunities were restricted during the Portuguese rule, subsistence fisheries increased during the civil war mostly due to strong migrations towards the coast, where fisheries are often sought to be the only available livelihood opportunity (Medeiros 1982) as opposed to patterns observed in e.g. Namibia.

Cabinda, part of Angola located between the two Congos, seems to be isolated in terms of catch reporting. Indeed, only a few catches, all industrial, were reported for this area between 1953 and 1990, and no small-scale catches were reported. The catch pattern observed for Cabinda also illustrates the marginalization of this area of Angola, as small-scale catches were relatively more important and showed an increasing pattern despite restrictions by Portugal, and high conflict occurrence.

This reconstruction also shows uncontrolled and unmonitored presence of foreign fleets during the civil war. Indeed, foreign legal and illegal fleets generated around half of the total removals from Angola between 1974 and 2002, and then their contribution declined to around a third when efforts of monitoring increased. However, their catches still remain relatively high as illegal fishing increases. Furthermore, as there are strong overlaps between the species taken by the industrial fleet and those taken by the artisanal fleet, blame is often cast towards industrial fisheries when stocks are depleted (Salopek 2004). Despite this depletion, Angola is still perceived to be one of the best recreational fishing destinations in West Africa. This is clearly illustrated by the rapid increase in recreational fisheries catches. However in contrast to Namibia, where recreational fisheries have various management strategies such as restriction of the numbers of bags, permits and fishing areas, Angola has rather large room for improvement as data are scarce and monitoring of recreational fisheries is nonexistent. This activity might generate strong economic returns if managed properly (Potts *et al.* 2009).

There is an urgent need to improve fisheries monitoring in Angola as official estimates are unreliable (Lankester 2002) and unreported catches are high as shown by the present study. Furthermore, the lack of monitoring, control and surveillance contributes to the increase of illegal fishing. Particularly, as illegal fishing is decreasing in Nambia, a neighboring country, as priority has been placed on improving surveillance.

Acknowledgment

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Appendix Table A1. FAO landings vs. reconstructed total catch (in tonnes), and catch by sector, with discards shown separately for Angola, 1950-2010.

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	135,700	182,000	136,000	12,100	20,300	178	13,400
1951	179,500	230,000	180,000	12,300	20,700	176	17,700
1952	153,800	206,000	154,000	12,500	21,200	174	18,500
1953	220,400	280,000	220,000	12,700	21,600	172	25,000
1954	261,200	321,000	261,000	12,900	22,100	169	24,300
1955	290,400	350,000	290,000	13,100	22,500	167	23,800
1956	420,500	487,000	421,000	13,300	22,900	165	30,100
1957	395,500	459,000	396,000	13,500	23,400	163	26,900
1958	278,200	337,000	278,000	13,700	23,800	161	20,700
1959	267,400	327,000	268,000	13,900	24,200	158	20,500
1960	252,000	311,000	253,000	14,100	24,700	156	19,800
1961	241,500	304,000	242,000	14,300	25,100	154	22,300
1962	269,300	335,000	270,000	14,500	25,500	152	24,100
1963	239,800	303,000	241,000	14,700	26,000	150	21,100
1964	356,500	423,000	358,000	14,900	26,400	147	23,100
1965	257,500	319,000	259,000	15,200	26,900	145	17,600
1966	329,500	395,000	331,000	15,400	27,300	143	20,800
1967	293,300	358,000	295,000	15,600	27,700	141	18,600
1968	297,100	365,000	300,000	15,800	28,200	139	21,400
1969	419,200	492,000	422,000	16,000	28,600	136	25,700
1970	368,501	438,000	371,000	16,200	29,000	134	21,300
1971	318,322	387,000	321,000	15,800	29,500	132	19,800
1972	600,656	684,000	604,000	15,400	29,900	130	34,100
1973	472,159	547,000	476,000	15,100	30,400	128	25,500
1974	393,284	467,000	397,000	14,700	30,800	125	24,600
1975	153,581	214,000	158,000	14,400	31,200	0	10,900
1976	74,542	131,000	78,000	13,700	31,700	0	7,600
1977	113,407	170,000	117,000	13,100	32,100	0	7,300
1978	118,630	178,000	125,000	12,500	32,500	0	8,800
1979	106,072	166,000	113,000	11,800	33,000	0	8,000
1980	77,585	139,000	86,000	14,300	33,400	0	6,000
1981	123,457	194,000	135,000	16,500	33,800	0	8,000
1982	103,988	179,000	118,000	18,700	34,300	0	7,800
1983	102,876	180,000	119,000	20,700	34,700	0	6,000
1984	87,688	165,000	101,000	24,400	35,800	0	3,200
1985	92,593	175,000	100,000	28,300	37,000	0	8,800
1986	76,660	160,000	85,000	32,400	38,100	0	4,700
1987	99,490	186,000	106,000	36,700	39,200	0	3,400
1988	118,031	214,000	125,000	41,400	40,300	0	6,700
1989	129,465	232,000	137,000	46,200	41,400	0	7,600
1990	125,088	238,000	134,000	51,300	42,500	0	10,400
1991	110,104	226,000	118,000	56,700	43,600	0	8,100
1992	106,625	238,000	114,000	66,600	44,800	2	12,400
1993	119,200	261,000	123,000	77,200	45,900	0	15,000
1994	125,413	284,000	131,000	88,300	47,000	0	17,400
1995	116,781	287,000	122,000	99,900	48,100	0	17,300
1996	131,815	317,000	138,000	111,300	49,200	0	18,600
1997	140,304	336,000	147,000	123,200	50,300	0	16,400
1998	188,280	381,000	164,000	135,600	51,400	0	29,500
1999	207,800	399,000	177,000	139,400	52,600	1	29,200
2000	232,351	432,000	203,000	143,200	53,700	1	32,400
2001	246,553	460,000	207,000	152,300	54,800	0	45,600
2002	246,443	382,000	131,000	164,600	55,900	0	30,500
2003	202,033	337,000	120,000	130,100	57,000	15	29,800
2004	230,002	361,000	134,000	134,400	58,100	30	34,000
2005	192,616	413,000	174,000	138,600	59,200	43	41,400
2006	215,241	438,000	189,000	142,800	60,300	55	45,600
2007	297,436	516,000	255,000	146,800	61,500	66	53,000
2008	298,262	500,000	249,000	150,900	62,600	76	37,800
2009	266,415	475,000	216,000	154,800	63,700	85	40,500
2010	250,000	458,000	197,000	158,700	64,800	92	37,800

Appendix Table A2: Reconstructed total catch (in tonnes), by major taxonomic composition for Angola, 1950-2010. 'Others' contain 177 additional taxonomic categories.

Year	*Trachurus* spp.	*Sardinella* spp.	Dasyatidae	*Dentex* spp.	*Euthynnus alletteratus*	*Pseudotolithus* spp.	*Merluccius* spp.	*Sardinops sagax*	*Pelates quadrilineatus*	Others
1950	38,400	32,200	123	8,910	4,270	0	0	9,850	4,680	83,200
1951	68,200	31,500	127	11,210	1,230	0	0	10,940	4,780	102,500
1952	50,200	19,400	136	12,270	3,610	0	0	6,380	4,870	109,300
1953	51,300	26,500	154	21,600	5,720	0	0	8,820	4,960	160,800
1954	54,900	32,800	0	16,810	8,520	0	0	11,100	5,050	191,400
1955	115,100	16,900	0	13,710	7,020	0	0	5,280	5,140	186,800
1956	163,300	132,500	113	13,340	2,810	0	0	48,300	5,240	121,400
1957	83,700	194,300	0	11,120	3,450	0	0	71,220	5,330	90,400
1958	99,400	79,700	1,696	10,050	5,120	2	1,070	28,800	5,420	112,600
1959	135,900	42,400	3,397	11,030	12,910	5	2,140	14,690	5,510	112,900
1960	107,700	55,300	4,867	8,420	5,360	7	3,210	19,520	5,600	122,700
1961	121,700	51,100	6,561	13,630	5,090	10	4,280	17,740	5,700	106,700
1962	111,600	74,300	1,459	16,790	8,000	12	5,350	25,970	5,790	120,800
1963	92,500	70,900	258	15,020	13,400	14	6,430	24,450	5,880	116,600
1964	179,100	93,200	379	8,620	2,610	17	7,680	33,200	5,970	141,700
1965	153,300	53,200	5,117	6,540	4,660	19	8,900	18,200	6,070	119,700
1966	209,400	62,600	9,429	7,300	4,260	22	9,960	21,640	6,160	128,300
1967	193,900	52,700	11,543	7,510	5,200	24	11,490	17,980	6,250	122,200
1968	162,700	84,800	20,846	9,000	3,840	27	12,770	29,820	6,340	114,000
1969	123,800	196,400	21,095	9,310	2,980	29	13,640	71,060	6,430	134,000
1970	190,500	81,000	20,000	8,630	7,470	31	14,400	56,800	6,530	145,400
1971	179,800	107,900	21,154	7,060	3,610	34	15,880	3,100	6,540	141,600
1972	324,100	168,100	23,077	6,870	2,210	36	16,930	83,290	6,550	159,400
1973	221,200	142,900	25,070	5,800	1,950	39	17,310	28,250	6,560	212,100
1974	158,400	64,600	31,137	6,500	2,310	41	27,540	40,420	6,570	237,600
1975	125,800	32,400	24,574	5,100	1,330	43	29,110	1,260	6,580	100,200
1976	44,700	30,000	22,020	6,040	870	43	29,500	1,250	6,550	102,000
1977	47,900	57,300	16,046	4,860	8,790	44	26,110	1,250	6,520	113,900
1978	61,400	59,000	10,064	5,110	11,650	17,151	41,200	1,240	6,500	138,300
1979	80,900	34,000	9,083	4,970	19,520	21,366	39,350	1,240	6,470	141,200
1980	63,000	34,800	10,239	4,540	24,560	16,059	34,250	1,320	6,880	161,000
1981	84,100	67,400	19,670	4,700	20,600	22,511	50,570	1,390	7,280	241,500
1982	88,800	45,300	35,038	5,130	33,350	11,127	59,790	1,460	7,650	264,300
1983	119,100	14,200	42,984	5,510	43,520	19,467	68,040	1,530	8,010	284,400
1984	45,600	41,100	33,059	5,660	46,830	11,860	57,930	1,660	8,690	300,800
1985	51,800	56,500	19,956	6,020	29,210	5,389	36,850	1,800	9,420	186,400
1986	54,100	47,300	24,558	6,480	25,830	14,141	38,150	1,940	10,170	180,700
1987	54,700	28,000	20,759	6,840	16,620	11,559	30,430	2,100	10,960	201,600
1988	100,600	46,600	419	7,330	16,500	12,044	33,540	2,250	11,790	187,200
1989	110,900	41,900	290	8,370	22,770	14,697	32,440	2,420	12,650	203,400
1990	121,500	31,000	27,222	9,060	28,380	6,041	17,910	2,590	13,550	213,400
1991	80,800	44,800	24,085	9,800	26,130	17,591	13,360	2,770	14,480	217,500
1992	81,500	37,100	24,693	11,480	25,350	21,105	14,330	3,070	16,080	224,400
1993	89,000	32,900	13,910	14,720	12,970	15,077	7,750	3,400	17,770	177,400
1994	73,700	49,000	18,124	16,660	17,400	22,263	9,140	3,730	19,530	225,600
1995	64,600	68,000	16,535	23,770	16,600	17,864	7,820	4,080	21,370	208,600
1996	64,300	49,700	18,133	18,770	18,820	25,283	2,100	4,430	23,170	273,300
1997	90,300	54,900	19,258	18,030	19,780	22,233	1,790	4,790	25,050	272,200
1998	95,400	93,700	23,033	27,690	21,960	33,257	0	4,300	22,510	280,100
1999	100,300	108,300	25,528	26,990	22,950	37,282	2,680	4,250	22,230	279,600
2000	92,200	152,400	32,648	30,330	30,350	42,035	3,980	4,330	22,670	335,900
2001	87,400	106,700	35,985	36,320	32,180	46,655	4,210	4,320	22,620	420,500
2002	81,800	57,600	37,453	20,730	30,920	70,293	990	2,590	13,550	389,000
2003	52,600	68,200	27,775	29,480	26,120	48,220	3,880	2,660	13,910	316,800
2004	61,200	86,300	30,093	29,200	25,280	50,063	7,110	2,420	12,640	321,600
2005	59,500	83,600	17,326	36,720	14,470	39,099	80	3,330	17,440	340,600
2006	63,400	88,300	17,964	42,560	17,130	42,391	230	3,230	16,890	350,600
2007	57,000	111,000	27,329	39,320	23,850	40,751	330	21,990	12,900	433,800
2008	74,800	110,200	17,745	44,980	18,250	48,010	420	5,940	13,590	404,500
2009	34,300	118,800	15,782	56,720	16,060	40,445	510	3,090	16,170	381,400
2010	34,800	113,200	13,681	54,560	13,160	36,688	710	3,410	17,840	358,200