ISSN 1198-6727

Fisheries catch reconstructions: West Africa, Part II

Fisheries Centre Research Reports
2015 Volume 23 Number 3

ISSN 1198-6727

Fisheries Centre Research Reports

2015 Volume Number

Fisheries catch reconstructions: West Africa, Part II

Fisheries Centre, University of British Columbia, Canada

Edited by

Dyhia Belhabib and Daniel Pauly

Fisheries Centre Research Reports 23(3)
128 pages © published 2015 by

The Fisheries Centre,
University of British Columbia
2202 Main Mall
Vancouver, B.C., Canada, V6T 1Z4

ISSN 1198-6727

Fisheries Centre Research Reports 23(3)
2015

Edited by
Dyhia Belhabib and Daniel Pauly

CONTENT

A Research Report from the Fisheries Centre at UBC

Fisheries Centre Research Reports 23(3)
128 pages

FISHERIES CENTRE RESEARCH REPORTS ARE ABSTRACTED IN THE FAO AQUATIC SCIENCES AND FISHERIES ABSTRACTS (ASFA)
ISSN 1198-6727

Editors' Preface

This Fisheries Centre Research Report presents reconstruction of the marine fisheries catches of 10 West African countries. Despite their distinctive geographic, historic and cultural features, these countries share a common past in that they were all colonized in the first half of the 20th century, by a motley assemblage of European powers. These were, from North to South: Guinea-Bissau by Portugal; Côte d'Ivoire by France; Togo by Germany, then France; Benin by France; Nigeria by the United Kingdom; Cameroon by Germany, then France and the UK; Gabon (by France); Congo (Brazzaville) by France; Congo (ex-Zaire) by Belgium; and Angola by Portugal.

The development trajectory upon which these West African countries found themselves when they became independent was strongly shaped by this colonialism, which was harsh and difficult to get rid of - particularly for the ex-Portuguese colonies. Traces of colonialism are thus felt at all levels, notably where the struggle for political and economic 'agency' after formal independence plunged these countries into perennial political instability (e.g., Guinea Bissau), or long and murderous civil wars and/or wars over natural resources (e.g., Angola, Congo ex-Zaire). Some other countries transited smoothly into neo-colonies, where development and research institutions fail to play their nation-building role, as they serve mainly to maintain previous colonial ties. This has resulted, particularly in the former French colonies, in a general reluctance to transfer knowledge to local institutions. Neo-colonial ties are also illustrated through the profile of exploitation of natural resources, notably fish stocks, to which the former colonial powers often maintains a privileged access. As a result, West African countries did not develop truly national industrial fisheries, which would have formed an obstacle to the foreign industrial fleets that gradually invaded their Exclusive Economic Zones (EEZ). As a consequence, in most of their coastal areas, foreign vessels and the stock depletions they cause(d) hinder the development of the artisanal and local industrial fisheries.

This has led to growing tensions, which are only partly alleviated by foreign fleets being reflagged to the countries in whose waters they operate, and landing the low-value part of their catch locally.

The resolution of these tensions, increased by growing demands for fish by both consumers in Western Europe and East Asia, and the inhabitants of West African countries, will determine whether issues of food security will prevail over the power of international markets. This is the reason why we contrast, for each country, the catches of small-scale fisheries, which mostly enter the local economies, and those of industrial (mostly foreign) fisheries, which tend to hinder their development.

The Editors
Vancouver,
April 2015

Fisheries in troubled waters: A catch reconstruction for Guinea-Bissau, 1950-2010[1]

Dyhia Belhabib and Daniel Pauly

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.belhabib@fisheries.ubc.ca; d.pauly@fisheries.ubc.ca

Abstract

Marine fisheries catches of Guinea Bissau were reconstructed to account for sectors that have never been considered previously. Two main sectors were identified, the large-scale (industrial) sector, which includes foreign industrial catches, the catches of so-called 'domestic' vessels, and the discards they both generate. The other main sector consists of the small-scale fisheries, including subsistence, recreational and, most importantly, the artisanal sectors. Catches were estimated at 13 million tonnes between 1950 and 2010, of which 1.6 million tonnes were caught by domestic fisheries. This is much higher than the 207,000 tonnes supplied to the FAO on behalf of Guinea Bissau. A sharp decline in catches is noted over the last decade, probably due to over-exploitation which threatens the food security of the population of Guinea-Bissau. On the other hand, losses due to illegal fisheries are very high, and controlling illegal fishing will go a long way towards improving the status of the fisheries of, and seafood supply to, Guinea Bissau.

Introduction

Guinea Bissau is located at the edge of the Guinea Current Large Marine Ecosystem (LME) and the Canary Current LME between 11°52'N and 15°36'W. Thanks to coastal upwellings and extensive nutrients from river input, the extensive continental shelves off Guinea Bissau – one of the largest in West Africa – within an Exclusive Economic Zone of 106,000 km² (Figure 1) is home to an estimated one million tonnes of fisheries resources, of which, according to Anon. (2009), 350,000 to 500,000 tonnes could be extracted annually.

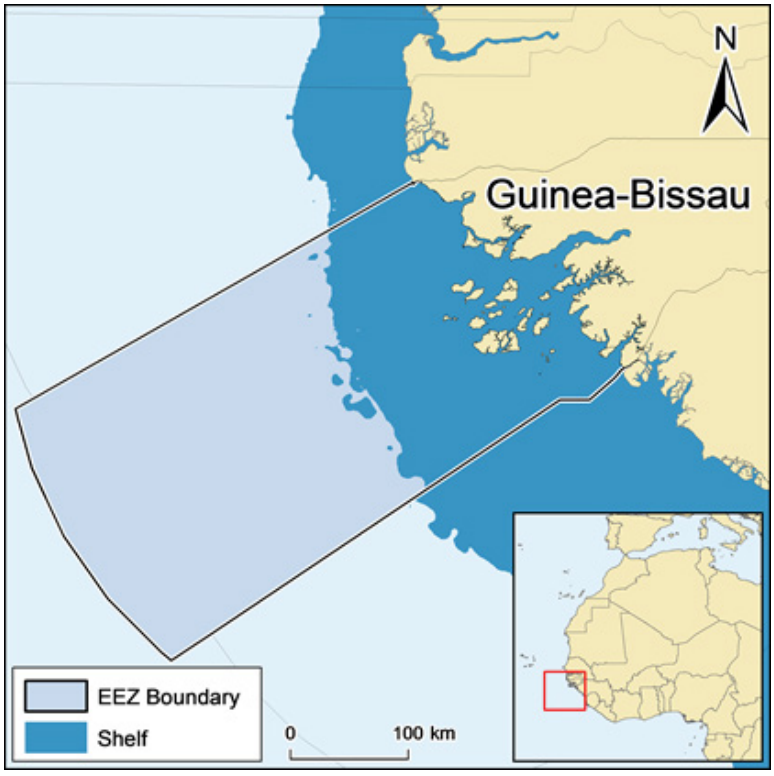

Figure 1. Map of Guinea-Bissau with its Exclusive Economic Zone (EEZ).

The history of Guinea Bissau could be described as eventful. Following independence from Portuguese colonial rule in 1974, after a long war of liberation, the first government was overthrown, and it was only twenty years later that the first democratic elections were held. A civil war occurred after a few years, in 1998, followed by a first coup d'état in 1999 and another in 2003. In 2004, the mutiny of a military faction again caused unrest, and eventually led, in 2009, to another coup d'état, after which a new government was elected. The sudden death of the newly elected president in 2012 led to another coup d'état. Unsurprisingly, these events stifled the development, economic and otherwise, of Guinea Bissau, now listed as one of the poorest countries in the world (www.worlbank.org); see also Fernandes (2012).

This, along with agricultural resources limited almost exclusively to cashew nuts, left fisheries as one of the few avenues for economy growth and food security (Dia and Bedingar 2001), although the people of Guinea Bissau were seen as "lazy fishers" in colonial times because they lacked a strong fishing tradition (Bordonaro 2006).

Yet, although the country's official statistics show that Guinea Bissau strongly depends on one export commodity – with 99% of the exports, Guinea Bissau is more dependent on cashew nuts than Nigeria is on oil – the fees from foreign fishing access agreements account for 40% of government revenues. This figure, which is among the highest in the world (Anon. 2013), demonstrates how important fishing is to the country's economy (Anon. 2010).

[1] Cite as: Belhabib, D. and Pauly, D. (2015) Fisheries in troubled waters: a catch reconstruction for Guinea-Bissau, 1950-2010. pp. 1-16. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

While legal foreign fishing started in 1978, with the first agreement signed with the former Soviet Union (DINÂMICA 2008), the first management plan ever to be implemented was only promulgated in 1996 (Anon. 2009). Other management plans dealt with capacity limits and total allowable catch, but given the very poor statistics and other constraints, the objectives of the plans were not met (Anon. 2009), repeating the unfortunate experience of fisheries development projects in the 1970s (Bordonaro 2006). Meanwhile, fish biomass in the Exclusive Economic Zone (EEZ) of Guinea-Bissau appears to have declined to at least 50% of its value in 1963, when the first acoustic survey was conducted, by '*la Rafale*' (Anon. 2009).

Official figures indicate that fisheries in Guinea Bissau consist of two main sectors. The artisanal sector relies on dugout canoes called *nhominkas*, of which about one quarter are motorized, and Senegalese-type pirogues of which 83% are motorized (Anon. 2009). The industrial sector consists of licensed foreign vessels, some of which are chartered and fly the flag of Guinea Bissau (Dia and Bedingar 2001). A thorough literature search revealed, however, the existence of other sectors, i.e., subsistence fishing, conducted mostly by women, and recreational fishing, popular among expatriates in Guinea-Bissau, and occurring in over twenty islands of the Bijago Archipelago. Finally, there are discards generated by the industrial fishing sector, and the illegal foreign fishing sector, as elsewhere in West Africa.

There is no regular monitoring system for fisheries in Guinea Bissau, but surveys were conducted by the Department of Fisheries in 1998, 2001 and 2003 (INS 2009), which included the number of pirogues and fishers, and estimates of the artisanal catch. Industrial catches are based on industry declarations and are grossly under-estimated (Dia and Bedingar 2001).

The present study presents the first exhaustive and comprehensive estimation of total marine and estuarine fisheries withdrawals from the waters of Guinea Bissau, including all the sectors alluded above for over six decades.

Methods

Artisanal fishing

In contrast to its neighbours, notably Senegal, Guinea Bissau does not have a long-standing fishing tradition (Campredon and Cuq 2001), and while in the past, *nhominkas* were commonly used, artisanal fishing by locals started only in the mid-1970s (Tvedten 1990; Chavance 2004). Thus, here the artisanal sector is divided into two categories, distinguished by the craft used, Senegalese *nhominka* pirogues and local dug-out canoes, or *pailão*, which have a capacity that is a third of that of the Senegalese *nhominka* pirogue (Tvedten 1990).

Table 1. Artisanal effort anchor points. Italics indicate interpolations and calculated values. (note that 100%–% *nhominka* effort =national effort)

Year	Total effort	Source	Nhominka		
			Effort	%	Source[c]
1950	195	Chavance (2004)	195	100	Assumption
1951	195	Chavance (2004)	195	100	
1952	215	Chavance (2004)	215	100	
1953	234	Chavance (2004)	234	100	
1954	254	Chavance (2004)	254	100	
1955	273	Chavance (2004)	273	100	
1956	313	Chavance (2004)	313	100	
1957	313	Chavance (2004)	313	100	
1958	313	Chavance (2004)	313	100	
1959	313	Chavance (2004)	313	100	
1960	313	Chavance (2004)	313	100	
1961	313	Chavance (2004)	313	100	
1962	352	Chavance (2004)	352	100	
1963	352	Chavance (2004)	352	100	
1964	352	Chavance (2004)	352	100	
1965	352	Chavance (2004)	352	100	
1966	391	Chavance (2004)	391	100	
1967	352	Chavance (2004)	352	100	
1968	430	Chavance (2004)	430	100	
1969	430	Chavance (2004)	430	100	
1970	391	Chavance (2004)	391	100	
1971	430	Chavance (2004)	430	100	
1972	469	Chavance (2004)	469	100	
1973	547	Chavance (2004)	547	100	
1974	547	Chavance (2004)	520	95	Tvedten (1990)[a]
1975	547	Chavance (2004)	493	90	Interpolation
1976	547	Chavance (2004)	467	85	Interpolation
1977	547	Chavance (2004)	440	80	Interpolation
1978	547	Chavance (2004)	413	75	Interpolation
1979	586	Chavance (2004)	414	71	Interpolation
1980	586	Chavance (2004)	385	66	Interpolation
1981	586	Chavance (2004)	356	61	Interpolation
1982	625	Chavance (2004)	349	56	Interpolation
1983	664	Chavance (2004)	339	51	Interpolation
1984	625	Chavance (2004)	288	46	Interpolation
1985	850	Weber and Durand (1986)	350	41	Interpolation
1986	664	Chavance (2004)	241	36	Interpolation
1987	703	Chavance (2004)	221	31	Interpolation
1988	1,094	Chavance (2004)	290	26	Interpolation
1989	1,445	Chavance (2004)	312	22	Interpolation
1990	1,836	Chavance (2004)	306	17	Tvedten (1990)[b]
1991	1,797	Chavance (2004)	307	17	Interpolation
1992	1,836	Chavance (2004)	322	18	Interpolation
1993	1,836	Chavance (2004)	330	18	Interpolation
1994	1,914	Chavance (2004)	352	18	Interpolation
1995	1,914	Chavance (2004)	361	19	Interpolation
1996	1,953	Chavance (2004)	376	19	Interpolation
1997	1,914	Chavance (2004)	377	20	Interpolation
1998	1,953	Chavance (2004)	393	20	Interpolation
1999	1,953	Chavance (2004)	402	21	Interpolation
2000	2,490	Dia and Bedingar (2001)	523	21	Interpolation
2001	2,379	Interpolation	512	21	Dia and Bedingar (2001)
2002	2,269	Interpolation	466	21	Interpolation
2003	2,158	Interpolation	425	20	Interpolation
2004	2,048	Interpolation	385	19	Interpolation
2005	1,937	Interpolation	347	18	Interpolation
2006	1,827	Interpolation	311	17	Interpolation
2007	1,716	Interpolation	277	16	Interpolation
2008	1,606	Interpolation	245	15	Interpolation
2009	1,495	Anon. (2009)	215	14	Anon. (2009)
2010	1,495	IRD (2011)	215	14%	IRD (2011)

a) artisanal national fishing started here;
b) *Nhominka* pirogues represented around 17% of the total in the area sampled;
c) the number of *pailão* canoes is obtained as the difference between the total effort and the *nhominka* effort.

Three major surveys were conducted in Guinea Bissau to estimate total artisanal effort for 1998, 2001 and 2003 (INS 2009), while the artisanal catch data included only the fish sold through the main market places up to the early 1990s, thus leaving a large part of catches unreported (Tvedten 1990; Kebe *et al.* 1993). Effort data were scattered across the literature and used unless contradictory; numbers that appeared too low or too high compared to the general average were not used. Total effort, i.e., the number of pirogues, was interpolated to complete the estimate for intervening years (Table 1). Using the few anchor points documenting the effort by category (Table 1), we estimated, and then interpolated the percentage of each category. We obtained the effort per category for the remaining years by multiplying the resulting rates (percentage of *nhominka* and *pailão* pirogues over the total) by the total number of pirogues (Table 1).

For 1990, Tvedten (1990) estimated a CPUE of 4.16 t·pirogue^{-1}·month^{-1} for 8 months fishing, i.e., 33.2 t·pirogue^{-1} for the *nhominka* pirogues. For 2001, *nhominka* CPUE was estimated at 150 kg·pirogue^{-1}·day^{-1} for 200 fishing days, i.e., 30 t·pirogue^{-1} (Dia and Bedingar 2001). Similarly, Tvedten (1990) documented a 1990 CPUE of 9.6 t·canoe^{-1} for the *pailão*. Assuming the same decreasing trend for CPUEs to 2001, we applied the percentage of change observed for the *nhominka* CPUE to the *pailão* CPUE, and estimated the latter at 8.67 t·canoe^{-1} for 2001. Given the clear signs of over-exploitation (Anon. 2009), we assumed the CPUE was a conservative 10% higher in 1950 compared to that in 1990. We interpolated to fill the gaps, and extrapolated the trend forwards from 2001 and 2010 to reflect on the decrease of CPUEs. The artisanal catch per category is the product of the effort and the CPUE of each category. Taxonomically, species caught by the artisanal sector are those used for local consumption. They include estuarine species like bonga shad (Dia and Bedingar 2001) and demersal species (Table 2).

Table 2. Species composition of the artisanal sector catches in Guinea Bissau. Numbers from 1993 to 2003 converted to percentages and then averaged (ECOST 2007).

Scientific name	Common name	Percentage
Ethmalosa fimbriata	Bonga shad	54
Argyrosomus regius	Meagre	17
Penaeidae	Shrimps	10
Cynoglossus spp.	Soles	9
Carlarius heudelotii	Smoothmouth sea catfish	6
Caranx spp.	Carangids (jacks)	2
Pomadasys jubelini	Sompat grunt	1

Migrant fisher catches

Migrant fishers are here defined as foreign artisanal fishers operating on pirogues and landing their catches outside Guinea Bissau. The most common case in Northwest Africa is the Senegalese migrant fishing activity. Their catches were estimated by Belhabib *et al.* (2014) as the product of the effort (number of Senegalese pirogues x number of trips) by the CPUE per trip. For purposes of the *Sea Around Us*, these Senegalese catches taken in Guinea Bissau waters are treated as 'industrial', despite being of 'semi-industrial' or even large 'artisanal' nature.

Subsistence fishing

Prior to the independence of Guinea Bissau from Portugal in 1974, fishing was primarily for subsistence (DINÂMICA 2008). Subsistence fishing is carried out by many people along Guinea Bissau's coastline (Anon. 2009). Some authors reported that most of the coastal population practices subsistence fishing (Said 2007); others allude to thousands of women and subsistence fishers operating in Guinea Bissau (Garcia 1992) and providing more animal protein than any other sectors for local consumption (Anon. 1994). This is compatible with the observation that almost all the animal protein consumed in Guinea Bissau comes from fish (Anon. 2009).

Table 3. Summary of the methods used to estimate subsistence catches in Guinea Bissau.

Year	Population	Consumption	kg·person^{-1}	Notes
1950	518,888	80% higher than in 1979	10.2	Part of the per capita consumption that comes from subsistence
1979	1,033,000	[28 x Population–Landings–(Imports +Exports)] x 0.4	6.8	Estimated as 40% of the supply from small scale
2000	1,241,000	30% increase due to the decrease in artisanal supply	8.9	During the civil war, pirogues have been stolen
2010	1,515,000	[26 x Population–Landings–(Imports +Exports)] x 0.35	11.0	No significant change in fish consumption since 2000

For 1979, Garcia (1992) reported a (survey-based) consumption rate of 28 kg·person^{-1}·year^{-1}, relying mostly on artisanal and subsistence catches, complemented by occasional imported fish. By multiplying the *per capita* fish consumption by the total population of 1,033,000 (Garcia 1992), we estimated a total fish supply of 28,924 t for 1979. We removed that part of industrial catches landed in Guinea, corresponding to 6,303 t·year^{-1} (COPACE 1981), the imports (caught outside Guinea Bissau) and exports (unavailable to fish consumers) of 260 t·year^{-1} and 4,435 t·year^{-1}, respectively. Therefore, we estimated a total small-scale catch of 17,661 t·year^{-1}. Given that a significant part of fish consumption is from subsistence fishing, women in estuarine waters, on beaches, or from household subsistence activities (Garcia 1992), we assumed 40% of the previous small-scale supply was generated by subsistence fishing, i.e., 7,064 t in 1979. We divided this catch by the total population to obtain a *per capita* consumption supported by subsistence fisheries (6.8 kg·person^{-1} for 1979). Given the evidence of a higher consumption rate from subsistence fishing in the past (before independence), when most catches were from the subsistence sector, we conservatively assumed this catch rate was 50% higher in 1950, i.e., 10.2 kg·person^{-1}, 30% higher in 2000 than in 1979 (8.9 kg·person^{-1}) due to the decline in artisanal supply during the civil war, and the shift of subsistence fishing to market artisanal fishing during the 1980s and 1990s (Tvedten 1990). Dia and Bedingar (2001) reported a consumption rate of 26 kg·person^{-1}·year^{-1} for the last decade. Thus, by following the same approach as for 1979, but assuming a lower rate for subsistence fishing (35%), and with landings of 6,650 t and imports and exports of 1,456 t and 4,526 t, respectively, we estimated the subsistence catch at 16,735 t for 2010. Table 3 summarizes the methods used. We then interpolated between these estimates to complete the time series.

Taxonomically, catches from mangrove-rich areas and/or the Bijagos Islands constitute a significant part of subsistence fisheries. Therein, molluscs gathered by women, mainly wild oysters (*Crassostrea gasar*), arks (*Anadara senilis*) and murex shells (*Murex* spp.) represent the dominant taxa, assumed here to make up 80% of the catch, divided evenly by the three above taxa. The remaining 20% are assumed to have the same taxonomic composition as the artisanal catches (see Table 2), with shrimp catches (2%) (Failler 2005) consisting mainly of white shrimp (*Farfantepenaeus notialis*; 73 %) and tiger shrimp (*Penaeus monodon*; 26%).

Recreational fishing

Sport fishing is apparently a notable segment of tourism in the Bijagos archipelago (Anon. 2010), but little information is available on the number of visitors to the archipelago, or the number of tourists using the services of fishing 'safaris'. Anon. (2010) reported the total number of international standard beds made available for tourists at 76 daily for 2001, each stay lasting 10 days at average, for 6 days fishing[2,3] during a tourist season lasting 6 months, which represents a potential of 1,387 tourists (Table 4). For 2012, the camps established for tourists in Guinea Bissau were visited by 1,200 persons, of which only 50% went fishing. There also were between 150 and 350 fishers (250 on average) for each of 4 other camps, and 500 visitors per year to a near-shore hotel, of which only a minority (20%) went fishing (Pierre Campredon, IUCN Guinea Bissau, pers. comm.). Therefore, the overall number of recreational fishers for 2012 was estimated as the sum of fishers for each camp and/or hotel, i.e., 1,500 fishers. We assumed that recreational fishing began in Guinea-Bissau in the late 1980s, with the emergence of the Bijagos archipelago as a tourist destination (CLPV 2012). Therefore, we assumed the number of recreational fishers was zero in 1988 and filled in the gaps with linear interpolations. We divided the resulting estimate by 2 for the years when there was a *coup d'état* and/or civil war, i.e., 1998, 2003 and 2009 (Table 4). To estimate the catch per fisher, we collected species and weight catch data from 30 *Youtube* videos documenting the experience of recreational fishers. From these, we could assemble catch data for 25 tourists and 17 fishing days, and estimated the catch per day per tourist by dividing the resulting total catch by the number of tourists and filtering out the released catch (representing 12%). The CPUE was then estimated at 18.7 kg·tourist^{-1}·day^{-1}. The annual catch is the product of the CPUE by the number of tourists per year by the number of days. We also derived the catch composition using visual recognition of species, matched with average weight data from FishBase (www.fishbase.org), which when multiplied by the number of individuals, allowed for the estimation of catch percentage per taxon (Table 5).

Table 4. Estimation of the number of recreational fishers in Guinea Bissau.

Year	Fishers	Event
1950-1988	0	See text
1989	105	
1990	210	
1991	316	
1992	421	
1993	526	
1994	631	First elections
1995	737	
1996	842	
1997	947	
1998	526	Civil war
1999	1,157	
2000	1,262	
2001	1,368	
2002	1,380	
2003	696	*Coup d'état* / Period of unrest
2004	1,404	Mutiny of military faction / Period of unrest
2005	1,416	
2006	1,428	
2007	1,440	
2008	1,452	
2009	732	*Coup d'*état
2010	1,476	
2011	1,488	
2012	1,500	Death of president / *Coup d'état*

Industrial fishing

Industrial fishing in Guinea Bissau is conducted by foreign vessels chartered or reflagged to Guinea Bissau, under private or partnership agreements. Although these vessels may fly the flag of Guinea Bissau, they are not considered domestic vessels (Gomes Barbosa 2009). Catches made under these agreement are generally landed elsewhere, notably in the Canary Islands (Spain) and Senegal (Anon. 2009) and are not reported to Guinea Bissau (COPACE 1981; Anon. 2010), nor anywhere else. Even the presence of observers onboard was revealed to be ineffective, including on EU vessels (Anon. 2009). Fleets (or flags) from many countries operated in the waters of Guinea Bissau, notably China, Korea, the EU, Russia, Cyprus, Senegal, Sierra Leone, Panama, Honduras, St Vincent and Grenadine, Morocco and Mauritania (DINÂMICA 2008). However, data on the vessel numbers and other information were scarce and often contradictory.

Table 5. Taxonomic breakdown for the recreational fishery in Guinea Bissau.

Common name	Scientific name	%
Barracudas	*Sphyraena barracuda*	33
Carangids or jacks	Carangidae	14
Cobia	*Rachycentron canadum*	19
Crevalle jack	*Caranx hippos*	9
Leerfish	*Lichia amia*	6
Marine fishes nei	-	5
Guinean snapper	*Lutjanus agennes*	3
Groupers	*Epinephelus* spp.	2
Meagre	*Argyrosomus regius*	2
Blackchin guitarfish	*Rhinobatos cemiculus*	2
Nurse shark	*Ginglymostoma cirratum*	2
Sparids	Sparidae	1
Sharks	*Selachimorpha* spp.	1
Requiem sharks	*Carcharhinus* spp.	1

As one source stated that industrial fishing in Guinea Bissau was initiated in the mid-1950s (Chavance 2004), we set its start in 1955, and performed a series of linear interpolations to complete the effort time series for each country (Table 6). We then estimated the CPUE from three different fleet categories when data were available. For

[2] http://www.fishipedia.com/destinations/guinea-bissau/ accessed on 17/05/2013
[3] http://www.worldsportfishing.com/by-destination/guinea-bissau/guinea-bissau-prices-details/ accessed on 17/05/2013

Table 6. Flag composition of the industrial fleet operating in Guinea Bissau, 1950-2010.

Year	Russia[d]	China	Motherships (Korea)	Europe	Korea	Japan	Africa	References
1950-1955	0	0	0	0	0	0	0	
1956	0	0	0	4	1	0	1	
1957	1	0	0	8	3	1	1	
1958	1	0	0	11	4	1	2	
1959	1	0	0	15	5	1	2	
1960	2	0	0	19	7	1	3	
1961	2	0	0	23	8	2	4	
1962	2	0	0	27	9	2	4	
1963	3	0	0	30	10	2	5	
1964	3	0	0	34	12	2	5	
1965	3	0	0	38	13	3	6	
1966	4	0	0	42	14	3	6	
1967	4	0	0	46	16	3	7	
1968	4	0	0	49	17	3	8	
1969	5	0	0	53	18	4	8	
1970	5	0	0	57	20	4	9	
1971	5	0	0	61	21	4	9	
1972	6	0	0	65	22	4	10	
1973	6	0	0	68	24	5	11	
1974	6	0	0	72	25	5	11	
1975	7	0	0	76	26	5	12	
1976	7	0	0	80	27	5	12	FAO (1979)
1977	27	0	0	94	29	6	13	
1978	48	0	0	107	30	6	13	
1979	68	0	0	121	31	6	13	Cissé (1980)
1980	68	0	0	123	30	6	13	a
1981	68	0	0	124	28	5	13	
1982	68	0	0	126	27	5	14	
1983	68	0	0	127	26	5	14	
1984	68	3	0	129	24	5	14	b
1985	68	6	0	130	23	4	14	Weber and Durand (1986)
1986	68	9	0	132	21	4	15	
1987	68	11	0	133	20	4	15	
1988	68	14	0	135	18	4	15	
1989	68	17	0	136	17	3	15	
1990	15	20	0	138	16	3	16	Kébé *et al.* (1993)
1991	15	17	0	123	21	3	24	Kébé *et al.* (1993)
1992	15	20	0	79	19	3	14	Kébé *et al.* (1993)
1993	14	20	0	81	20	2	13	
1994	14	21	0	83	22	2	12	
1995	13	21	0	85	24	2	10	
1996	13	21	0	88	25	2	9	Anon. (2009)
1997	12	21	0	90	27	2	7	Anon. (2009)[c]
1998	11	22	0	92	29	2	6	Anon. (2009)
1999	11	22	0	94	31	1	5	Anon. (2009)
2000	10	34	23	109	32	14	3	Anon. (2009), Anon. (2013)
2001	5	31	21	101	9	2	3	Anon. (2009), Dia and Bedingar (2001) and Anon. (2013)
2002	6	33	20	108	18	7	3	SOFRECO (2002) and Anon. (2013)
2003	6	32	18	102	22	9	4	Anon. (2013)
2004	5	30	17	91	17	6	4	Anon. (2010) and Anon. (2013)
2005	5	25	15	74	34	1	12	Anon. (2009), Gomes Barbosa (2009), Anon. (2013)
2006	5	34	13	49	20	3	15	Anon. (2010), Gomes Barbosa (2009), Anon. (2013)
2007	5	27	11	59	22	2	17	Anon. (2009), Gomes Barbosa (2009), Anon. (2013)
2008	4	19	8	84	12	4	3	Anon. (2009), Anon. (2013)
2009	4	19	6	56	10	4	0	Anon. (2009), Anon. (2013)
2010	4	19	4	56	10	4	0	Anon. (2013)

a) Europe started agreements with Guinea in 1980 (Anon. 2010);
b) China started fishing in 1984 (Anon. 2010);
c) In 1997, 202 licenses were issued for US $ 16 million; half the licenses went to EU countries, the other half to Senegal, Japan and chartered vessels (Dia and Bedingar 2001);
d) The former USSR was Russia (DINÂMICA 2008).

Russia, 68 pelagic trawlers (4,000 to 6,000 GRT) operating between 1981 and 1991 caught around 130,000 t·year^{-1} of small pelagics (DINÂMICA 2008), which corresponds to a CPUE of 1,912 t·vessel^{-1}·year^{-1}. Given the recent interest in the exploitation of small-pelagics by large trawlers in Guinea Bissau and the absence of evidence of small-pelagic over-exploitation, we assumed a constant CPUE over time between 1950 and 2010. For China, operating cephalopod, shrimps and fish trawlers (Anon. 2013), we estimated from data in Pauly *et al.* (2013), a CPUE of 1,200 t·vessel^{-1}·year^{-1} between 2000 and 2010. Based on the fact that these stocks are overexploited, we assumed the CPUE was 20% higher in 1950 compared to 2000 and then interpolated linearly. The use of motherships (which

take small pirogues and artisanal fishers onboard to fish for periods up to 3 months) by Korea in Guinea Bissau started in 2000. These 'reefers' were taking up to 40 pirogues of a Senegalese type (Anon. 2013), operating similarly to the artisanal *nhominka* fleet, with a CPUE of 30 t·pirogue^{-1}·year^{-1} in 2000. However, they were operating only half of the year in Guinea Bissau, i.e., 600 t·reefer^{-1}·year^{-1} when multiplied by the total number of pirogues onboard each vessel. The efficiency and production per boat taken onboard increased during the last decade at an alarming extent (Anon. 2013); therefore we assumed the CPUE increased by 20% in 2010 compared to the CPUE of 2000, i.e., 720 t·reefer^{-1}·year^{-1}. For the rest of the fleet, catches were estimated at 60,000 t·year^{-1} of mostly demersal species for a total fleet of 145 vessels (Dia and Bedingar 2001), i.e., a CPUE of 414 t·vessel^{-1} for 1996. Given the over-exploitation of demersal taxa, we assumed the CPUE was 20% higher in 1950 and 10% lower in 2010, and then interpolated linearly. We then multiplied the effort by the corresponding CPUE to estimate industrial catches per country from the waters of Guinea Bissau between 1950 and 2010.

To investigate the real ownership of vessels flying Belizean flags of convenience (FoC), we cross-checked the most recent position of vessels flying Belizean flag listed in www.grosstonnage.com (accessed on 15/05/2013) with the reflagging and ownership history, and inferred the real ownership. Of the total Belize vessels, 16% were Japanese, 6% Norwegian, 15% Spanish, 2% Swedish, 15% Russia, 12% Chinese, 8% Ghanaian, 6% Ukrainian, 2% Italian, and 15% from Iceland, the UK, the United States and others. Only 4% of these vessels, owned by Japanese firms, appear to be operating within the EEZ of Guinea Bissau[4]. We applied the same method to the flags of Panama, St Vincent and Grenadine, and Honduras, while vessels from Togo were assumed to be of Spanish ownership.[5] Twenty-one percent of Panama-flagged vessels were owned by South Korean companies and the remaining was divided between 20 other countries. Assuming that Panama-flagged vessels operating in Guinea Bissau were mostly of South Korean origin aligns well with similar conclusions for neighbouring Guinea (Belhabib *et al.* 2013). Following the same approach, vessels flagged to St Vincent and Grenadines were assigned predominantly to Russian (30%) and Spanish companies (26%), while Japan and Latvia and others represent 13%, 17% and 13% of the fleet flagged to St Vincent and Grenadine, respectively. However, most of the vessels flagged to Russia were based and/or operating in Namibia; thus, we concluded that vessels flagged to St Vincent and Grenadines operating in Guinea Bissau most likely had a Spanish ownership. For the Honduran flag, most of the fleet is owned by Taiwanese and Chinese companies (71%). Given the diplomatic relations and the history between Guinea Bissau and Taiwan in the past, we assumed that the fleet flying Honduran FoC and operating in Guinea Bissau was from Taiwan (Table 6).

To disaggregate catches onto taxa, we used the species disaggregation by Anon. (2009) and subdivided the major categories by the number of taxa represented in each category for African and FoC countries (Table 7). For example, the category 'mackerel, horse mackerel and sardinella' (48%) was divided into 3 taxa with 16% each. For Russia, we used the species disaggregation provided by ter Hofstede and Dickey-Collas (2006) and for Europe and Korea (i.e., mostly demersal fleets), we used the species disaggregation provided by Belhabib *et al.* (2013) for Guinea (Table 8). Similarly, we applied the species breakdown provided by Lesnoff *et al.* (1999) to Chinese catches.

Table 7. Species disaggregation for industrial catches (in %) by foreign catches in Guinea Bissau

English name	Scientific name	%
African and Flag of Convenience countries[a]		
Mackerel	*Scomber* spp.	16.00
Horse Mackerel	*Trachurus* spp.	16.00
Sardinella	*Sardinella* spp.	16.00
Breams	Sparidae	8.00
Sweetlips	Haemulidae	8.00
Croakers	Sciaenidae	8.00
Catfishes	Ariidae	8.00
Soles	*Cynoglossus* spp.	8.00
Cuttlefish	*Sepia* spp.	3.00
Octopus	*Octopus* spp.	3.00
Tuna	Thunninae	5.00
Shrimps	*Penaeus* spp.	1.00
Crabs	*Callinectes* spp.	1.00
EU and Korea[b]		
Clupeidae	Clupeidae	0.90
Croakers	Scianidae	40.00
Breams	Sparidae	6.20
Marine fishes nei	-	4.00
Sharks	Selachimorpha	1.70
Crabs	*Callinectes* spp.	2.60
Shrimps	*Penaeus* spp.	19.00
Cephalopods	Cephalopoda	25.00
Tuna	Thoninnae	0.30
Russia[c]		
Cunene horse mackerel	*Trachurus trecae*	3.70
Round sardinella	*Sardinella aurita*	63.80
Flat sardinella	*Sardinella maderensis*	4.60
Chub mackerel	*Scomber japonicus*	9.30
European pilchard	*Sardina pilchardus*	12.90
Marine fishes nei	-	5.70

[a] (Anon. 2009);
[b] (Belhabib *et al.* 2013);
[c] (ter Hofstede and Dickey-Collas 2006).

Illegal and unregulated fishing

The number of foreign fishing vessels operating without a license in Guinea Bissau was estimated at 33% of the industrial fleet for 2005 (Agnew *et al.* 2010), i.e., 47 vessels. For 2007, Anon. (2009) estimated the number of industrial vessels operating in Guinea Bissau at 30, a number that we assumed constant between 2007 and 2010. We interpolated the effort for 2006 (39 vessels), and estimated an industrial CPUE of 573 t·vessel^{-1} for 2005, 622 t·vessel^{-1} for 2006, 591 t·vessel^{-1} for 2007, 538 t·vessel^{-1} for 2008, 585 t·vessel^{-1} for 2009 and 580 t·vessel^{-1} for 2010, by dividing the total industrial catch (legal segment) by the total number of legal vessels per year. We then multiplied these CPUEs by the corresponding number of illegal vessels, and estimated illegal catches between 2005 and 2010. Then we interpolated from zero in 1955, when industrial fishing began in Guinea Bissau to the first estimate in 2005. Catches taken within the EEZ-equivalent

[4] Of the total, 21% were located in Dakhla (Western Sahara), 18% in Las Palmas, 14% in Conakry (Guinea), 7% in Côte d'Ivoire, 10% in Ghana, 4% in Cape Town (South Africa), 7% in Namibia, 4% in China, and 4% in Panama.
[5] http://www.stopillegalfishing.com/togo.php accessed on 13/06/2013

waters of Guinea Bissau prior to the EEZ declaration by Guinea Bissau in 1986 are considered 'unregulated' but legal. Unregulated activities are conducted mostly by China and Korea, and to a lesser extent by the EU (Italy) (Agnew *et al.* 2010; Anon. 2013). Therefore, we assumed that between 1955 and 1983, 100% of catches were Korean, and then between 2000 and 2010 Chinese and Korean catches each represented 45% of the illegal catch, and 10% were Italian. We interpolated these percentages and completed the time series. Thereafter, we multiplied these percentages by total estimated illegal and unregulated catches. We used the same species breakdown as for the legal component of the industrial fishery.

Discards

Discards of the trawl fishery in Guinea Bissau are estimated at 87% of the catch (Kelleher 2004), i.e., 6.7 times the landings for 2004, and between 60 and 62% for 2010 (Anon. 2009), i.e., 1.5 times the landings. While these estimates are strongly divergent, the over-exploitation of fish species might have led to keeping more by-catch, or selling the latter to artisanal fishers, a pattern observed also in Liberia, Senegal and Ghana. Therefore, we conservatively used the latter rates for the demersal fleets. We separated out demersal from pelagic catches to account for the demersal portion of the retained catch, then applied the latter discard rate to demersal catches between 1950 and 2010. The taxonomic composition of the discards was documented by Caverivière and Rabarison Andriamirado (1988) for the southern areas of Senegal as including bigeye grunt (*Brachydeuterus auritus*), lesser African threadfin (*Galeoides decadactylus*), Atlantic bumper (*Chloroscombrus chrysurus*), cuttlefish (*Sepia* spp.), largehead hairtail (*Trichiurus lepturus*), catfishes (*Arius* spp.), croakers (*Pseudotholithus* spp.), and Guinean tonguesole (*Cynoglossus monodi*). Given the similar profile of the fleets operating in both countries, we assumed this catch composition also applies to Guinea Bissau discards. We allocated an equal percentage to each of these taxa (i.e., 12.5%).

Table 7 cont: Species disaggregation for industrial catches (in %) by foreign catches in Guinea Bissau

China[d]		
Meagre	*Argyrosomus regius*	0.44
Catfishes	Ariidae	2.03
Triggerfish	*Balistes* spp.	0.10
Carangidae	Carangidae	0.94
Cephalopods	*Cephalopoda* spp.	18.93
Herrings	Clupeidae	4.75
Soles	*Cynoglossus* spp.	1.01
Breams	Sparidae	2.68
African sicklefish	*Drepane africana*	0.43
Sharks and rays	Elasmobranchii	0.30
West African ladyfish	*Elops lacerta*	0.11
Groupers	*Epinephelus* spp.	0.35
Bonga shad	*Ethmalosa fimbriata*	8.75
Southern pink shrimp	*Farfantepenaeus notialis*	0.05
Lesser African threadfin	*Galeoides decadactylus*	2.96
Sweetlips	Haemulidae	2.07
Snappers	*Lutjanus* spp.	0.32
Marine fishes nei	-	18.64
Hakes	*Merluccius* spp.	0.13
Marine crustaceans nei	-	0.05
Mullets	Mugilidae	0.41
Octopus	*Octopus* spp.	0.00
Shrimps	*Penaeus* spp.	0.02
West African goatfish	*Pseudupeneus prayensis*	0.31
Royal threadfin	*Pentanemus quinquarius*	0.18
Perch-like fish	Perciformes	0.55
Flatfishes	Pleuronectiformes	0.03
Giant African threadfin	*Polydactylus quadrifilis*	0.22
Grunts	*Pomadasys* spp.	0.71
Croakers	*Pseudotolithus* spp.	9.36
European pilchard	*Sardina pilchardus*	0.01
Sardinella	*Sardinella* spp.	2.61
Tuna	Scombridae	9.79
Cuttlefish	*Sepia* spp.	2.01
Catfishes	Siluriformes	1.37
Soles	*Solea* spp.	4.34
Barracudas	*Sphyraena* spp.	0.68
Torpedo (ray)	*Torpedo* spp.	0.50
Jack mackerels	*Trachurus* spp.	0.16
Largehead hairtail	*Trichiurus lepturus*	0.01
Drums	*Umbrina* spp.	0.11

[d] (Lesnoff *et al.* 1999).

Results

Artisanal

Total catches by the artisanal fleets operating in Guinea Bissau were estimated at 1.06 million t between 1950 and 2010. Catches increased from 7,100 t in 1950 to a peak of 33,000 t in 2000 (Figure 2). The small artisanal sector operating *nhominkas* between 1950 and the early 1970s caught between 7,100 t in 1950 and 14,000 t in 1970 (Figure 2), while catches by the Bissau-Guinean (*pailão*) fishers were estimated at 344,000 t between 1974, when they started, and 2010. Bissau-Guinean catches peaked at around 17,000 t in 2000, then declined rapidly to around 11,000 t in 2010 (Figure 2). Total catches landed in Guinea Bissau (alluded herein as catches by the two ethnic craft types, (*nhominka* and *pailão*) were lower than catch estimates by Failler (2005) between 1991 and 1997, with an average 25,600 t·year^{-1} estimated herein, compared to 34,000 t·year^{-1} estimated by that author (Figure 2). Reconstructed catches were thereafter similar to

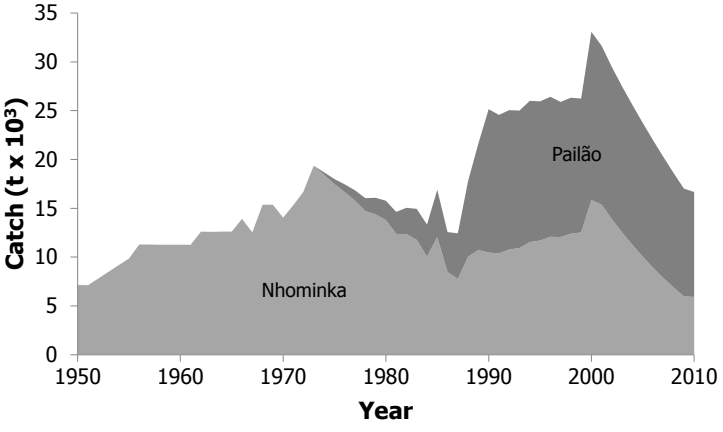

Figure 2. Reconstructed artisanal catches (*Nhominka* and *Pailão*) from Guinea Bissau, 1950-2010.

those provided by Gomes Barbosa (2009) and Anon. (2009) during the 1998-2009 time period (Figure 2). Artisanal catches landed in Guinea Bissau were dominated by bonga (*Ethmalosa fimbriata*; 50% of artisanal) as well as meagre (*Argyrosomus regius*; 16.3% of artisanal) and shrimp (*Penaeus*; 9.3% of artisanal).

Subsistence

Subsistence catches totalled 535,000 t between 1950 and 2010, which is the equivalent of around half of the artisanal reconstructed catches landed in Guinea Bissau. Subsistence catches increased from 6,400 t in 1950 to 7,000 t·year^{-1} in the late 1970s. Following the first development project, conducted in the Bijagos archipelago, subsistence catches increased at a fast pace, to around 11,000 t in 1999, after the 1998 civil war, which because of the decrease in artisanal catches, resulted in a further increase in subsistence catches to 16,700 t in 2010 (Figure 3). Taxonomically, the species the most commonly eaten in Guinea Bissau are reflected in the subsistence catch, i.e., mostly bivalvia (81%) and bonga (11%).

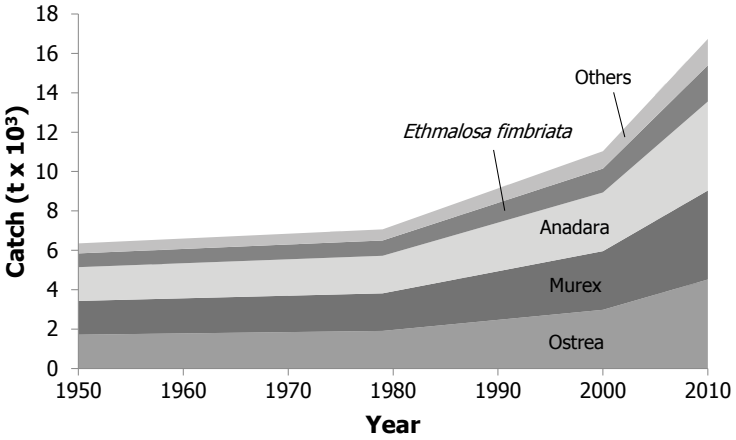

Figure 3. Reconstructed subsistence catches from Guinea Bissau, 1950-2010.

Recreational

Recreational catches increased overall since the introduction of sport fishing to Guinea-Bissau. Catches increased from zero in 1988 to a peak of 166 t in 2010 (Figure 4); catches frequently dropped, along with the numbers of recreational visitors to Guinea Bissau, due to political instability. Recreational catches, mostly from protected areas in the Bijagos archipelago, were dominated by carangids (i.e., jacks), cobias and barracudas (Figure 4).

Industrial

Industrial catches (all assigned to foreign beneficial ownership even if flying domestic flag) were estimated at 11.4 million t between 1950 and 2010, increasing from zero in 1955, when industrial fishing began in Guinea Bissau, to a peak of around 387,000 t in 1989 due to the operation of fleets from the former Soviet Union (Russia), then declined to 73,000 t in 2010.

Our estimates were 30% higher than the estimate by Kaczynski (2005) for 1981-1982, 52% lower than the estimate provided by Kaczynski (1989) for 1989, 41% higher than the estimates provided by Fond Africain de Developpement (2001) for 1995, around 30% higher than the estimate by Kaczynski and Djassi (2006) for 2003; 11% higher than the estimate by Gomes Barbosa (2009) for 2005. For 2009, our industrial reconstructed catch was similar to the estimate by Anon. (2009) with less than 1% difference (Figure 5a).

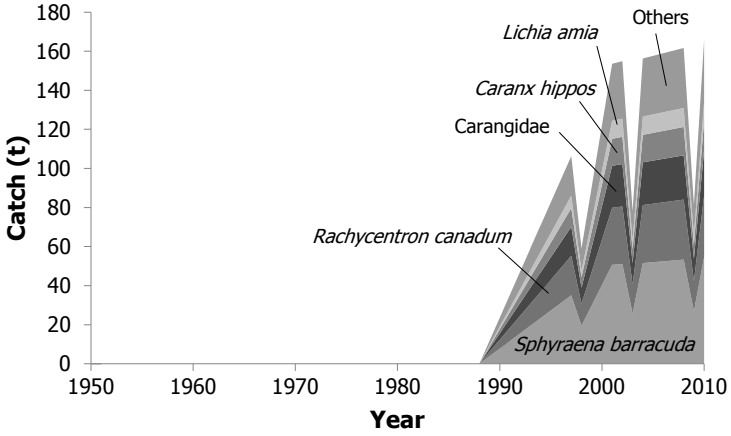

Figure 4. Reconstructed recreational catches from Guinea Bissau, 1950-2010.

Catches by the EU dominated in the past between 1955 and the late 1970s, then started decreasing, and were slowly compensated for by Chinese catches, while the Russian presence was overwhelming between the late 1970s and the early 1990s with 130,000 t·year^{-1} on average (Figure 5a). Similarly, given the Russian presence, catches were dominated by small-pelagic species, notably sardinella, pilchards and mackerels in the past (Figure 5b). Conversely, demersal species (cephalopods, shrimps and sciaenids) dominate in more recent years, due to the presence of demersal fleets from South Korea, China and the EU.

Migrant fishers catches increased from zero in 1970 to 37,000 t in 1995 (compared to 50,000 t estimated by Anon. 2010), then to 51,000 t in 2005 (compared to 111,000 (Gomes Barbosa 2009)), and finally to 58,000 t in 2010 (Figure 2). Our conservative approach uses migrant catch data mainly from surveys and documented effort, while the approach by the literature is doubtful, non-transparent and resulting catches are highly divergent. Catches by migrant fishers were dominated by smoothmouth sea catfish (*Carlarius heudelotii*), with around a third of catches, and soles (*Cynoglossus* spp.), with 20% of catches.

Illegal and unregulated catches

Illegal and unregulated catches were estimated at 786,000 tonnes between 1950 and 2010. These catches increased from zero in 1950 to a peak of 27,000 t in 2005 and declined thereafter with slightly better monitoring to around 18,000 t in 2010. Illegal catches are taken mostly by Chinese and Korean vessels, given the assumptions stated above (Figure 6).

Discards

Discards of both the legal and the illegal unregulated sectors were estimated at 5.2 million tonnes between 1950 and 2010, of which 3.9 million tonnes were generated by the legal industrial sector, about 3.7 times the artisanal domestic catch. Discards increased from zero in 1955 to a peak of 162,000 t in 2000 to decrease thereafter to around 82,000 t in 2010 (Figure 7).

Total catches

Reconstructed total catches from Guinea Bissau were estimated at 13.0 million tonnes between 1950 and 2010, of which 1.6 million tonnes were generated by Guinea Bissau as a flag state compared to 207,000 tonnes supplied to the FAO during the same time period, and 1.2 million tonnes by migrant fishers' landing catches in Senegal. Total removals from Guinea-Bissau waters increased from around 13,000 t in 1950 (exclusively by small-scale fisheries) to a first peak of 420,000 t in 1989 (Figure 8a), a second peak of 359,000 t in 2000 and then declined steadily to less than 189,000 t in 2010 (Figure 8a). Domestic catches increased slowly from 13,000 t in 1950 compared to 300 t supplied to the FAO, to a peak of 44,000 t in 2000 compared to 5,300 t supplied to the FAO, and then decreased to around 34,000 t in 2010 despite an increasing fishing effort (Figure 8b).

Taxonomically, domestic catches were dominated by bivalves and bonga shad and meagre catches caught mostly by the small-scale sectors. The contribution of fish species such as bonga shad, croakers, sciaenids, threadfins and meagre to the total catch, however, decreased over time and was compensated by increasing catches of bivalve (Figure 8c).

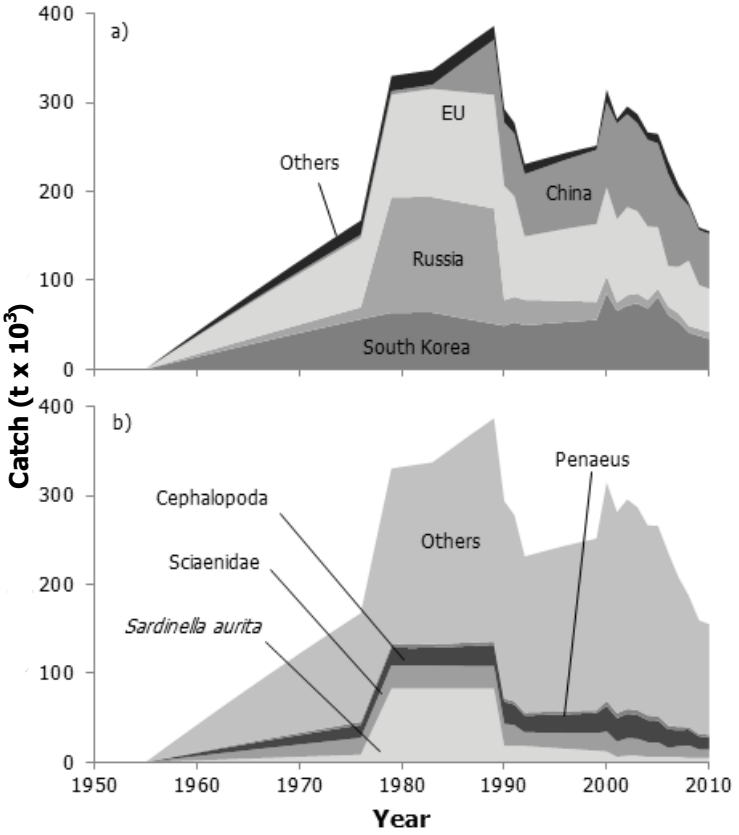

Figure 5. Reconstructed industrial catches from Guinea Bissau a) by country, "others" represent 9 additional countries and b) by taxon, 1950-2010.

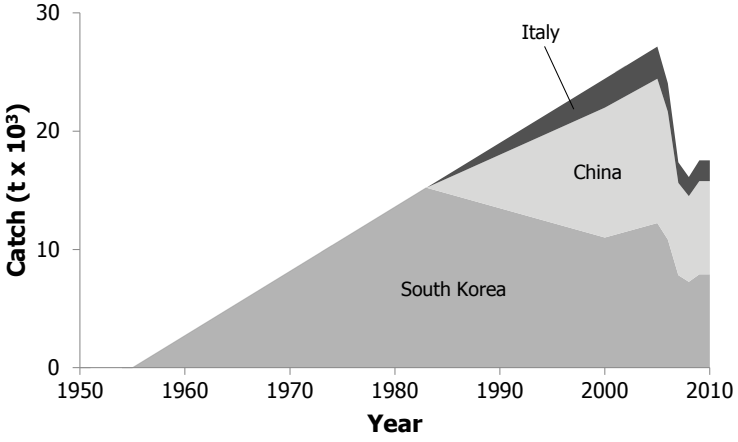

Figure 6. Reconstructed IUU catches from Guinea Bissau by country, 1950-2010.

Discussion

Total removals from Guinea Bissau's EEZ were reconstructed at 13.0 million tonnes between 1950 and 2010; of this, 1.6 million tonnes were domestic (small-scale) and around 503,000 tonnes caught by Guinea Bissau flagged industrial fleet. Catches by Guinea Bissau as a flag state were 10 times higher than the catch data supplied by the FAO (207,000 tonnes). The under-reporting component was significantly higher in the past, around 44 times as much as supplied to and by the FAO, and then decreased to be around 4 times.

Although, this work is the first comprehensive attempt to obtain a realistic estimate of removals from the EEZ of Guinea Bissau between 1950 and 2010, the literature contains earlier, but partial attempts. The estimates by Pires (1999), Failler (2005), IRD (2011) and Anon. (2009) for the artisanal sectors were either higher or similar to the reconstructed artisanal catch estimated herein. Estimates of industrial catches, on the other hand, were generally lower than those presented here and can probably be explained by differences in the methods and definitions previously used, which are often unclear.

Doubtful biomass estimates in Guinea Bissau's EEZ show a total of 479,000 t·year^{-1} of valuable species, of which 96,000 t·year^{-1} could be sustainably exploited (Gomes Barbosa 2009). However, such catch levels were reached, and then exceeded already in the 1970s, with catches reaching a maximum of around 400,000 t·year^{-1} in the late 1980s. This can mean two things; (1) maximum sustainable yield and the corresponding biomass are strongly under-estimated and/or (2) the fisheries of Guinea-Bissau are at the edge of collapse as catches are dangerously high. While these two possibilities are not exclusive, declining domestic catches for over a decade despite (or rather because of) an increasing effort are signs of over-exploitation. The other sign is the decrease in the industrial catch, which according to Anon. (2013), declined because of unsustainable exploitation. In all cases, this MSY level appears to be lower than the Total Allowable Catch of small pelagics set at 100,000 t·year^{-1} (Anon. 2009).

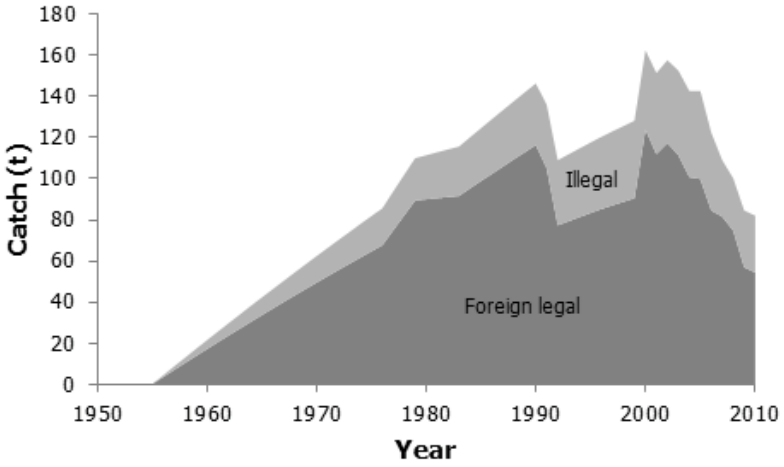

Figure 7. Reconstructed industrial discards from Guinea Bissau, 1950-2010.

Cyclic political crises in Guinea Bissau, and extreme poverty (Gomes Barbosa 2009) have certainly affected the behaviour of local populations and their interactions with fisheries resources. For example, catches declined significantly immediately after independence from Portugal, and after the 1998 civil-war. Catches increased rapidly with the introduction of motorized pirogues in the late 1980s, after which they stagnated, a sign of failing development projects. On the other hand, poor populations are driven to compensate for the decline in fish supply due to decreasing artisanal catches by increasing subsistence catches, thus illustrating the importance of fish in the national diet and food security of the country. Fisheries, indeed could play a major role in rebuilding the country's economy, now further distorted by drug-smuggling, as also manifested in the $100,000 cars that the first author recently saw in the capital city of a country that ranks last in human development index in the world.

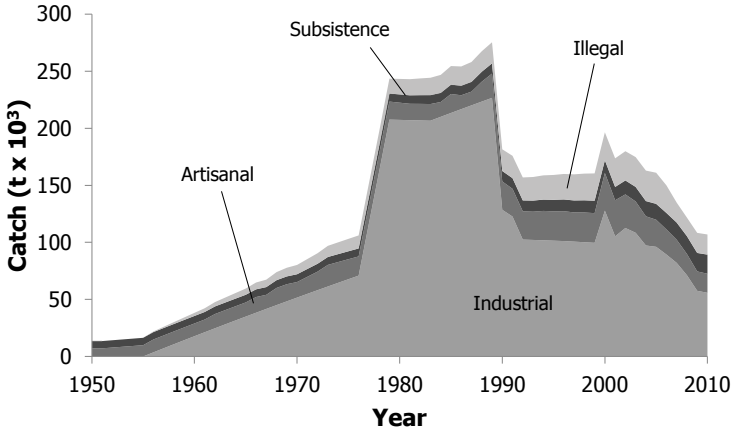

Figure 8. Reconstructed total catches (foreign and domestic) by sector from Guinea-Bissau EEZ, 1950-2010.

It is thus important to re-iterate the vital role that fisheries play in Guinea Bissau: of the 120,000 people employed by this sector, 52% are women, and all depend on fish as a source of revenue and basic food stable. Moreover, the value lost to Guinea Bissau because of illegal or undervalued foreign fishing (i.e., either by unlicensed vessels, or foreign vessels misreporting, or landing their catches elsewhere) and the discards they generate was here estimated at around $338 million US annually, which is almost as high as the value generated by drug smuggling in the country (Cornwell 2013). It is clear that Guinea Bissau does not have the capacity to process, or even land a large part of these catches *in-situ*. However, if an inferred 15% is used as the licence fee (Kaczynski 1989) for illegal vessels, this would mean that Guinea Bissau could capture as much as $15 million US annually. Furthermore, the value of catches by the foreign fleets ($238 million US) should be an incentive to impose sanctions on trans-shipping which is already illegal, enhance the level of monitoring, control and surveillance, and increase license fees.

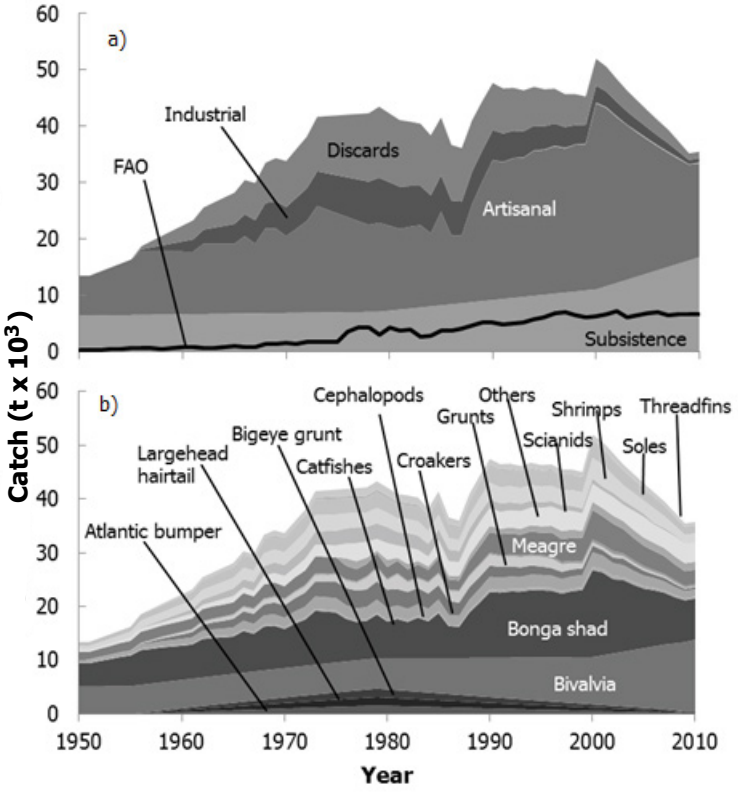

Figure 9. Reconstructed total catch by Guinea-Bissau within its EEZ by a) sector with landings reported to FAO overlaid as line graph and b) by taxonomic categories. 'Others' represent 34 additional taxonomic groups.

Acknowledgements

We thank the MAVA Foundation for supporting the project "*Sea Around Us* in West Africa, research and collaboration", and acknowledge the support of the *Sea Around Us*, a collaboration supported by the Pew Charitable Trusts and the Paul G. Allen Family Foundation. D.B. thanks the Centre for Applied Fisheries Research of Guinea Bissau (Centro de Investigação Pesqueira Aplicada–CIPA) for their hospitality and transparency during a short visit to Guinea Bissau.

References

Agnew D, Walmsley SF, Leotte F, Barnes C, White C and Good S (2010) West Africa regional fisheries project. Estimation of the cost of illegal fishing in West Africa. Final report, MRAG, London. 97 p.

Anon. (1994) Planificacao costeira da Guiné Bissau. Relatorio tecnico 1, UICN, Bissau. 150 p.

Anon. (2009) Contrat cadre pour la réalisation d'évaluations d'études d'impact et de suivi concernant les accords de partenariat dans le domaine de la pêche (FPA) conclus entre la Communauté européenne et les pays tiers. et plus généralement sur le volet externe de la Politique Commune de la Pêche : Ex-post evaluation of the current protocol to the Fisheries Partnership Agreement (FPA) between the European Union and Guinea Bissau and analysis of the impact of the future Protocol on sustainability. Final Report, Final report to the European Commission by Oceanic Dévelopement and MegaPesca Lda, Concarneau, France. 129 p.

Anon. (2010) Guinea-Bissau. Cashew and beyond: diversification through trade. Diagnostic trade integration study for the Enhanced Integrated Framework for Trade-related Technical Assistance. 150 p.

Anon. (2013) Industrial fisheries in Guinea Bissau. Transparent Sea. Available at: http://transparentsea.co/index.php?title=Guinea,Bissau:Industrial_fisheries [Accessed: 17/05/2013].

Belhabib D, Doumbouya A, Diallo I, Traoré S, Camara M, Camara OT, Copeland D, Gorez B, Harper S, Zeller D and Pauly D (2013) Guinean fisheries, past, present and 'future?' pp. 91-104 In Belhabib D, Zeller D, Harper S and Pauly D (eds.), Marine fisheries catches in West Africa, 1950-2010. Fisheries Centre Research Reports 20(3). Fisheries Centre, University of British Columbia, Canada.

Belhabib, D., Koutob, V., Sall, A., Lam, V.W.Y. and Pauly, D. 2014. Fisheries catch misreporting and its implications: The case of Senegal. Fisheries Research 151:1-11

Bordonaro LI (2006) Living at the margins. Youth and modernity in the Bijago Islands (Guinea-Bissau). Doctor in Anthropology thesis, University Institute for Social Sciences, Business Studies and Technologies, Department of Anthropology, Bissau. 275 p.

Campredon P and Cuq F (2001) Artisanal fishing and coastal conservation in West Africa. Journal of Coastal Conservation 7(2001): 91-100.

Cavérivière A and Rabarison Andriamirado GA (1988) Captures secondaires et rejets de la pêche crevettière à *Penaeus notialis* du Sénégal 111, CRODT, Dakar. 113 p.

Chavance P (2004) Towards reconstructing half a century of change in West African fisheries. pp. 113-132 In Chavance P, Ba M, Gascuel D, Vakily JM and Pauly D (eds.), Pêcheries maritimes, écosystèmes et societés en Afrique de l'ouest. Un demi-siècle de changement. Actes du symposium international Dakar — Sénégal — 24-28 juin 2002. Collection des Rapports de recherche halieutique ACP-UE 15 (1) Bruxelles.

Cissé M (1980) Quelques informations sur la pêche maritime: les rendements de chalutage et la communauté des sparides en Guinée. In FAO (ed.), Report of the second *ad hoc* working group on coastal demersal stocks from southern Mauritania to Liberia (CECAF statistical division 34.3.1 and 34.3.3. Interregional fisheries development and management programme–INT/79/01980 (23). FAO, Rome.

CLPV (2012) Guine Bissau. Archipel des Bijagos. CLPV, Paris. 3 p.

COPACE (1981) Rapport de la 5è session du Groupe de travail de l'évaluation des ressources, Dakar, Sénégal, 15-17 octobre 1980. FAO Rapport sur les pêches 244. Organisation des Nations Unies pour l'alimentation et l'agriculture, Comité des pêches pour l'Atlantique Centre-Est, Rome. 133 p.

Cornwell R (2013) West African leader linked to $400m cocaine smuggling ring. The Independent.

Dia AK and Bedingar T (2001) Fishing sector support project. Republic of Guinea Bissau. Appraisal Report, African Development Fund. 24 p.

DINÂMICA (2008) Projet pour le développement rationel et durable du secteur de la Pêche en Guineé-Bissau. Projet pour le développement rationnel et durable du secteur de la Pêche (INT/07/16M/SPA). DINÂMICA Gabinete de Estudos & stratégias Sar, Ministerio de Medio Ambiente y Medio Rural y Marino. 95 p.

ECOST (2007) Ecosystems, Societies, Consilience, Precautionary principle: Development of an assessment method of the societal cost for best fishing practices and efficient public policies. Guinea Bissau Case study presentation. INEP. 4 p.

Failler P (2005) Environment and Economics of Production and Transformation units. The case of the Farim/Cacheu, Mansoa and Geba/ Corubal Rivers. INEP, Bissau. 31 p.

FAO (1979) Project for the development of fisheries in the eastern central atlantic. CECAF/ECAF 78, CECAF, Rome. Available at: http://www.fao.org/docrep/003/X6585E/x6585e00.htm#Contents [Accessed: 17/06/2013].

Fernandes R (2012) Job satisfaction in the marine and estuarine fisheries of Guinea-Bissau. Social Indicators Research 109(1): 11-23.

Fond Africain de Développement (2001) Rapport d'évaluation. Projet d'appui au secteur de la pêche. République de Guinée Bissau.GUB/PAAF/2001/01, OCDW.

Garcia F (1992) O consumo de pescado na Guine-Bissau (Estimativa). FAO, Rome. 30 p.

Gomes Barbosa T (2009) Republique de Guinee Bissau. Secrétariat d'état à l'environnement et développement durable Bissau. 99 p.

INS (2009) Comptes nationaux de la Guinée-Bissau. Ministère de l'Économie, du Plan et de l'Intégration Régionale, Bissau. 44 p.

IRD (2011) Programme régional de renforcement de la collecte de données statistiques des pêches dans les états membres et de la création d'une base de données régionale de renforcement de collecte de données. Enquête cadre. GT n°1 -16 au 20 Mai 2011. IRD, Ouagadoudou. 32 p.

Kaczynski VM (1989) Foreign fishing fleets in the subSaharan West African EEZ. The coastal state perspective. Marine Policy 13(1): 2-15.

Kaczynski VM (2005) The IUU seafood trade in the West Africa region: impacts on environment and poverty. Overfishing, Global Trade, and Food Security Workshop. May 24, 2005. School of Marine Affairs, University of Washington, Dakar. 27 p.

Kaczynski VM and Djassi S (2006) Illegal activities in Marine Protected Areas: the case of Guinea-Bissau, West Africa. Jackson School of International Studies. University of Washington, Seattle, WA. 11 p.

Kebe M, Gallene J and Thiam D (1993) revista sectorial de pesca artesanal na Guine-Bissau. Relatório técnico 46, DIPA, Cotonou. 42 p.

Kelleher K (2004) Discards in the world's marine fisheries: an update. FAO Fisheries Technical Paper 470, FAO, Rome. 134 p.

Lesnoff M, Morize E and Traore S (1999) La pêcherie industrielle en Guinée: état et bilan des données disponibles. pp. 175-198 In Domain F, Chavance P and Diallo A (eds.), La pêche côtière en Guinée : ressources et exploitation. Insitut de recherche et de développement, Conakry.

Pauly D, Belhabib D, Blomeyer R, Cheung WWWL, Cisneros-Montemayor AM, Copeland D, Harper S, Lam VWY, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2013) China's distant-water fisheries in the 21st century. Fish and Fisheries doi: 10.1111/faf.12032.

Pires V (1999) ACP- EU training. Rapport national sur les pêches en Guinée–Bissau. Cours ACP-UE sur la gestion des pêches et de la biodiversité, Dakar, Sénégal, du 12 au 23 avril 1999. EU, Dakar. 5 p.

Said AR (2007) Analyse des acteurs de la zone côtière. Le cas de la Guinée-Bissau. Programme « Capacités et connaissances de la FIBA ». FIBA, Bissau. 56 p.

SOFRECO (2002) Diagnostic strategique de filière agro-industrielles. Rapport Guinée-Bissau.765, SOFRECO, Clichy, France. 15 p.

ter Hofstede R and Dickey-Collas M (2006) An investigation of seasonal and annual catches and discards of the Dutch pelagic freezer-trawlers in Mauritania, Northwest Africa. Fisheries Research 77(2): 184-191.

Tvedten I (1990) The difficult transition from subsistence to commercial fishing. The case of the Bijagos of Guinea-Bissau. MAST 3(1): 119-130.

Weber J and Durand H (1986) Le secteur des pêches dans les pays de l'Afrique. Réunion préparatoire pour l'Afrique en vue de la première Consultation sur l'industrie de la pêche, Dakar (Sénégal), 16-19 septembre 1986.86-60897, Organisation des nations unies pour le developpement industriel, Paris. 29 p.

Appendix Table A1. FAO landings vs. reconstructed total catch (in tonnes), and catch by sector for Guinea-Bissau, 1950-2010.

Year	FAO landings	Reconstructed total catch	Artisanal	Subsistence	Recreational
1950	300	13,500	7,120	6,350	0
1951	300	13,500	7,110	6,380	0
1952	300	14,200	7,800	6,400	0
1953	400	14,900	8,490	6,420	0
1954	400	15,600	9,170	6,450	0
1955	600	16,300	9,860	6,470	0
1956	581	17,800	11,270	6,500	0
1957	564	17,800	11,250	6,520	0
1958	456	17,800	11,220	6,550	0
1959	532	17,800	11,200	6,570	0
1960	603	17,800	11,170	6,600	0
1961	587	17,800	11,140	6,620	0
1962	500	19,200	12,500	6,650	0
1963	489	19,100	12,480	6,670	0
1964	637	19,100	12,450	6,700	0
1965	701	19,100	12,420	6,720	0
1966	547	20,500	13,760	6,740	0
1967	523	19,100	12,360	6,770	0
1968	1,000	21,900	15,060	6,790	0
1969	1,058	21,800	15,030	6,820	0
1970	1,087	20,500	13,630	6,840	0
1971	1,024	21,800	14,950	6,870	0
1972	1,252	23,200	16,270	6,890	0
1973	1,284	25,800	18,930	6,920	0
1974	1,256	25,200	18,230	6,940	0
1975	1,197	24,500	17,530	6,970	0
1976	2,920	23,800	16,830	6,990	0
1977	3,394	23,200	16,140	7,020	0
1978	2,785	22,500	15,450	7,040	0
1979	1,584	22,900	15,810	7,060	0
1980	3,023	22,300	15,080	7,250	0
1981	1,733	21,800	14,350	7,440	0
1982	2,684	22,200	14,530	7,630	0
1983	1,732	22,400	14,610	7,820	0
1984	1,494	21,000	12,990	8,010	0
1985	2,141	24,800	16,630	8,200	0
1986	2,167	20,600	12,180	8,390	0
1987	2,273	20,600	12,040	8,580	0
1988	2,897	26,200	17,420	8,770	0
1989	3,439	30,200	21,280	8,950	12
1990	3,526	34,000	24,850	9,140	24
1991	3,262	33,700	24,290	9,330	35
1992	3,424	34,300	24,780	9,520	47
1993	3,507	34,500	24,740	9,710	59
1994	4,097	35,700	25,750	9,900	71
1995	4,227	35,900	25,710	10,090	83
1996	4,883	36,500	26,180	10,280	95
1997	5,378	36,200	25,600	10,470	106
1998	5,096	36,800	26,070	10,650	59
1999	4,773	36,900	26,000	10,840	91
2000	5,338	44,200	33,070	11,030	122
2001	5,430	43,400	31,630	11,600	154
2002	6,262	41,800	29,450	12,170	155
2003	5,279	40,300	27,450	12,740	78
2004	5,740	39,000	25,560	13,310	156
2005	5,972	37,800	23,740	13,880	158
2006	5,510	36,600	21,970	14,450	159
2007	5,379	35,400	20,260	15,020	160
2008	5,806	34,400	18,610	15,590	162
2009	5,902	33,300	17,010	16,160	81
2010	5,907	33,600	16,670	16,730	166

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxonomic categories for Guinea-Bissau, 1950-2010. 'Others' contain 34 additional taxonomic groups.

Year	*Ethmalosa fimbriata*	*Argyrosomus regius*	*Murex* spp.	*Ostrea* spp.	*Anadara* spp.	Penaeidae	*Cynoglossus* spp.	Others
1950	4,540	1,400	1,710	1,710	1,710	712	641	1,030
1951	4,540	1,400	1,720	1,720	1,720	711	639	1,030
1952	4,910	1,520	1,730	1,730	1,730	780	702	1,100
1953	5,290	1,640	1,730	1,730	1,730	849	764	1,170
1954	5,660	1,750	1,740	1,740	1,740	917	826	1,240
1955	6,030	1,870	1,750	1,750	1,750	986	887	1,310
1956	6,800	2,110	1,750	1,750	1,750	1,127	1,015	1,450
1957	6,790	2,110	1,760	1,760	1,760	1,125	1,012	1,450
1958	6,780	2,100	1,770	1,770	1,770	1,122	1,010	1,450
1959	6,770	2,100	1,770	1,770	1,770	1,120	1,008	1,450
1960	6,760	2,100	1,780	1,780	1,780	1,117	1,005	1,450
1961	6,750	2,090	1,790	1,790	1,790	1,114	1,003	1,450
1962	7,480	2,330	1,790	1,790	1,790	1,250	1,125	1,580
1963	7,470	2,320	1,800	1,800	1,800	1,248	1,123	1,580
1964	7,460	2,320	1,810	1,810	1,810	1,245	1,120	1,580
1965	7,440	2,310	1,810	1,810	1,810	1,242	1,118	1,580
1966	8,170	2,540	1,820	1,820	1,820	1,376	1,238	1,710
1967	7,420	2,300	1,830	1,830	1,830	1,236	1,112	1,570
1968	8,880	2,760	1,830	1,830	1,830	1,506	1,356	1,850
1969	8,860	2,760	1,840	1,840	1,840	1,503	1,352	1,840
1970	8,110	2,520	1,850	1,850	1,850	1,363	1,227	1,710
1971	8,830	2,750	1,850	1,850	1,850	1,495	1,346	1,840
1972	9,540	2,970	1,860	1,860	1,860	1,627	1,464	1,970
1973	10,980	3,430	1,870	1,870	1,870	1,893	1,704	2,240
1974	10,610	3,310	1,870	1,870	1,870	1,823	1,641	2,170
1975	10,230	3,190	1,880	1,880	1,880	1,753	1,578	2,100
1976	9,070	2,820	1,890	1,890	1,890	1,537	1,383	3,350
1977	8,480	2,640	1,890	1,890	1,890	1,427	1,284	3,650
1978	8,250	2,560	1,900	1,900	1,900	1,384	1,246	3,340
1979	8,740	2,720	1,910	1,910	1,910	1,475	1,327	2,890
1980	8,040	2,500	1,960	1,960	1,960	1,341	1,207	3,370
1981	7,920	2,460	2,010	2,010	2,010	1,316	1,184	2,880
1982	7,800	2,420	2,060	2,060	2,060	1,289	1,160	3,310
1983	8,180	2,540	2,110	2,110	2,110	1,356	1,221	2,800
1984	7,440	2,310	2,160	2,160	2,160	1,215	1,094	2,450
1985	9,100	2,830	2,210	2,210	2,210	1,518	1,366	3,380
1986	6,730	2,080	2,260	2,260	2,260	1,075	968	2,920
1987	6,640	2,050	2,320	2,320	2,320	1,056	950	2,970
1988	9,420	2,920	2,370	2,370	2,370	1,566	1,409	3,770
1989	11,350	3,530	2,420	2,420	2,420	1,920	1,728	4,460
1990	13,280	4,140	2,470	2,470	2,470	2,274	2,046	4,860
1991	13,090	4,080	2,520	2,520	2,520	2,235	2,011	4,680
1992	13,330	4,150	2,570	2,570	2,570	2,274	2,047	4,830
1993	13,300	4,140	2,620	2,620	2,620	2,266	2,039	4,890
1994	13,590	4,520	2,670	2,670	2,670	2,315	2,083	5,190
1995	13,530	4,440	2,720	2,720	2,720	2,300	2,070	5,360
1996	13,500	4,690	2,770	2,770	2,770	2,291	2,062	5,680
1997	13,180	4,550	2,830	2,830	2,830	2,228	2,005	5,730
1998	13,540	4,650	2,880	2,880	2,880	2,291	2,062	5,610
1999	13,670	4,660	2,930	2,930	2,930	2,310	2,079	5,440
2000	17,470	5,850	2,980	2,980	2,980	3,011	2,710	6,250
2001	16,770	5,600	3,130	3,130	3,130	2,869	2,582	6,170
2002	15,290	5,490	3,290	3,290	3,290	2,584	2,325	6,220
2003	14,710	4,910	3,440	3,440	3,440	2,464	2,218	5,650
2004	13,740	4,580	3,590	3,590	3,590	2,272	2,045	5,620
2005	12,810	4,250	3,750	3,750	3,750	2,089	1,880	5,510
2006	11,910	3,950	3,900	3,900	3,900	1,912	1,721	5,380
2007	11,120	3,670	4,060	4,060	4,060	1,753	1,578	5,150
2008	10,180	3,380	4,210	4,210	4,210	1,567	1,410	5,210
2009	9,320	3,100	4,360	4,360	4,360	1,397	1,258	5,090
2010	9,200	3,060	4,520	4,520	4,520	1,363	1,227	5,170

Côte d'Ivoire: fisheries catch reconstruction, 1950-2010[1]

Dyhia Belhabib and Daniel Pauly

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.belhabib@fisheries.ubc.ca ; d.pauly@fisheries.ubc.ca

Abstract

Côte d'Ivoire had a strong industrial fleet both in capacity and reach. Despite the decline of the sector the country still held a particular place within West Africa due to its harbour and shore facilities, which have made Abidjan the second most important fishing port in the region. Its industrial fleets returned to the waters of Côte d'Ivoire after West African countries declared their EEZ which, along with large foreign fleets, contributed to over-exploiting the country's EEZ. Despite all this, official data suggest catches are increasing, which raises doubts as to their reliability. Moreover, official data do not include a large part of artisanal and subsistence catches, and also omits discards and a relatively important part of the industrial catch. They include, on the other hand, the foreign catches of '*faux poissons*' from the water of neighboring countries, but labeled domestic fish when landed in Côte d'Ivoire. To estimate total catches and improve their geographical resolution, we reconstructed them by sector, considering effort, catch per effort, and geographical distribution of catches and their taxonomic identity. Total catches from Côte d'Ivoire EEZ were estimated at 7.06 million t between 1950 and 2010, which is 2.67 times the data supplied to the FAO (this accounts for 374,200 t of '*faux poissons*' in the data supplied to FAO). Domestic catches declined, in contrast to the increase suggested by official data, but the catch of foreign fleets, mostly illegal, increased. Some social consequences for Côte d'Ivoire are outlined.

Introduction

Côte d'Ivoire, with Abidjan, the capital city at 6°51'N – 5°18'W, is located in Sub-Saharan West Africa (Figure 1). The country is bordered by Liberia and Guinea from the West, Mali and Burkina Faso from the North, Ghana from the East and the Atlantic Ocean from the South, making Côte d'Ivoire one of the largest coastal countries of the Gulf of Guinea. The location of Côte d'Ivoire within the Equatorial Savanah of Africa and the Gulf of Guinea is ideal as it experiences seasonal coastal upwelling, strong river flow and discharge into the ocean (Hardman-Mountford 2000). This has contributed to the development of a coffee and cocoa based economy in the 1960s and 1970s as well as further expansion of the fisheries sector.

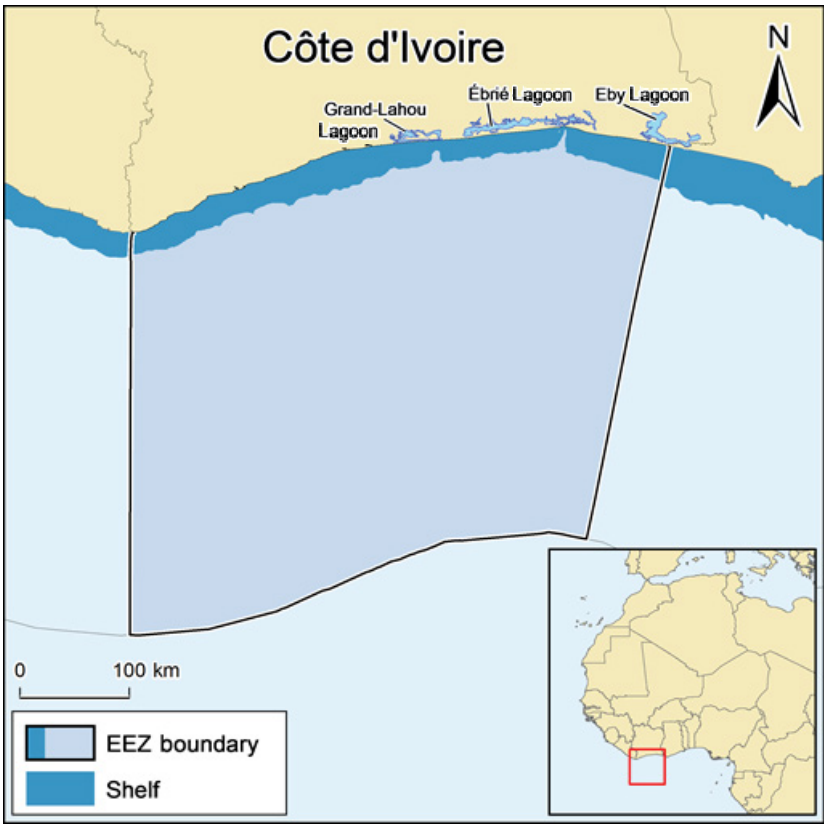

Figure 1. The Côte d'Ivoire's Exclusive Economic Zone (EEZ) and major coastal lagoons.

Côte d'Ivoire gained independence from France in 1960; it was, at the time, one of the most prosperous countries of West Africa. This prosperity increased under the rule of president Houphouët-Boigny; the French expatriate community doubled, the country became a world leader in cocoa and coffee production (third after Brazil and Columbia in coffee production), its exports flourished by 40% as its annual economic growth rate stabilized at 10% (the highest of African non-oil exporting countries).

The beginning of the economic collapse was triggered in combination of a drought that heavily impacted cocoa plantations and the world economic recession of 1980 that

[1] Cite as: Belhabib, D. and Pauly, D. (2015) Côte d'Ivoire: fisheries catch reconstruction, 1950-2010. pp. 17-36. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(#). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

affected cocoa prices on the other. This led to a social crisis that began with protests in 1990. With the death of the former president who had maintained ethnic accommodation, the pseudo-nationalist concept of 'Ivoirité' was used to discriminate against the many recent (and not-so-recent) immigrants to the country, who had arrived in colonial time to work in Côte d'Ivoire (Connelly *et al.* 2013). Along with the devaluation of the currency FCFA (Akindes 1995), the prohibition of immigrant southward migrations within Côte d'Ivoire, the vulnerability of the immigrants to forceful land grabs in the south (Dabalen *et al.* 2012) and a number of incidents against Ghanaians (Kouadio 2009) were all precursors to a number of coup attempts in the 1990s (Dabalen *et al.* 2012). These regional disparity were triggers that exploded into a civil war in 2002, ending the long-lived, peaceful political and productive economic conditions in Côte d'Ivoire (Morric MacLean 2004). The situation was exacerbated during the 2000s, as violence heightened (2000 and 2004-2006), instability grew in the North, 'foreigners' were increasingly expelled, 500,000 people were internally displaced and 224,000 became refugees (Global Witness 2007). Widespread chaos was fueled by the lack of wealth and income as the number of people living under the national poverty line increased from 10% in 1985 to 45% in 2008 (Global Witness 2007; Connolly *et al.* 2013).

Such historical events, social crisis and natural disasters had a large impact on Côte d'Ivoire fisheries. For example, during the 1958 conflicts between Côte d'Ivoire and Benin, fishers were driven to migrate westwards. Also, at the end of World War II, the number of Ghanaian fishers in Côte d'Ivoire had increased tremendously (Koffie-Bikpo 2012). Similarly, military-political crises since 2002 have negatively affected fisheries (Koffie-Bikpo 2012), e.g., Ghanaians small-scale fishers being expelled from Côte d'Ivoire. After independence (1960), the number of artisanal fishers along the coast increased, due in part to the development of infrastructure, notably a coastal road (Koffie-Bikpo 2012).

Fisheries are sensitive to the conditions surrounding them and have high importance for local populations, notably to food security. As poverty increases in the country, fisheries are an alternative way of sustaining livelihood after the collapse of the cocoa and coffee economies. Local populations began to view fisheries as a major asset, which leads them, in the absence of government structures, to manage fisheries on a local scale. For example, in 1982, all foreign artisanal fishers using mainly collective gear were denied access to Ebrié Lagoon, one of the largest lagoons of Côte d'Ivoire (Koffie-Bikpo 2012), leading to an increase in the number of fishers in the neighbouring lagoons (Figure 1).

Although these kind of initiatives are common in Côte d'Ivoire, the overexploited state of fisheries, as reported since the 1970s (Cormier 1983; Garcia and Poinsard 1989), raises questions regarding the management of fisheries and the reliability of reported data, particularly during this period of instability. Officially, there are two main sectors in Côte d'Ivoire, artisanal and industrial. The artisanal sector, operating canoes and pirogues, is difficult to assess given the disparity of landing sites, the consumption of a portion of the catches by fishers and their families and the variability of fishing techniques (Cormier 1983). Although field surveys started in 1978, they only included a part of the canoes and pirogues along the coast, and they omitted land-based fishing, resulting in all individual fishing techniques excluded from official reports (Ecoutin 1992). Furthermore, no artisanal fishery data have been collected in recent years and most data failed to reach FAO since 1990 (FAO 2008; 2009). On the other hand, the industrial fishery, which includes trawlers, small-pelagic seiners and tuna purse-seiners "is monitored at the Abidjan fishing port, every day. The entry and exit data of vessels and fish sales slips are collected every two weeks by the research team from the Oceanographic Research Centre (CRO) to estimate the effort and catch per species" (FAO 2009). The foreign industrial fishery of Côte d'Ivoire, however, still remains difficult to assess given their geographical and gear disparity, and few reliable data are made available through logbooks (EU 2008).

Given the importance of fisheries for the livelihood and food security of Ivoirians, and the current over-exploitation status of its marine fisheries resources, there is a serious need to address the lack of fisheries catch data in Côte d'Ivoire and analyze the impact of the different fisheries sectors.

Methods

Coastal population

Total population was obtained through the WorldBank database (data.worldbank.org [2014]) covering the period between 1960 and 2010 and from Populstat database (www.populstat.com [2014]) for 1950. These data were interpolated to obtain the total population of Côte d'Ivoire between 1950 and 2010. CIESIN (2012) provides coastal rural population estimates (here: rural population living within 10 km from the coast) for 1990, 2000 and 2010. This allowed for the estimation of the coastal population percentage over the total population for Côte d'Ivoire. This was found to be at 1.5% for 1990, 1.9% for 2000 and 2.1% for 2010, which suggest migrations towards the coast, notably to escape conflicts. We assumed this rate was constant between 1950 and 1990 and interpolated linearly to fill in the gaps (Figure 2).

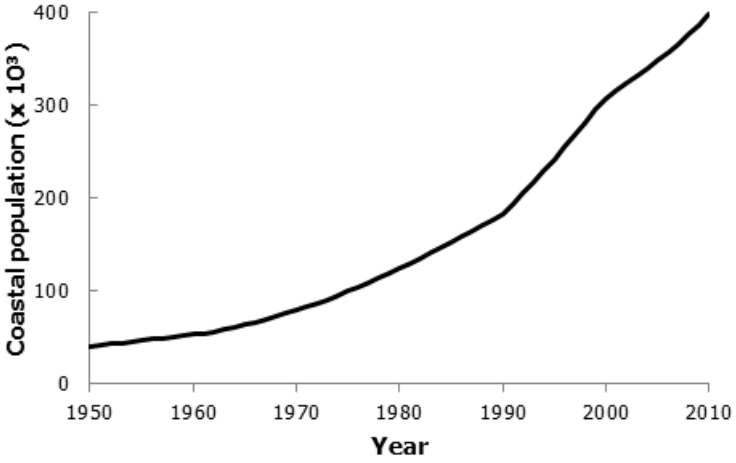

Figure 2. Coastal population in Côte d'Ivoire , 1950-2010.

Artisanal fisheries

Artisanal catches were mainly lagoon-based prior to 1960. After independence in 1960, the number of artisanal fishers along the coast increased due in part to the development of infrastructures, notably a coastal road (Koffie-Bikpo 2012) along with the opening of the Ebrié Lagoon and the industrialization of lagoon-based subsistence fisheries, which translated into the expansion of fishing grounds to the maritime coast of Côte d'Ivoire. In 1982, foreign artisanal fishers were denied access to Ebrié Lagoon and collective gears, e.g. beach seines, prohibited, which increased the number of foreign fishers in neighboring lagoons (Koffie-Bikpo 2012). Later on, artisanal fishing practiced initially by a few ethnic groups, e.g. Alladians, Keta, Apollonians, but mostly Fanti from Ghana (Delaunay 1992), was heavily impacted by socio-political conditions. For example, the number of Alladian fishers had declined from 1,100 in 1950 (Ecoutin 1992) to 18 in 2010 (Koffie-Bikpo 2012). Conflicts drove Ghanaian fishers to return to Ghana, and the number of Ghanaians in Côte d'Ivoire declined by 20% between 1988 and 1998 (Badmus 2009). Ghanaians had dominated the fishing industry previously(Kouadio 2009), so their departure significantly reduced the number of fishing vessels, similar to the situation in Liberia as a result of the civil war (Belhabib *et al.* 2013). These fishers, who initially migrated to Côte d'Ivoire because of a crisis in Nigeria and Ghana in the 1970s and 1980s, constituted around 17% of the coastal population of Côte d'Ivoire (Kouadio 2009). Understanding these dynamics and the historical evolution of artisanal fisheries is an important preliminary step to the reconstruction of catches, as it allows for critical evaluation (whether to accept or reject) of the estimates by literature, which appear to be either unreliable, under-estimated or obtained via ad hoc meetings (FAO 1981; FAO 1985, 2008a, 2009). Furthermore, artisanal catch and effort data reported by literature often do not reflect socio-demographic changes alluded above, e.g. the decline of lagoon catches by artisanal fishers in the 1970s, due to the development of industrial fisheries and the departure of Ghanaian (Koffie-Bikpo 2012), does not show in official data. Indeed, it is not even always clear whether these data include lagoon and freshwater catches. For instance, artisanal catches are marked as "unknown" in official reports of the CECAF Working Group between 1963 and 1975 and for 1979 for *Sardinella aurita*, and are unrealistically low between 1976 and 1978 (FAO 1981); this situation re-appears even after 1981 (Cury and Roy 1987).

Landing data were available for the 1980s and 1990s, when the CRO was at its peak activity, and collaborating with the French Institute of Research for Development (IRD); some data from the 2000s are also available. We reconstructed artisanal marine catches based on the number of artisanal boats along with the average catch per unit of effort (CPUE), and we interpolated between the available numbers of artisanal boats, which we used as anchor points (Table 1). We estimated CPUEs based on the catch estimate by Ecoutin (1992), i.e., 35,000 t for 1984, divided by the interpolated number of artisanal marine boats (1,632 boats), i.e., 21.4 t·boat^{-1}·year^{-1}. Considering over-exploitation (Cormier 1983; Garcia and Poinsard 1989) and the increasing capacity of artisanal fishing boats, we assumed the CPUE was 15% higher in 1950 and 15% lower in 2010. We interpolated between the CPUE estimates, then multiplied the latter by the effort to estimated artisanal marine catches between 1950 and 2010.

Table 1. Number of artisanal marine pirogues between 1950 and 2010 in Côte d'Ivoire.

Year	Boats	Source
1950	1,095	Postel (1950); Cormier (1983);
1956	1,000	Lassarat (1958);
1964	1,438	2,650 pirogues (Domingo 1980) of which 54% are marine (Gerlotto and Stequert 1978; Cormier 1983);
1969	1,500	Gerlotto and Stequert (1978); Cormier (1983);
1975	1,574	Total number of artisanal boats averaged between 3,000 and 2,800 (Cormier 1983; Collari 1986) of which 54% were marine (Gerlotto and Stequert 1978);
1979	1,638	Over 3,018 artisanal boats (Domingo 1980), 54% of which were marine (Gerlotto and Stequert 1978);
1996	1,618	A total of 3,326 artisanal boats (Kébé *et al.* 1997) of which 48% were active marine boats (Shep *et al.* 2011; Pérez-Ruzafa and Marcos 2012);
1999	1,860	We assumed an increase of 15% of the effort because of increased migrations towards the coast from the lagoons because of political events (new elections and violence);
2010	1,372	Shep *et al.* (2011)

Lagoon catches

There are three main lagoons in Côte d'Ivoire: Ebrié Lagoon, Aby Lagoon and Grand-Lahou Lagoon. In these lagoons, only collective fisheries are monitored, i.e., cast nets, traps and lines are not included in official statistics, the individual gear being more appropriate for subsistence purposes, and/or yielding a catch sold directly to restaurants (N'Goran 1990). Prior to 1975, lagoon catches were not taken into consideration in official statistics (Kébé *et al.* 1997). Post-1979, only partial catch and effort data are taken into consideration. If partial effort was examined then partial geographic areas and partial catches were assessed (Doucet *et al.* 1985).

Total lagoon landings were reported between 1994 and 1996 (Kébé *et al.* 1997) and were herein considered reliable. We estimated total lagoon catches for 2010 by multiplying the CPUE of 3,744 kg·fisher^{-1}·year^{-1} by the total number of fishers (2,898) provided by Pérez-Ruzafa and Marcos (2012) for 2010. To complete the time series, we estimated lagoon catches separately for the three lagoons mentioned above between 1950 and 1985 for Ebrié and Grand-Lahou Lagoons, 1950 and 1998 for Aby Lagoon, the sum of which represents the annual artisanal lagoon catch.

Landings for Ebrié Lagoon were estimated by Cormier (1983) and Ecoutin (1992) between 1975 and 1985 and were considered reliable. The number of fishers using collective gear in Ebrié Lagoon was estimated at 5,300 fishers for 1974 (Ecoutin 1992). Thus, we estimated the number of fishers for 1950 by adjusting the estimate to account

for changes in coastal population, i.e., we multiplied the number of fishers for 1974 by the rate of change in the coastal population between 1950 and 1975 (Figure 2). We then multiplied the number of fishers by the CPUE of 3,744 kg·fisher^{-1}·year^{-1} (Pérez-Ruzafa and Marcos 2012). This CPUE was kept constant between 1950 and 2010, assuming that villages adjusted for overexploitation due to non-selective fishing gear and mesh-size (Cormier 1983) by implementing new regulations such as the prohibition of collective fishing gears, e.g., in Ebrié Lagoon (Ecoutin 1983). We interpolated to complete the Ebrié Lagoon catch time series between 1950 and 1985.

Collective fishing catches for Aby Lagoon were estimated and reported by different literature sources for the period between 1979 and 1998 (Charles-Dominique *et al.* 1980; Bayley 1988; Konan 1998), which we considered reliable. The number of fishers was estimated at 1,654 for 1967 (Cormier 1983). We estimated the number of fishers for 1950 by following the same adjustment approach described above using coastal population estimates and estimated a number of 960 fishers for 1950. We multiplied the number of fishers for 1967 and 1950 by a CPUE of 3,744 kg·fisher^{-1}·year^{-1} (Pérez-Ruzafa and Marcos 2012), and then interpolated to complete the time series between 1950 and 1998.

Similarly, catches for Grand-Lahou Lagoon were estimated at 4,140 t for 1969 (Bayley 1988) and 1,500 t for 1985 (Ecoutin 1992). To estimate collective fishing catches in Grand-Lahou Lagoon in 1950, we estimated the number of fishers using the estimate provided for 1969 of 2,995 fishers (Bayley 1988), adjusted by the coastal population, i.e., 1,593 fishers in 1950. We then multiplied the latter by the CPUE provided by Pérez-Ruzafa and Marcos (2012), and interpolated to complete the catch time series for Grand-Lahou Lagoon between 1950 and 1985.

We calculated the annual sum of collective fishing catches for the three previous areas between 1950 and 1985 and then interpolated to the first estimate of total lagoon catches for 1994 (Kébé *et al.* 1997) and then between the estimate for 1996 (Kébé *et al.* 1997).

Subsistence catches

Subsistence fishing in Côte d'Ivoire plays a major role in providing local communities with fish, as households looked for other economic alternatives, particularly after the devaluation of the FCFA (Akindes 1995). Evidence from nearby Liberia and other countries have shown that when communities struggle for food in conflict situations, subsistence activities such as hunting and fishing increases (Foster *et al.* 2009). Although small-scale fishing in Côte d'Ivoire was mainly subsistence in the past, there has been a certain degree of 'professionalization' since the early 1980s, which translated into a decline of individual fishing aimed at subsistence in villages excluded from the ban of collective fishing techniques (Verdeaux 1981). When collective fishing techniques were banned, rather than an increase in the number of individual subsistence fishers, an expansion of the fishing areas occurred (Verdeaux 1981).

There are three main types of subsistence fishing in Côte d'Ivoire considered in the present study: (i) fishers using individual gear in the lagoons, (ii) artisanal fishers taking lagoon fish home, and (iii) artisanal fishers taking sea-caught fish home. Item (iii) was restricted in the past to a few species of sparids and groupers being kept for personal consumption, while sardines, sardinellas and sharks were sold in the markets (Koffie-Bikpo 2012). Lagoon fishers use several techniques, the most wide-spread one is the *acadja* method that is called "*tegbe*" or "*niapra*" in Côte d'Ivoire (Verdeaux 1981), in reference to the hollow wood used to form enclosures used to concentrate and catch fish (Durand *et al.* 1994). Although catches taken using these methods are occasionally sold, we consider it to belong to the subsistence sector.

Cast net fishing

We estimated subsistence catches using cast nets separately for Aby and Ebrié Lagoons, and other lagoons, as the product of the catch per fisher and the number of fishers.

The number of cast net fishers in Ebrié Lagoon were assessed by Durand *et al.* (1978) at 3,375 fishers (1972 and 1973), Laë (1992) at 2,160 fishers for 1977, and by Durand *et al.* (1994) at 2,970 fishers for 1994. To obtain the number of fishers for 1950, we multiplied the mean percentage of cast net fishers over the coastal population of 1973-1977 by the coastal population of 1950. This mean was assumed to be constant between 1950 and the 1970s because of the overall unchanged conditions in the lagoon. The number of cast net fishers increased to 2,932 fishers in 1986 (Laë 1992) partly due to the prohibition of collective fishing techniques in Ebrié Lagoon. To estimate the number of cast net fishers for 2010, we assumed the rate of individual fishers over the coastal population declined by 20% since 1994, due to migrations caused by conflicts, and estimated a percentage of 1% for 2010. By multiplying this percentage by the coastal population for 2010, we obtained the number of cast net fishers for 2010 at 4,118 and interpolated between the previous effort estimates. Catches were assessed for the period between 1975 and 1984 (Durand *et al.* 1978; Anon. 1981; Laë 1992), which allowed to estimate the CPUE by dividing these catch estimates by the previous effort. We obtained the CPUE for 1950 as the geometric mean of the 1975-1978 CPUEs, given the overall unchanged conditions. On the other hand, the overexploitation of certain species of small pelagic fishes in the early 1980s led to a decrease in CPUE, which remained constant since then, notably because of the high adaptability of fishing villages (e.g., the prohibition of collective fishing gear). Consequently, we obtained the CPUE for 2010 as the geometric mean of the 1982-1984 CPUEs. We interpolated between the CPUE anchor points and then multiplied CPUEs by effort estimates (Table 2).

Konan (1998) reported the number of cast net fishers at 2,160 for 1996 in Aby Lagoon, which represented 0.8% of the coastal population. Given the decline in subsistence fishing using individual gear in lagoons other than Ebrié Lagoon (Verdeaux 1981), we conservatively assumed that this percentage was 20% higher in 1950 (1 %) and 50% lower in 2010 (0.4%). We then multiplied these percentages by the coastal population of 1950 and 2010 respectively and obtained the number of fishers at 407 (1950) and 1,684 (2010). We interpolated linearly and multiplied the resulting effort by the CPUE estimated previously for Ebrié Lagoon (Table 2).

Table 2. Effort and CPUE anchor points for the estimation of cast net fishing in Ebrié and Aby Lagoons. Interpolations are indicated by italics.

	Ebrié Lagoon		Aby Lagoon		Estimated CPUE	
Year	Effort (fishers)	Source	Effort (fishers)	Source	CPUE kg·fisher^{-1}·year^{-1}	Source
1950	1,217	Assumed	407	Assumed	810	Geometric mean 1975-1978 CPUE
1973	3,375	Durand *et al.* (1978)	*1,284*	Interpolation	*642*	Interpolation
1974	3,375	Durand *et al.* (1978)	*1,322*	Interpolation	*635*	Interpolation
1975	*2,767*	Interpolation	*1,360*	Interpolation	627	Estimated catch (Durand *et al.* 1978) by interpolated effort
1976	2,159	Laë (1992)	*1,398*	Interpolation	*738*	Interpolation
1977	*2,237*	Interpolation	*1,436*	Interpolation	849	Estimated catch (Anon. 1981) by interpolated effort
1984	*2,777*	Interpolation	*1,703*	Interpolation	730	Estimated catch (Laë 1992) by interpolated effort
1986	2,932	Laë (1992)	*1,779*	Interpolation	*725*	Interpolation
1994	2,970	Durand *et al.* (1994)	*2,084*	Interpolation	*704*	Interpolation
1996	*3,113*	Interpolation	2,160	Konan 1998	*698*	Interpolation
2010	4,118	Assumed	1,684	Assumption	662	Geometric mean 1981-1983 CPUE

To estimate catches for the Grand-Lahou Lagoon, for which no data on the number of individual fishers were available, we first estimated the average annual catch by square km for the two previous lagoons and then multiplied these by the surface area of Grand-Lahou.

Personal consumption

Personal consumption was estimated by Konan (1998) at 3% of artisanal catches for 1996. We assumed that this consumption rate was constant between 1950 and 1996, and increased it by 30% in 2010, because of the increase of insecurity, which increased informal activities. We interpolated linearly to fill in the gap and then multiplied the resulting rates by the estimated artisanal marine and lagoon catches.

Tegbe (acadja) catches

The number of fishers using the *tegbe* technique was estimated to be the equivalent of 14% of fishers around lagoons (Verdeaux 1981). We first calculated the total number of fishers in Côte d'Ivoire's lagoons as the sum of previously estimated number of fishers in each lagoon between 1950 and 1969. We then interpolated to 10,000 fishers in 1979 (Cormier 1983) and to 2,898 fishers in 2010 (Pérez-Ruzafa and Marcos 2012). We interpolated to complete the time series of the total number of lagoon artisanal fishers, and then multiplied the resulting numbers by 14%. Assuming that a *tegbe* system has a similar production rate than an acadja system, i.e. around 3.4 t· acadja^{-1}· year^{-1} (Belhabib *et al.* 2015), we multiplied this rate by the number of fishers (each fishers conservatively using one *tegbe*) and estimated *tegbe* catches between 1950 and 2010. Total subsistence catches are calculated as the sum of the three components estimated above.

Industrial catches

Industrial fisheries in Côte d'Ivoire include a domestic component, which in turn, consists of three different categories: (i) tuna purse-seiners, (ii) shrimp and fish trawlers and small pelagic purse seiners, and (ii) foreign fleets including trawlers, but mostly tuna vessels. The Canal of Vridi, opened in 1950, links Ebrié Lagoon to the sea, and led to the creation of the port of Abidjan. By providing good berthing facilities, the new port fostered the development of an industrial fishery (Koffie-Bikpo 2012), which expanded its fishing grounds from the coast of Côte d'Ivoire in the early 1950s to Liberia and Ghana in the early 1960s, and later to Mauritania (Cormier 1983).

Trawl landings were recorded by observers since 1966, along with related data on fishing effort, fishing zones and ex-vessel prices. Data on fishing zones and the time spent at sea were collected from the skippers and boat owners themselves; when this information was lacking, it was inferred from vessels of the same size class (Fonteneau and Troadec 1969); such extrapolations were performed for around 30% of the trawl fleet between 1966 and 1978 (Fonteneau and Troadec 1969). Similarly, small-pelagic purse-seine catch data was collected since 1966 by the CRO, and then by the *Projet de Développement de la Pêche Pélagique Côtière*. Catch data from the marketing services of the landing site and from skippers were collected and then compared and harmonized, while trip durations were obtained using the time of exit and re-entry to port (Fonteneau and Marchal 1970). Between 40% to 50% of the fishing trips were covered by this process (Fonteneau and Marchal 1970). Tuna catch surveys began in the early 1990s by IRD and CRO, but they became reliable only since 1996, when their catches became assessed on deck (Romagny *et al.* 2000).

Over 100,000 t of fish are transhipped annually through Abidjan port, which make catch recording very difficult, despite these efforts, the quantities and/or the geographical provenance of these catches is often not available (Chavance *et al.* 2011). Rather, the spatial resolution and the accuracy of such data are based on the good will and honesty of skippers. Herein, we reconstruct the catches taken within the Exclusive Economic Zone (EEZ) of Côte d'Ivoire, and distinguish them from catches taken outside, but landed/transhipped through Abidjan, in an effort to retrace the history of the domestic fisheries of Côte d'Ivoire and understand the reasons behind their collapse.

Domestic fisheries

Domestic catches are defined as catches taken by vessels flagged to Côte d'Ivoire and landed in Côte d'Ivoire. These could be caught within or outside the country's EEZ.

Trawl catches

Total trawl fish landings by the domestic fleet, taken within or outside the EEZ, were reported by Lassarat (1958) for 1955, Cavérivière (1979) between 1955 and 1968, Cormier (1983); Rey (1993); Kébé *et al.* (1997) between 1969 and 1995, Coulibaly (2010) between 2000 and 2005 and by Bikbo-Koffie (2010) between 2006 and 2008. On the other hand, landings taken from within Côte d'Ivoire's EEZ were reported by Cavérivière (1979) and Ménard *et al.* (2001) between 1955 and 1997. Landings as reported by Cavérivière (1979) under-estimated catches as suggested by Lassarat (1957, 1958). Therefore, we reconstructed catches based on the reported effort and CPUE, then compared these to the landings reported in the literature.

The CPUE of trawlers was estimated at 22.36 $t \cdot day^{-1}$ for 4 units operating 25 fishing days a month (Lassarat 1958), which translates into a CPUE of 1,677 $t \cdot trawler^{-1} \cdot year^{-1}$ for 1956. The author observed a lower CPUE by experimental trawlers the previous year, i.e., 443 $t \cdot trawler^{-1} \cdot year^{-1}$. Therefore, we calculated the geometric mean of the CPUEs at 1,060 $t \cdot trawler^{-1} \cdot day^{-1}$ and assumed the latter was constant between 1950 and 1956. Given the over-exploitation pattern observed in the mid-1980s (Cormier 1983), which included a growing vessel capacity and the retaining of more bycatch species, we assumed the CPUE declined by 5% between 1956 and 1984, i.e., to 1,007 $t \cdot trawler^{-1} \cdot year^{-1}$. Similarly for 2010, we assumed a decline of 15% and estimated a CPUE of 856 $t \cdot trawler^{-1} \cdot year^{-1}$, and interpolated to fill in the gaps.

The total number of fish trawlers, reported through the 1950-2010 time period (Lassarat 1958; Cormier 1983; Rey 1993; Kébé *et al.* 1997; Bikbo-Koffie 2010), was completed by a series of interpolations. The number of demersal fish trawlers and their respective GRT was reported by Cavérivière (1979) for the period between 1950 and 1980, when vessels under 300 GRT fished exclusively in Côte d'Ivoire, while trawlers with a GRT between 300 and 600 GRT fished mostly (here assumed to be 70% of the time) in Côte d'Ivoire and at a lesser extent in Sierra Leone, Liberia and Ghana (30%); finally, trawlers of GRT 600 GRT fished between Sierra Leone and Mauritania (Cavérivière 1979). We estimated the number of vessels operating within Côte d'Ivoire between 1950 and 1980 as the total number of vessels under 300 GRT to which are added 70% of the vessels between 300 and 600 GRT. We calculated the percentage of these two categories over the total for 1980, last data point for the GRT categories, and then multiplied this percentage by the total number of fish trawler for the subsequent years, 100% of the first category (300 GRT) and 70% of the second category operated within the Côte d'Ivoire EEZ. We thus obtained the number of vessels operating in Sierra Leone, Liberia and Ghana as 30% of the second category, and obtained the number of vessels operating from Sierra Leone to Mauritania (GRT600) as the difference between the total number of vessels and the sum of the two first GRT categories. To estimate total catches by these two categories, we first estimated the CPUE per GRT by dividing the CPUE per trawler of the first category by 300 GRT between 1950 and 2010 and then multiplied the resulting CPUE ($t \cdot trawler^{-1} \cdot GRT \cdot year^{-1}$) by 450 (average GRT of the second category), and 600 GRT for the third category. Finally, we multiplied the resulting CPUEs for both categories by their respective effort. We assumed catches by vessels over 300 GRT from outside Côte d'Ivoire started declining since 1984 to zero in 1990, given no indication of access agreements between the Côte d'Ivoire and any other country in Africa, and their declaration of EEZs. [Ghana's distant-water fleet suffered a similar fate (Atta-Mills *et al.* 2004)]. The remaining catch was allocated to the Côte d'Ivoire's EEZ.

While Cavérivière (1979) refers to landings from Sierra Leone, Liberia and Ghana for 30% of the vessels ranging between 300 and 600 GRT, the same author, in 1978 reported that landings were taken, between 1966 and 1976, only in Ghanaian and Liberian waters, while Fonteneau and Troadec (1969) reported no landings from Liberia. We calculated the percentage of landings taken from Sierra Leone and Ghana by dividing the landings taken from the EEZ-equivalent waters of each country by the total of the two between 1966 and 1976 and assumed these percentages were constant from then to 1990 (when catches from outside Côte d'Ivoire were zero), and backwards from 1960 to 1966.

Catches taken between Sierra Leone and Mauritania, i.e., mainly from Guinea and Senegal (Cavérivière and Marcille 1978), from Guinea Bissau (Cavérivière 1978), and from Gambia and Angola, were only mentioned casually in the 1960s (Fonteneau and Troadec 1969) and made up only 3% of the Ivorian catch in 1969. They were not included in the present study. However, we allocated a third of the catch taken from outside Côte d'Ivoire by trawlers of over 600 GRT to each country's EEZ (Guinea, Senegal and Guinea Bissau).

Shrimp trawl catches

Shrimp trawl catches were reported from 1969, when the fishery began to 1981, when the fishery collapsed (Cormier 1983; Rey 1993; Kébé *et al.* 1997). These catches are taken from both Côte d'Ivoire and Nigeria, but catches post-1981, after the economic collapse of Côte d'Ivoire's industrial fishery in 1978-1979 (Garcia and Poinsard 1989), were likely from Nigeria (FAO 1985). We assumed these catches were reliable given the monitoring system used then, and divided them by the number of shrimp trawl vessels obtained from various sources (Cormier 1983; Rey 1993) to obtain a series of CPUEs averaging at 47 t· vessel^{-1}· year^{-1}. We assumed that this CPUE was constant later on, as vessels adapted to decreasing catches (and ultimately to the collapse of the fishery in Côte d'Ivoire) by fishing in Nigerian waters. We then multiplied this CPUE by the reported number of vessels between 1982 and 2010 (Kébé *et al.* 1997; Bikbo-Koffie 2010). The number of vessels operating in Nigeria and the number of fishing days between 1970 and 1975 were reported by FAO (1985) along with the catch for 1973 which allowed to estimate the CPUE at 0.27 t·vessel^{-1}· day^{-1}. Assuming a constant CPUE from 1970 to 1975, we estimated catches taken from Nigerian waters for the same time period. We also considered that all catches after 1981 were taken from Nigeria (FAO 1985). The difference between catches taken from Nigeria and total catches represents the catch taken by domestic shrimp trawlers from Côte d'Ivoire.

Industrial small-pelagic catches

Although the number of small pelagic purse-seiners was documented throughout the 1950-2010 time period (Lassarat 1958; Bouberi 1981; Cormier 1983; Rey 1993; Kébé *et al.* 1997; Bikbo-Koffie 2010), along with catches for the periods 1967-1995 and 2000-2008 (Cormier 1983; Cury and Roy 1987; Rey 1993; Kébé *et al.* 1997; FAO 2009; Bikbo-Koffie 2010; Coulibaly 2010), little is known on the geographical distribution of catches beyond the EEZ of Côte d'Ivoire . The few data points illustrating the origin of the purse-seine catch taken from Côte d'Ivoire, Sierra Leone, Senegal, Ghana and Congo covered only years within the period between 1966 and 1979 (Hem 1976; Cavérivière and Marcille 1978; Bouberi 1981, 1984a, 1984b). To complete the time series of total small pelagic catches, i.e. taken within and outside Côte d'Ivoire EEZ, we estimated the average CPUE for the early 1980s based on the effort and the catch documented by Bouberi (1981, 1984b) at 1,345 t· vessel^{-1}· year^{-1}. We assumed the CPUE for 1950 was 30% higher (1,748 t· vessel^{-1}· year^{-1}), thus reflecting in one hand the impact of the collapse of the sardinella fishery of the 1970s and the quota limitations imposed by fishers syndicates in the 1980s (Bouberi 1984a). We multiplied this CPUE by the number of vessels for 1950 and obtained a catch of 3,497 t. Given the decline in CPUE and number of vessels in the 2000s (Pigeaud 2012), we assumed catches declined by 5% between 2008 and 2010. We then interpolated linearly to fill in the gaps between 1950 and 2010.

We interpolated catch estimates from zero in 1950 to the first anchor point available for catches taken from Sierra Leone (1967), Senegal (1975), Ghana (1966) and Congo (1974) and then from the last anchor point for Sierra Leone and Senegal (1979), Ghana (1978) and Congo (1975) to zero in 2010 for Sierra Leone and Senegal, and zero in 1979 for Ghana and Congo. The difference between total catches taken within and outside Côte d'Ivoire EEZ and the sum of catches taken from Sierra Leone, Senegal, Ghana and Congo, represents the domestic small pelagic catches taken within Côte d'Ivoire EEZ.

Industrial tuna catches

Tuna fisheries surveying for foreign vessels began only in 1990 and became efficient in 1996 (Romagny *et al.* 2000). On the other hand, literature review showed domestic tuna catches as early as 1957 when experimental tuna fishing began (Lassarat 1958), for 1965 (Ecoutin 1992) and between 1970 and 1986 (Cavérivière and Marcille 1978; Cormier 1983; Ecoutin 1992; Rey 1993; Kébé *et al.* 1997), when domestic tuna seiners stopped operating in Côte d'Ivoire (Rey 1993). These catches included only main species of skipjack (*Katsuwonus pelamis*) and albacore (*Thunnus alalunga*). The bycatch, called "faux poissons"[2] meaning "false fish", and which is "a peculiar term for an important by-product of the purse-seine fishery in West Africa and particularly in Abidjan"(Amandè *et al.* 2010) was not included in official statistics (Cavérivière and Marcille 1978). We completed the time series by interpolating linearly between the anchor points, assuming tuna domestic catches were correctly reported.

Foreign catches

Demersal trawl fisheries

Herein we reconstruct Chinese trawl catches within Côte d'Ivoire, given the large number of legal Chinese trawlers in the country's EEZ. FAO (2008b) reported that 9 Chinese trawlers were authorized to fish in Côte d'Ivoire EEZ, with a CPUE of around 415 t·vessel^{-1} for 2005. Other estimates show a CPUE of 1,252 t·vessel^{-1}·year^{-1} (Pauly *et al.* 2013). We assumed that China started fishing in Côte d'Ivoire in 1990, at the time when foreign trawlers were reported for the first time within the Ivoirian EEZ (FAO 2008b), and that the effort was constant between 2005 and 2010; then, we linearly between zero in 1990 and the first data point in 2005. Total Chinese trawl catches from Côte d'Ivoire are calculated as the product of effort and a CPUE of 808 t·vessel^{-1}·year^{-1}, i.e., the mean between values in (FAO 2008a, 2008b; Pauly *et al.* 2013).

[2] This sector is treated further below in the section on "faux poissons."

Tuna fisheries

Scarce documentation is available on foreign tuna fishing in Côte d'Ivoire. When reviews are found, often the geographical allocation of catches remains confusing, as literature refers to landings in "Abidjan" rather than catches from Côte d'Ivoire. A few hints show the number of vessels within Côte d'Ivoire waters, and/or describe the presence or the absence of an agreement for tuna fishing. For example, the first agreement with France was signed right after independence in 1961 (Cormier 1983; Folsom *et al.* 1993). It is reasonable to assume that Spain and Senegal, for which the number of vessels was reported for 1972 (Cormier 1983), also began fishing in Côte d'Ivoire in 1961, given that Senegalese vessels were mainly from Spanish and French origin (Belhabib *et al.* 2014). A total number of 270 tuna vessels were reported for 1972, of which 22% were Japanese, 30% French, 18.5% Korean, 18.5% Taiwanese, 6% Spanish, 2% Senegalese and 3% allocated evenly between Yugoslavia, the United States, Canada and Israel (Cormier 1983). We assumed all fleets, excluding those from Spain, Senegal and France, started fishing in 1968, when domestic tuna fishing resumed (Rey 1993). We kept this effort constant in the 4 years from 1972 and 1975, which is the average duration of a fishing agreement. We then interpolated to zero in 1991 for Japan, Korea, Taiwanese, Senegal, Yugoslavia, United States, Canada and Israel, given the absence of any reference indicating an agreement with these countries in the 1990s (in contrast to the agreement with the EU). Similarly, we interpolated data for countries of the European Union (EU), i.e., Spain, France and Portugal for which the effort was indicated in the agreements signed with the EU (Table 3). We completed the effort time series by performing interpolations as needed.

Table 3. Foreign tuna fleet anchor points, 1950-2010.

Year	Japan	France	Korea	Taiwan	Spain	Senegal	Yugoslavia	US	Canada	Portugal	Israeli	Reference
1960		0			0	0						Assumption
1961[a]												
1968	0		0	0			0	0	0		0	Assumption
1972	59	81	50	50	16	5	2	2	2		2	Cormier (1983)
1973	59	81	50	50	16	5	2	2	2		2	Assumption
1974	59	81	50	50	16	5	2	2	2		2	Assumption
1975	59	81	50	50	16	5	2	2	2		2	Assumption
1978[b]											0	Lankester *et al.* (2001)
1991-1993	0	45	0	0	45	0	0	0	0		0	European Economic Community (1990); Folsom *et al.* (1993)
1994-1996	0	45	0	0	45	0	0	0	0		0	European Economic Community (1990); Folsom *et al.* (1993)
1996	0	45	0	0	45	0	0	0	0	0	0	OECD (2000)
1997-1999	0	25	0	0	30	0	0	0	0	5	0	European Union (2004); OECD (2000)
2000	0	30	0	0	36	0	0	0	0	5	0	European Union (2004)
2001	0	30	0	0	36	0	0	0	0	5	0	European Union (2004)
2002[c]	30	30	0	0	37	0	0	0	0	5	0	European Union (2004); Oceana (2004)
2003	30	30	0	0	37	0	0	0	0	5	0	European Union (2004); Oceana (2004)
2004	30	20	0	0	24	0	0	0	0	5	0	eur-lex.europa.eu/Index.do; Oceana (2004)
2005	30	20	0	0	24	0	0	0	0	5	0	eur-lex.europa.eu/Index.do; Oceana (2004)
2006	30	20	0	0	24	0	0	0	0	5	0	eur-lex.europa.eu/Index.do; Oceana (2004)
2007	30	20	0	0	24	0	0	0	0	5	0	eur-lex.europa.eu/Index.do; EU (2008)
2008	30	20	0	0	24	0	0	0	0	0	0	eur-lex.europa.eu/Index.do; EU (2008)
2009	30	20	0	0	24	0	0	0	0	0	0	eur-lex.europa.eu/Index.do; EU (2008)
2010	30	20	0	0	24	0	0	0	0	0	0	eur-lex.europa.eu/Index.do; EU (2008)

a) First agreement here with France (Cormier 1983);
b) First agreement here, reciprocity not implemented and only Guinea Bissau was fishing in Côte d'Ivoire (Lankester et al. 2001);
c) Agreement signed with Japan for 30 vessels but the agreement was never used (European Union 2004).

The next step was to estimate total catches of these vessels within the EEZ of Côte d'Ivoire or the EEZ-equivalent waters prior to the declaration of the EEZ in 1977. First, we estimated total catches of these vessels within and outside Côte d'Ivoire waters, based on the CPUE of domestic tuna vessels from Côte d'Ivoire. We obtained the latter by averaging the CPUEs obtained by dividing the estimated domestic tuna catch by the domestic effort between 1957 and 1986, i.e., 747 $t \cdot vessel^{-1} \cdot year^{-1}$. We multiplied this CPUE by the number of vessels assuming that the decrease of the CPUE due to over-exploitation would be compensated by the increase in vessel efficiency and the decrease in vessel number over time. We multiplied the resulting catch by the average percentage of the catch originated from Côte d'Ivoire, i.e., 6% (Menard *et al.* 2000; European Union 2004). Although these percentages were reported only for the EU fleet, we assumed that it applied to all other fleets, given that they hold agreements with other West African countries, except for Israel, whose entire catch was assumed to be from the Côte d'Ivoire EEZ.

"Faux poisson"

Chavance *et al.* (2011) timed the beginning of the 'faux poissons' fishery back to the early 1980s, when "the development of the log fishing practice for purse seiners produced quantities of juvenile major tunas, minor tunas or by-catch species that started to be landed in Abidjan for consumption according to a Nigerian (Houssa) recipe, the garba", a cheap meal that gradually gained popularity (Romagny *et al.* 2000).

Catches of "faux poisson" were grossly under-estimated in the 1980s (Romagny *et al.* 2000) and are considered absent from more recent official statistics (Amandé *et al.* 2010). While these were estimated by CRO based on customs reports, the nature of the activity that requires payment allows for a large gap in estimations, a bias that drives catch estimates downwards as fishers would report less to pay less. Also, very often, agents will not report these catches. Estimations by CRO, as opposed to official numbers improved overtime (Amon Kothias 1986; Romagny *et al.* 2000) from very poor in the early 1980s to relatively better in the late 1990s (Romagny *et al.* 2000). Catches reported as 'faux poissons' by the Department of Fisheries (DAP) in national reports remain relatively low and unreliable when compared to catches estimated more realistically by CRO, as the former were obtained via logbooks while the latter by estimation onsite (Romagny *et al.* 2000). Even in 2010, accounting for 'faux poissons' landings remained informal, and many issues were observed by Chavance *et al.* (2011), notably regarding the localization of the catch, the gear, and the amount of the catch. The authors noted that the activity remained relatively undeclared in official statistics.

While many fleets operate within Côte d'Ivoire EEZ and the Central Eastern Atlantic area, 'faux poissons' landings are reported only by European, Japanese, South Korean, Ghanaian and Guinean vessels and vessels flying flags of convenience of countries such as Cambodia (Chavance *et al.* 2011). We first attributed an underreporting rate of "grossly unreliable/underestimated", "low reliability" and "good reliability" to CRO estimated catches (Romagny *et al.* 2000) for the periods considered by the author. We assumed catches were under-estimated by 60% for 1988-1991, 40% in 1991-1994, 30% between 1995 and 1999 and interpolated to 20% (conservatively) in 2010. We first estimated total catches, i.e., added the unreported component for the EU fleets by multiplying the former percentages by the reported catch and then adding it to the reported catch between 1991 and 2010. These estimates include Spain, France and Portugal for the most recent periods. Then, we estimated Spanish, French and Portuguese 'faux poissons' bycatch rates by dividing the catch of 'faux poissons' by the corresponding total tuna catch, i.e., tuna catches landed in Abidjan regardless of the catch area, between 1991 and 2010, and interpolated from zero in 1981 (Chavance *et al.* 2011) to the first estimated bycatch rate in 1991, i.e. 35%. Given the similarities between the EU fleets and the Senegalese (mainly French and Spanish based in Dakar) and domestic fleets (given that tuna fishing was introduced to Côte d'Ivoire by France (Lassarat 1957, 1958; Belhabib *et al.* 2014), we assumed the same bycatch rates and applied them to the estimated tuna catch by the Senegalese and Côte d'Ivoire fleets.

Japanese tuna catches were estimated between 1969 and 1990, a period during which Japan had an agreement with Côte d'Ivoire (see foreign tuna catch section), while "faux poissons" catches were only reported for Ghana, also known to have a significant number of Japanese tuna boats flagged to it (Nunoo *et al.* 2014), and covered only the period between 1988 and 2009 (Chavance *et al.* 2011). Therefore, we could only estimate bycatch rates for the three overlapping years (1988-1990). We interpolated bycatch rates between zero in 1981 and 29% estimated herein in 1988 and multiplied the resulting time series by Japan's tuna catch, thus obtaining Japanese "faux poissons" catches landed in Abidjan. Similarly, knowing that Korea also used to reflag its tuna boats to Ghana, we used the same bycatch rates and applied them to the Korean tuna catch between 1981 and 1990, when Korea stopped operating in Côte d'Ivoire as "Korea". We used these same bycatch rates for the other fleet that had agreements with Côte d'Ivoire and landed their catches in Abidjan, i.e., Israel, Canada, United States, Yugoslavia and Taiwan. For Ghana, Guinea and Cambodia, for which only 'faux poissons' catches were reported by Chavance *et al.* (2011), we calculated the unreported catch by multiplied the reported catch by the underestimation rates alluded above based on the reliability of catch estimates as described by Romagny *et al.* (2000). Although only 6% of the foreign catches landed in Côte d'Ivoire are taken from the country's EEZ, the reported landings of 'faux poissons' from outside the EEZ were likely included in the data submitted to FAO.

Illegal fisheries

With over 600-700 fishing vessels visiting the ports of Côte d'Ivoire, there are no inspectors responsible for fisheries compliance (SIF 2010). Furthermore as of 2011, Côte d'Ivoire did not have patrol boats and relied on it its navy to monitor fisheries and the Monitoring Control and Surveillance (MCS) unit and Vessel Monitoring System (VMS) were not functional (Manning 2011). This fostered illegal fishing, e.g., by over 40 Chinese trawlers in 2004 and 2005 (Anon. 2007) of which only 8 and 9 vessels were legal, respectively. For 2010, illegal catches were estimated at 55,116 t (Valdmanis and Akam 2010). We multiplied the number of illegal Chinese pair trawlers, i.e., 32 and 31 respectively for 2004 and 2005 by a CPUE of 1,252 $t \cdot vessel^{-1} \cdot year^{-1}$ (Pauly *et al.* 2013), slightly higher than the average CPUE estimated for legal trawlers, and then interpolated starting from 0 in 1990, as 1991 coincides with the beginning of Chinese fishing operations in Côte d'Ivoire.

Discards

Trawlers

Discard rates observed and reported for Côte d'Ivoire are relatively low, as only a few species are discarded within the EEZ. Furthermore, these low rates have already been declining in recent years reflecting that trawlers keep their fish of lower value (Cavérivière 1983). Discards rate of 15% were reported from 1958 and 1959 (Cavérivière 1983), which we assumed constant for the 1950s. For 1966 and 1967, we used the acoustic trawling survey report by Troadec *et al.* (1969), which showed that of over about 1,940 kg· h^{-1} of catch, 1,550 kg·h^{-1} were commercial species, the remainder being discarded. Thus, relying on the assumption that the survey trawler performed similarly than other trawlers (300 CV and mesh size of trawl 40 mm) over the same fishing grounds, we obtained a discard rate of 20% of total catches, which was kept constant between 1966 and 1969 (Troadec *et al.* 1969). For 1983, Cavérivière (1983) reported a discard rate ranging between 5% and 30%, which is herein averaged at 18% for demersal trawlers. Knowing that discard rates have been declining (Cavérivière 1983), we assumed a decline of 20% for 2010, i.e., a discard rate of 14%. We applied these discard rates to the estimated domestic trawl catch within and outside Côte d'Ivoire EEZ. For the Chinese legal trawl fleet, we applied a discard rate of 40% (Belhabib *et al.* 2013), while for the illegal pair trawl fleet, we applied a discard rate of 80% of the trawl catch (Belhabib *et al.* 2013).

Similarly, the discards of the Spanish and French tuna fleet were estimated at 14% for 1998 (Romagny *et al.* 2000), which we assumed constant between 1998 and 2010 across fleets of different origins. We assumed discards generated by tuna fleets were conservatively 20% higher in 1950 given the decline in tuna discards due to development of a market for "faux poissons" (Romagny *et al.* 2000; Chavance *et al.* 2011). We interpolated and applied these discard rates to the estimated tuna catch taken within Côte d'Ivoire by both the domestic and foreign fleets.

Cavérivière (1983) observed that around 1% of small pelagic purse-seine catches were discards and were constituted mainly of West African ilisha (*Ilisha Africana*). We assumed this discard rate was constant between 1950 and 2010 and applied it to the small pelagic domestic purse-seine catch within Côte d'Ivoire.

Species disaggregation

We disaggregated subsistence lagoon and artisanal catches using the species composition described by Laë (1992). For industrial catches, we derived a species disaggregation from the reported landings dataset (supplied by the FAO), while for the foreign component, we disaggregated catches based on FAO (2008b). We disaggregated discards based on the description by Cavérivière (1983) and Romagny *et al.* (2000).

Results

Artisanal

Total artisanal catches were estimated at over 2.9 million t between 1950 and 2010, 67% of which were marine. Lagoon artisanal catches were estimated at 982,300 t during the 61 years' time period. Lagoon catches increased from 14,200 t in 1950 to a peak of 22,000 t in 1979, right before they collapsed due to the decline of the small pelagic catches and the proliferation of collective fishing gear (Figure 3). Lagoon catches varied later on, while increasing toward their second peak of 15,800 t in 1998. They have been declining since, due to increasing migrations towards the coast (Figure 3). Artisanal marine catches decreased slightly in the early 1950s, due to the conflict between Côte d'Ivoire and Benin, which drove fishers from the latter country to leave Côte d'Ivoire. Artisanal catches increased again, to 35,000 t in 1984 and then decreased to 25,000 t in 2010, their minimum since 1957 (Figure 3).

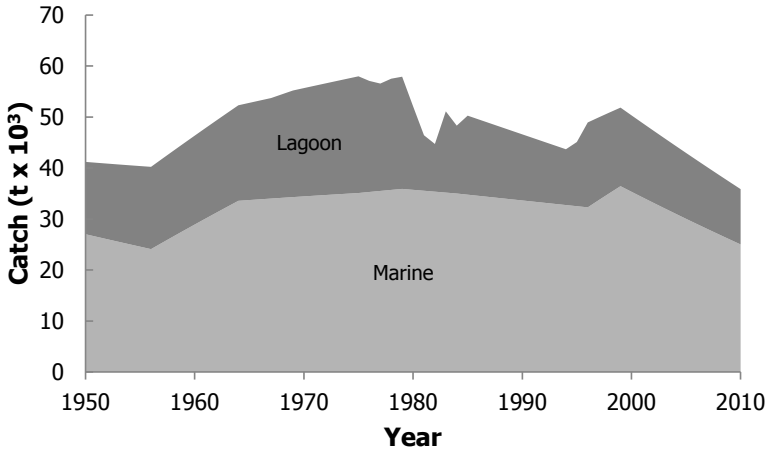

Figure 3. Reconstructed artisanal marine and lagoon catches from Côte d'Ivoire EEZ, 1950-2010.

Subsistence

Subsistence catches were estimated at 523,000 t over the 1950-2010 time period, of which 456,100 t were from the lagoons of Côte d'Ivoire (83%). Lagoon subsistence catches taken mostly by cast nets and *tegbe* systems increased to a peak of 9,100 t in 1977, and then decreased to less than 6,500 t in 2010 as the use of Tegbe systems fishers migrating towards the coast (Figure 4). Subsistence marine catches, including the catch taken home by artisanal fishers, were estimated at 67,200 t·year^{-1} between 1950 and 2010, less than 12% of the total subsistence catch, and, overall, remained relatively constant at around 1,000, with slight increases from the 1970s to the 1990s (Figure 4).

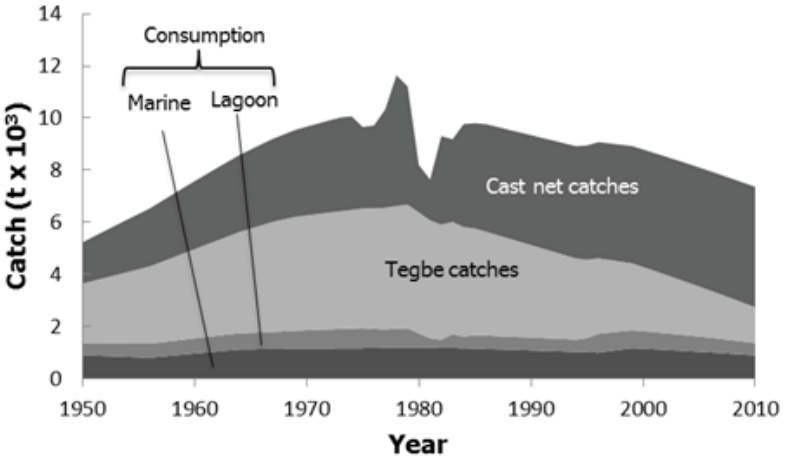

Figure 4. Reconstructed subsistence catch from Côte d'Ivoire , 1950-2010.

Industrial domestic

Total industrial domestic catches were estimated at 2.9 million t between 1950 and 2010, around a third of which were taken from outside of Côte d'Ivoire EEZ. Small pelagic purse-seine contributed over half of total domestic catches, followed by demersal catches with around 40% the total domestic industrial catch, while tuna catches including 'faux poissons' catches represented only 7%. The latter number is explained by the fact that the domestic tuna fleet operated only between the mid-1960s and the mid-1980s. Total catches increased from around 6,200 t in 1950 to a first peak of around 78,000 t in 1972, corresponding to the peak of demersal and shrimp trawl catches and a second peak of around 80,000 t in 1981 corresponding to the peak of tuna fisheries (Figure 5). Catches remained relatively constant at around 78,000 t·year^{-1} on average during that time, which corresponds to the period of economic prosperity. Thereafter, catches declined steadily to less than 22,048 t in 2010 (Figure 5).

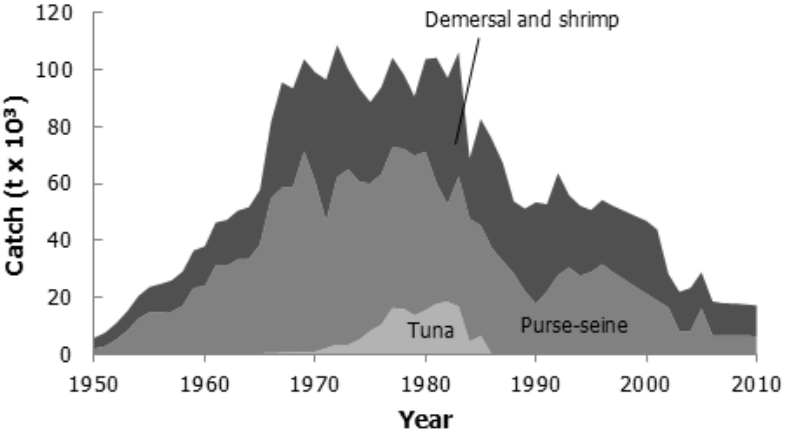

Figure 5. Total industrial domestic catches of the fleets of Côte d'Ivoire within and outside Côte d'Ivoire EEZ by gear.

Domestic demersal trawl catches were estimated at 1.5 million t between 1950 and 2010, 20% of which were caught from outside Côte d'Ivoire, but landed in Côte d'Ivoire ports. Catches taken from Côte d'Ivoire EEZ increased from around 2,400 t in 1950 to a peak of 35,600 t in 1966, declined to a minimum of 3,300 t in 1982, increased gradually to a second peak of around 32,900 t in 1996, with increasing number of domestic trawlers returning to fish in Côte d'Ivoire, to decrease thereafter to around 8,800 t in 2010. In contrast, domestic demersal trawl catches taken from outside Côte d'Ivoire EEZ reached their maximum between 1972 and 1980, a period of economic prosperity, before decreasing gradually to zero in 1990 (Figure 6). The decrease of catches taken from the outside coincides with the increase of catches taken from within Côte d'Ivoire EEZ (Figure 6).

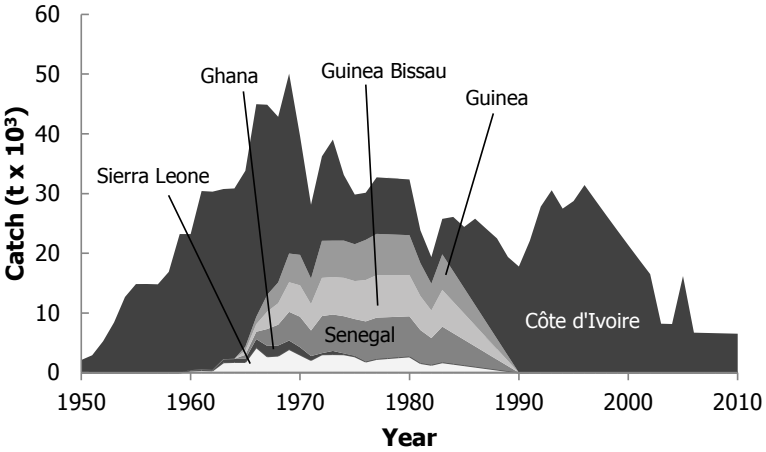

Figure 6. Total industrial domestic catches of the demersal trawl fleet within and outside Côte d'Ivoire EEZ..

The same pattern is observed for shrimp catches, which peaked at around 700 t in 1971 (mostly from Côte d'Ivoire EEZ), and then declined to its peak again in 1988 (330 t) and 1996 (280 t), all of which were caught in Nigeria, before collapsing (Figure 7).

Tuna catches (including "faux poissons") were estimated at 191,400 t between 1950 and 2010. Tuna catches started at around 250 t in 1957 and increased to 20,615 t in 1981, after which 'faux poissons' started to be landed in Abidjan by the domestic tuna fleet and increased to a peak of 1,100 t in 1983, corresponding to a tuna catch of 18,100 t (Figure 8). Domestic tuna fisheries collapsed as domestic tuna boats stopped operating in 1987 due to the economic crisis. A small component of 'faux poissons' was reported as being domestic, although, a large fraction of it was landed in Abidjan by foreign fleets.

Small pelagic purse-seine catches totalled 1.5 million t between 1950 and 2010, most of which was caught within Côte d'Ivoire EEZ. Catches increased from around 3,800 t in 1950 to a first peak of 56,100 t in 1971, decreased to 21,300 t in 1979 due to the decline in the number of boats to increase again to a second peak of 44,400 t in 1982 after catches from outside Côte d'Ivoire EEZ started declining, and then decreased gradually to 13,200 t in 2010 (Figure 9).

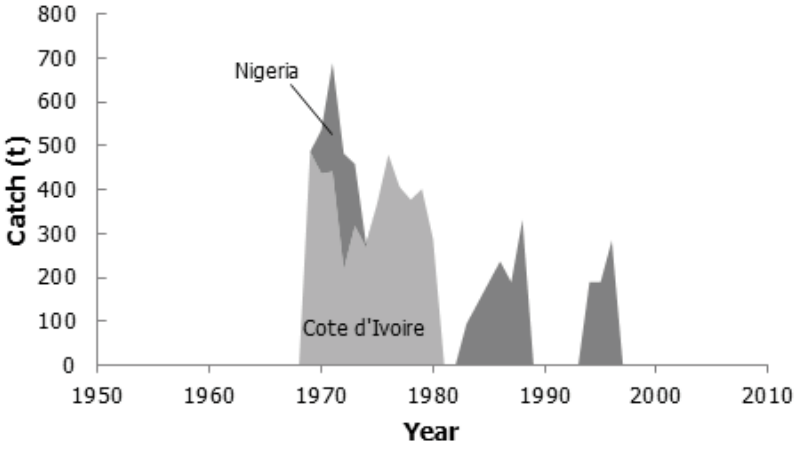

Figure 7. Total industrial domestic catches of the shrimp trawl fleet within and outside Côte d'Ivoire.

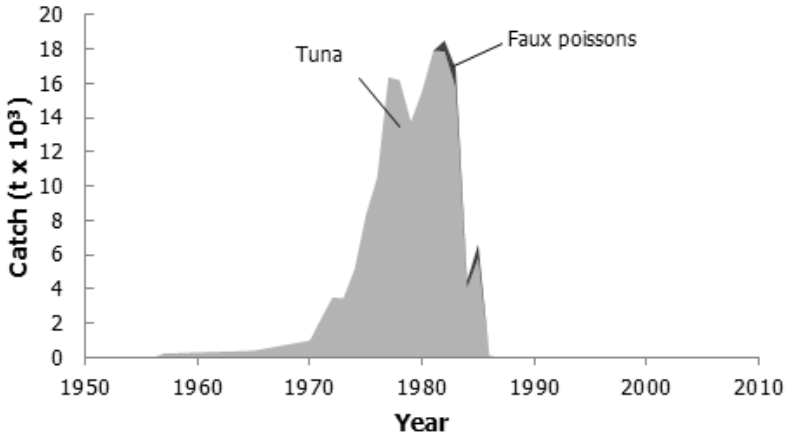

Figure 8. Total industrial domestic catches of the tuna fleet and its 'faux poissons' bycatch within Côte d'Ivoire EEZ.

Industrial foreign catches

Total foreign catches were estimated at over 989,000 t from 1950 to 2010, 58% of which were caught by illegal trawlers (578,500 t), 32% by the tuna fleets, including 'faux poissons' catches within Côte d'Ivoire, with the remainder caught by Chinese legal trawlers.

Total catches by the tuna fleet (excluding 'faux poissons') increased from around 469 t in 1961, when the fishery began to a peak of 14,000 t·year^{-1} on average during the early 1970s and then declined to 2,100 t in 2010 (Figure 10). Tuna catches by France and Spain dominated over the 1950s-2010 time period, while catches by Japan, Korea, Taiwan and Israel peaked in the early 1970s to be zero later on Figure 10.

'Faux poissons' catches were estimated at around 30,300 t between 1950 and 2010, which represented the equivalent of 10% of the tuna catch. 'Faux poissons' catches increased from 200 t in 1980 with the introduction of the log fishing practice in the tuna purse-seine fishery, to a peak of around 2,000 t in 1993, and then remained more or less constant thereafter (Figure 10).

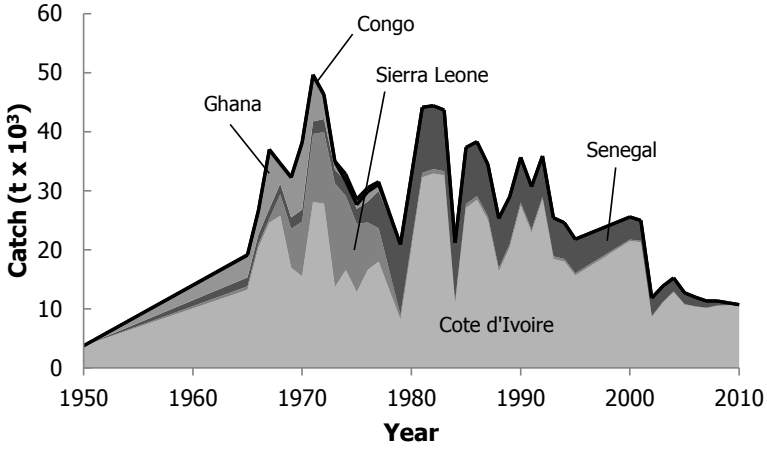

Figure 9. Total industrial domestic catches of the tuna fleet and its 'faux poissons' bycatch within Côte d'Ivoire EEZ.

Legal Chinese trawl catches were estimated at 94,500 t between 1990, when they began, and 2010. Catches increased from zero in 1990 to a maximum of 7,300 t in 2005, then remained relatively constant (Figure 10). Illegal Chinese trawl catches increased from zero in 1990 to over 55,100 t in 2010, and then totalled over 578,500 t.

Discards

Discards within Côte d'Ivoire waters were estimated at over 777,400 t from 1950 to 2010, most of which were by illegal trawlers operating within Côte d'Ivoire EEZ (60%), followed by the domestic and the foreign fleets with 27% and 14% respectively.

Discards by the domestic fleets increased from around 360 t in 1950 to a peak of 7,400 t in 1966 with the peak of industrial trawl catches. Discards by the domestic fleet within Côte d'Ivoire EEZ decreased thereafter, which corresponds with the start of the domestic fleet venturing outside Côte d'Ivoire waters (Figure 11). Domestic discards increased thereafter to a second peak of 5,100 t·year^{-1} in the mid-1990s to decrease again to around 1,000 t in 2010 (Figure 11).

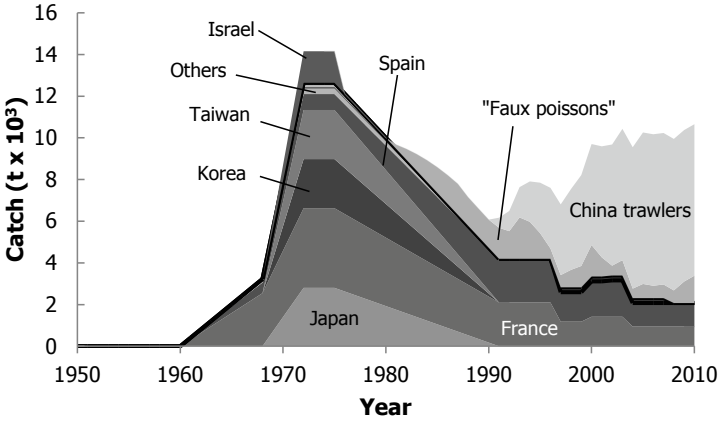

Figure 10. Total foreign legal catches from Côte d'Ivoire, 1950-2010.

Discards by foreign tuna fleets were estimated at 43,400 t from 1950 to 2010, increasing from 66 t in 1961 to a peak of 2,200 t·year^{-1} between the early and the mid-1970s, then decreasing to less than 300 t in 2010 (Figure 10). Discards by the legal trawl (China) fleet, on the other hand, increased steadily from 320 t in 1990 to around 4,500 t in 2005, a level at which they remained (Figure 11). Illegal trawl discards represented the overwhelming majority of discards, with over 462,800 t from 1950 to 2010, increasing from around 2,300 t in 1990 to around 44,100 t in 2010 (Figure 11).

'Faux poissons' from outside Côte d'Ivoire EEZ

Total foreign 'faux poissons' catches from outside Côte d'Ivoire EEZ landed in Abidjan were estimated at over 599,300 t between 1950 and 2010, of which about 374,200 t (62%) were reported to FAO as Côte d'Ivoire catch. 'Faux poissons' catches increased rapidly since the Fish Aggregating Device was introduced in the early 1980s, and peaked twice, in 1993 with around 29,800 t and in 2000 with around 28,600 t (Figure 12). Catches reached a maximum in 2010 (Figure 9). Unreported catches of 'faux poissons' declined as reporting improved, from 13,800 t·year^{-1} on average in the 1980s to less than 5,200 t in 2010 (Figure 12).

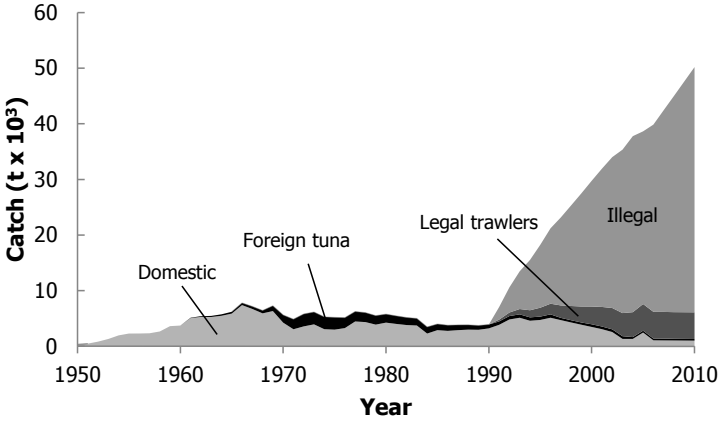

Figure 11. Total reconstructed discards by domestic and foreign fleets within Côte d'Ivoire EEZ, 1950-2010.

Total catches

FAO data reported by Côte d'Ivoire include catches of 'faux poissons' taken by foreign fleets from outside the EEZ of Côte d'Ivoire which are recorded locally. Similarly, catches taken by Côte d'Ivoire from other countries' EEZs were reported to the FAO. Total domestic reconstructed catches were estimated at 5.6 million t over the period from 1950 to 2010 of which only 2.6 million t was reported to FAO. Total removals from Côte d'Ivoire EEZ increased from 52,700 t in 1950 compared to 14,600 t reported to FAO to 105,100 t·year^{-1} on average from the early 1970s through the early 1980s compared to 43,000 t·year^{-1} reported to the FAO after removing 'faux poissons' catches, which started being reported in 1981. Domestic catches within Côte d'Ivoire EEZ declined steadily thereafter to less than 65,500 t in 2010 compared to 56,889 t reported to FAO. It is herein strongly suspected that a large portion of the miscellaneous marine fish component is taken by foreign fleets from EEZs outside of Côte d'Ivoire and landed

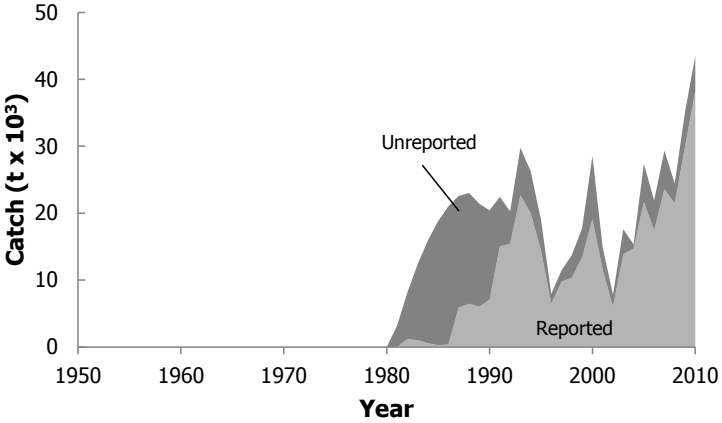

Figure 12. Total 'faux poissons' caught by foreign fleets outside Côte d'Ivoire EEZ and landed in Côte d'Ivoire ports, 1950-2010.

in Abidjan then reported to the FAO as being domestically caught. In fact one strong reason for the increase in reported landings, which doubled in 2010, seems to be due to the reporting of around 15,000 t of 'faux poissons'. This is supported by the fact that literature refers to a large part of these catches as 'reported', while many reports from the CRO include reported 'faux poissons' catches. When these are filtered out, catches decline (Figure 13).

Overall total removals from Côte d'Ivoire EEZ (domestic and foreign) were estimated at around 7.0 million t between 1950 and 2010. Catches increased and remained relatively constant at 116,000 t·year^{-1} on average between the mid-1960s when Côte d'Ivoire signed agreements for foreign tuna fishing (mainly), and the early 1980s, when the economy collapsed. Catches decreased slightly in the 1990s and increased again due to increasing illegal catches and be over 167,000 t in 2010.

Discussion

Total catches in Côte d'Ivoire were estimated at 7.1 million t between 1950 and 2010, of which 5.6 million t were caught domestically within Côte d'Ivoire EEZ. Total reconstructed domestic catches exhibit a constant decline since the mid-1980s due to poor economic conditions and over-exploitation, in contrast to the increasing trend suggested by the data supplied to the FAO. The latter is primarily due to a massive increase in 'faux poissons' catches landed by foreign fleets but reported by Côte d'Ivoire. This is dangerous, as it masks the decline in domestic catches from Côte d'Ivoire EEZ. Thus, not only is the over-exploitation problem hidden, but it suggests the sector to be flourishing, while in reality is far from the truth.

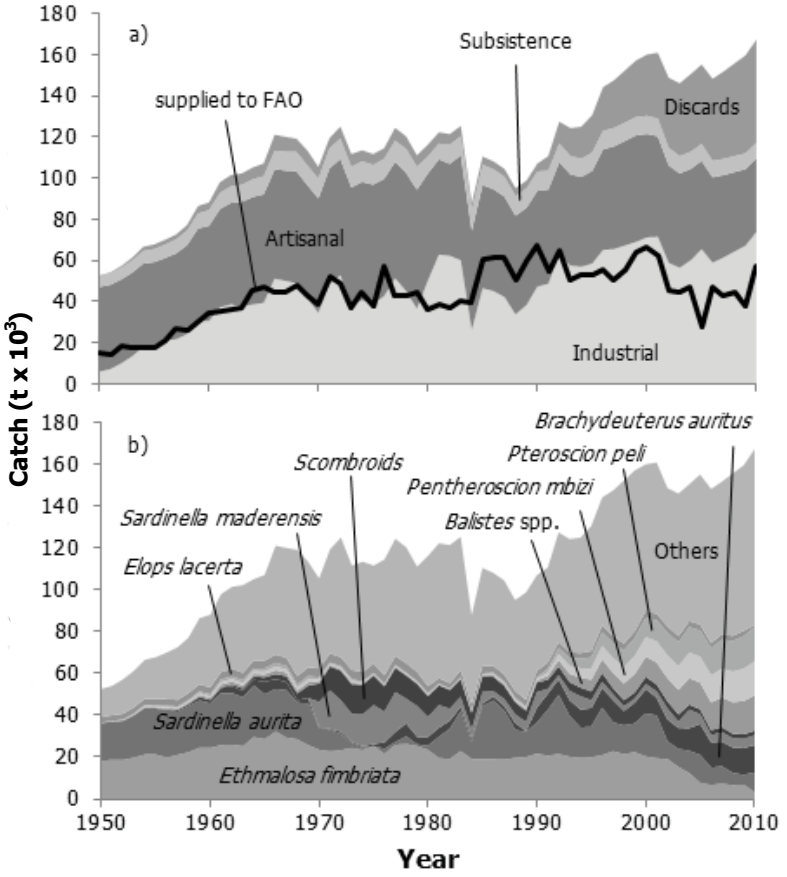

Figure 13. Reconstructed total catch for Côte d'Ivoire EEZ, 1950-2010, by a) sector with official reported data overlaid as a line graph and b) taxon with "Others" consisting of 78 additional taxonomic categories.

The symptoms of this decline are further illustrated through a general over-exploitation of the Côte d'Ivoire EEZ (Cormier 1983), the collapse of the shrimp fishery which is believed to be the result of artisanal shrimp fishing in lagoons (Garcia and Fonteneau 1971), the tuna fleet which went "out of business" as early as the late 1980s, the general decrease in the number of boats operating within and outside Côte d'Ivoire and even the proliferation of unwanted species such as triggerfishes in the early 1970s (Troadec and Garcia 1979). Despite this, artisanal fisheries still retain an important role with around 50% of total domestic catches. Indeed, their role has increased as industrial fisheries declined. The constraint to fisheries exacerbated by poor economic conditions, has driven artisanal fishers to adopt diverse adaptation strategies to avoid suffering a similar fate. For example, Ecoutin (1992) shows that the pirogues of Côte d'Ivoire have evolved in size, capacity and motorization from those described by Lassarat (1958), thus increasing their reach and fishing grounds, a pattern also observed elsewhere, e.g. Senegal (Belhabib *et al.* 2014). This is further illustrated by the disappearance of motors with low power (Ecoutin 1992). Fishers also adapted to other conditions; for example, droughts in the 1970s and 1980s in Niger delta in Mali drove fishers to migrate to the Côte d'Ivoire fishing grounds (Njock and Westlund 2010). Another condition that strongly impacted the fisheries of Côte d'Ivoire is related to conflicts and the migrations they incur. The Ebrié Lagoon which was once "filled with fish" (Chenery 1875) has witnessed changes in the populations through migrations from the conflicted areas of the North, which translated into increasing catches. Later on, these catches decreased due to over-exploitation and conflicts that again drove fishers to migrate towards the already overexploited coastal marine fisheries. This describes a chaotic situation where artisanal fishers of Côte d'Ivoire become trapped between socio-political conflicts, the desire for a better life and over-exploitation triggered in part by the large number of illegal fishing vessels operating in Côte d'Ivoire.

Another effect of the collapsing economy was the devaluation of the Franc CFA, which has increased the price of fish and thus reduced fish consumption (Akindes 1995). The increase of post-conflict consumption of fish (Dabalen and Saumik 2013) is due in part to the increase in informal food business (Akindes 1995), i.e, subsistence fishing through the use of cast nets as documented herein. Furthermore, the role of fish in post-conflict diets appears to have increased (Kouame and Enoh 2011), thus giving fish an even greater weight in the balance of food security and poverty alleviation in the country.

Despite multiple efforts, notably to tackle the issue of the non-reporting of 'faux poissons' (which are now being reported as part of Côte d'Ivoire catches, the objectives of fishery development in Côte d'Ivoire are questionable. First, reporting 'faux poissons' in FAO datasets and using these for fishery analysis masks the declining trend of fisheries and jeopardizes the movement towards sustainable fisheries. Furthermore, to counter the effect of over-exploitation and declining supplies, Ivoirian fisheries planners consider modernizing and/or replacing of aging vessels in order to "increase efficiency", which however, will increase fishing effort on overexploited resources and further reduce catches. Finally, while they assert that they want to increase protein supply for domestic consumption as a first objective, they also plan to promote fish exports (Mabawonku 1990).

The important economic role that fisheries play in Côte d'Ivoire is undisputedly due to the small scale fisheries (Diaby 1996; Golé Bi Golé *et al.* 2005). Yet, while the dependence of small scale communities upon fish increases in the face of conflicts (see UNDP 2011), catches that decline, jeopardizing the livelihoods as poverty increases. We illustrated herein that the opportunity to further develop industrial fisheries is no longer justified. Rather, efforts should be focused on controlling the proliferation of illegally operating fleets and on local-scale management plans at the artisanal level (e.g. Laë 1997).

Acknowledgements

We acknowledge the support of the *Sea Around Us*, a scientific collaboration between the University of British Columbia and the Pew Charitable Trusts. D.B. thanks Duncan Copeland for helpful information and Dirk Zeller for his guidance and advice.

References

Akindes F (1995) Dévaluation et alimentation à Abidjan (Côte d'Ivoire). Les Cahiers de la Recherche Développement 40, ORSTOM, Abidjan. 24-42 p.

Amandé MJ, Ariz J, Chassot E, de Molina AD, Gaertner D, Murua H, Pianet R, Ruiz J and Chavance P (2010) Bycatch of the European purse seine tuna fishery in the Atlantic Ocean for the 2003–2007 period. Aquatic Living Resources 23(04): 353-362.

Amon Kothias J (1986) Analyse des débarquements des thonidés mineurs et poissons porte-épée en Côte d'Ivoire en 1984-1985. Collect. Vol. Sci. Pap. ICCAT 25, ICCAT. 262-264 p.

Anon. (1981) Les écosystèmes côtiers de l'Afrique de l'ouest: lagunes, estuaires et mangroves. Rapport d'un atelier. Dakar, 11-15 juin 1979. UNESCO. 3 p.

Anon. (2007) Côte d'Ivoire: des bateaux de pêches chinois accusés de «pillage». AFP, Abidjan. 1 p.

Atta-Mills J, Alder J and Sumaila UR (2004) The decline of a regional fishing nation: the case of Ghana and West Africa. Natural Resources Forum 28: 13-21.

Badmus I (2009) Even the stones are burning: explaining the ethnic dimensions of the civil war in Côte d'Ivoire. J. Soc. Sci. 18(1): 45-57.

Bayley P (1988) Accounting for effort when comparing tropical fisheries in lakes, river-floodplains, and lagoons. Limnology and Oceanography 33(4): 963-972.

Belhabib D, Subah Y, Broh NT, Jueseah AS, Nipey J, WY B, Copeland D, Zeller D and Pauly D (2013) When 'reality leaves a lot to the imagination': Liberian fisheries from 1950 to 2010. Fisheries Centre Working Paper #2013-06, UBC Fisheries Centre, Vancouver.

Belhabib D, Koutob V, Sall A, Lam VW and Pauly D (2014) Fisheries catch misreporting and its implications: The case of Senegal. Fisheries Research 151: 1-11.

Belhabib D, Koutob V, Zeller D and Pauly D (2015) The marine fisheries of Togo, the 'Heart of West Africa' 1950 to 2010. pp. 37-50. *In*: Belhabib D and Pauly D (eds.), Fisheries catch reconstructions: West Africa Part II, 1950-2010. Fisheries Centre Research Reports 23(3), Vancouver [this volume]

Bikbo-Koffie C (2010) La pêche maritime en Côte-d'Ivoire face à la piraterie halieutique. Les Cahiers d'Outre-Mer 251(Juillet-Septembre 2010): 321-346.

Bouberi D (1981) Statistiques de pêche des sardiniers ivoiriens, année 1981. Arch. Sc. Cent, Rech. Océanogr. Abidjan IX, Centre de Recherche Océanographique d'Abidjan, Abidjan. 13-39 p.

Bouberi D (1984a) Statistiques de pêche des sardiniers ivoiriens, année 1982. Arch. Sc. Cent, Rech. Océanogr. Abidjan X, Centre de Recherche Océanographique d'Abidjan, Abidjan. 1-32 p.

Bouberi D (1984b) Statistiques de pêche des sardiniers ivoiriens, année 1983. Arch. Sc. Cent, Rech. Océanogr. Abidjan X, Centre de Recherche Océanographique d'Abidjan, Abidjan. 1-19 p.

Cavérivière A (1978) La pêche des chalutiers ivoiriens dans les zones FAO 34.3.1 (littoral Cap Vert) et FAO 34.3.3 (Sherbro). . p. 12 In Report of the *Ad Hoc* Working Group on Coastal Demersal Fish Stocks from Mauritania to Liberia, Dakar 14-19 nov. 1977 FAO/CECAF/ECAF Series 78/8 Rome.

Cavérivière A (1979) La pêche industrielle des poissons demersaux en Côte d'Ivoire. Généralités, localisation, homogénéité relative des zones de pêche ivoirienne. Doc. Scient. Centre Rech. Oceanogr. Abidjan X, Centre de Recherches Océanographique d'Abidjan, Abidjan. 43-93 p.

Cavérivière A (1983) Les espèces demersales du plateau continental ivoirien. Biologie et exploitation.Volume II, Universite d'Aix-Marseille II, Marseille. 312 p.

Cavérivière A and Marcille J (1978) La pêche industrielle en Côte d'Ivoire. ORSTOM, Paris. 7 p.

Charles-Dominique C, Ecoutin J and San Gnanmilin A (1980) La pêche artisanale en lagune Aby-Tendo-Ehy (Côte d'Ivoire): premières estimations de la production. Arch. Scient. Centre Rech. Océanogr. Abidjan 6, Centre de Recherche Océanographique d'Abidjan, Abidjan. 1-26 p.

Chavance P, Amon Kothias J, Dewals P, Pianet R, Amandè MJ, De Molina AD and Djoh A (2011) Statistics on tuna surface fishery's bycatch landed in Abidjan, Côte d'Ivoire, for the 1982-2009 Period. Collect. Vol. Sci. Pap. ICCAT 66, ICCAT. 2104-2112 p.

Chenery L (1875) The West coast of Africa, Part II. United States Hydrographic Office 47. Government Printing Office, Washington DC.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). Center for International Earth Science Information Network (CIESIN)/Columbia University. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3 [Accessed: 29/04/2013].

Collari A (1986) Development planning for small-scale fisheries in West-Africa: practical technical and socio-economic aspects of fish production and processing.7, Programme for the Integrated Development of Artisanal Fisheries in West Africa, Cotonou. 41 p.

Connolly K, Fall A, Fazio R and Wittman M (2013) Côte d'Ivoire Report 2013. University of Oregon, Eugene, OR. 31 p.

Cormier M (1983) La pêche en Côte d'Ivoire. Mise au point des connaissances et perspectives. Université de Paris X, Nanterre. 135 p.

Coulibaly R (2010) Analyse de la contribution de la pêche à l'économie ivoirienne. The African Capacity Building Foundation, World Bank Institute, Abidjan. 34 p.

Cury P and Roy C (1987) Upwelling et pêche des espèces pélagiques côtières de Côte-d'Ivoire: une approche globale. Oceanologia Acta 10(3): 347-357.

Dabalen A, Kebede E and Saumik P (2012) Causes of Civil War: Micro Level Evidence from Côte d'Ivoire. HiCN Working Paper 118, The Institute of Development Studies at the University of Sussex -, Brighton. 60 p.

Dabalen A and Saumik P (2013) Effect of conflict on dietary energy supply: evidence from Côte d'Ivoire. HiCN Working Paper 156, Households in Conflict Network, The Institute of Development Studies, University of Sussex. 46 p.

Delaunay K (1992) Fanti and Ewe fishermen's migration and settlment in Côte d'Ivoire. MAST 5(2): 96-103.

Diaby S (1996) Economic impact analysis of the Ivorian sardinella fishery. Marine Resource Economics 11(1996): 31-42.

Domingo J (1980) Aspects de l'évolution récente des pêches artisanales en Côte-d'lvoire. Norois: 181-198.

Doucet F, Chauvet C, Gilly B and Meuriot E (1985) Programme d'action de la FAO pour Le'aménagement et le développement des pêches.W/R8692, FAO, Rome. 177 p.

Durand J, Amon Kothias J, Ecoutin J, Gerlotto F, Hie Dare J and Lae R (1978) Statistiques de pêche en lagune Ebrié (Côte d'Ivoire): 1976 et 1977. Doc. Scient. Centre Rech. Océanogr. Abidjan IX, Centre de Recherche Océanographique d'Abidjan, Abidjan. 67-114 p.

Durand J, Dufour P, Guiral D and Zabi S (1994) Environnement et ressources aquatiques de Côte d'Ivoire. Tome II: les milieux lagunaires. ORSTOM, Paris.

Ecoutin J (1983) Evolution récente de la pêche collective en lagune Ebrié. Note à Diffusion Restreinte 1, Centre de Recherche Oceanographique d'Abidjan, Abidjan. 7 p.

Ecoutin J (1992) Dynamique des flottilles en pêche artisanale. L'exemple des sennes tournantes en Côte d'Ivoire. ORSTOM, Paris. 214 p.

EU (2008) Protocol setting out the fishing opportunities and the financial contribution provided for by the Agreement between the European Community and the Republic of Côte d'Ivoire on fishing off the coast of Côte d'Ivoire for the period from 1 July 2007 to 30 June 2013. Official Journal of the European Union 48/46, European Union, Brussels. 18 p.

European Economic Community (1990) Protocol establishing the fishing rights and financial compensation provided for in the Agreement between the European Economic Community and the Republic of Côte d'Ivoire on fishing off the coast of Côte d'Ivoire. European Economic Community, Brussels. Available at: http://eur-lex.europa.eu/Notice.do?val=160570:cs&lang=en&pos=2&phwords=cote%20d%20ivoire~fish*~&checktexte=checkbox [Accessed: 07/01/2014].

European Union (2004) Proposition de Règlement du Conseil relatif à la conclusion du protocole fixant les possibilités de pêche et la contrepartie financière prévues dans l'accord entre la Communauté économique européenne et la République de Côte d'Ivoire concernant la pêche au large de la Côte d'Ivoire, pour la période allant du 1er juillet 2004 au 30 juin 2007. European Union, Brussels. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52004PC0619:FR:HTML [Accessed: 07/01/2014].

FAO (1985) Report of the CECAF Ad Hoc working group on the demersal and shrimp resources of the Central Gulf of Guinea Division (34.3.5). CECAF/ECAF Series 86/36, FAO, Rome. 200 p.

FAO (2008a) Report of the FAO/CECAF Working Group on the assessment of demersal resources – Subgroup South. Freetown, Sierra Leone, 9–18 October 2008. CECAF/ECAF 11/73, FAO, Rome. 311 p.

FAO (2008b) Vue générale du secteur des pêches nationales. La République de Côte d'Ivoire. PROFILS DES PÊCHES ET DE L'AQUACULTURE PAR PAYS FAO, Rome. 43 p.

FAO (2009) Report of the FAO/CECAF Working Group on the assessment of small pelagic fish – Subgroup South CECAF/ECAF Series 12/74, FAO, Accra. 172 p.

FAO CdpplAC-E (1981) Rapport de la 5e session du Groupe de travail de l'évaluation des ressources, Dakar, Senegal, 15-17 Oct. 1980. FAO Rapport sur les pêches 244. FAO, Rome.

Folsom W, Rovinski D and Weidner D (1993) World fishing fleets: an analysis of Distant-water Fleet operations. Past–Present–Future. Volume VI: Western Europe and Canada. NOAA Tech. Memo. NMFS-F/SPO-14. National Oceanic and Atmospheric Administration, Silver Sping, Maryland. 374 p.

Fonteneau A and Marchal E (1970) Récolte, stockage ettraitement des données statistiques relatives à la pêche des sardiniers (filet tournant) en Côte d'Ivoire. Doc. Scient. Centre Rech. Oceanogr. Abidjan 1, Centre de Recherches Océanographiques, Paris. 21-30 p.

Fonteneau A and Troadec J (1969) Récolte, stockage et traitement des données statistiques relatives à la pêche au chalut en Côte d'Ivoire. Document Scientifique Provisoire 38, ORSTOM, Paris. 19 p.

Foster D, Heins D, Kalla M, McKenzie M, O'Neal J, Park R, Phillips R, Prestholdt J, Sirleaf II A and Young L (2009) "Everyone Scattered" Experiences of the Liberian Diaspora. pp. 301-398 In Rights TAfH (ed.), A house with two rooms: final report of the Truth and Reconciliation Commission of Liberia Diaspora ProjectThree (VII).

Garcia S and Fonteneau A (1971) La pêche de la crevette en Côte d'lvoire. Bilan 1969-1970 et perspectïves ORSTOM, Paris. 4 p.

Garcia S and Poinsard F (1989) The Committee for the Eastern Central Atlantic Fisheries (CECAF) and the management of West African resources: critical review and implications of extended jurisdiction. pp. 121-156 In Miles E (ed.), Management of world fisheries: Implications of extended coastal state jurisdiction. The University of Washington Press, Seattle.

Gerlotto F and Stequert B (1978) La pêche maritime artisanale en Afrique de l'ouest. Caractéristiques générales. La Pêche Maritime 1202, Abidjan. 180 p.

Global Witness (2007) Hot chocolate: how cocoa fueled the conflict in Côte d'Ivoire. The Global Witness, Washington DC. 72 p.

Golé Bi, Golé G, Koffi K and Dadi S (2005) Contribution socio-économique de la pêche artisanale en Côte d'Ivoire. FAO-DFID, Abidjan. 49 p.

Hardman-Mountford N (2000) Environmental variability in the Gulf of Guinea Large Marine Ecosystem Physical features, forcing and fisheries. PhD thesis, University of Warwick, Department of Biological Sciences. 233 p.

Hem S (1976) Statistiques de pêche des sardiniers ivoiriens, année 1975. Serie Statistiques 1, Ministère de la recherche scientifique, Abidjan. 65 p.

Kébé M, Njock J and Gallène J (1997) Revue sectorielle de la pêche artisanale maritime et lagunaire en Côte d'Ivoire. Document Technique 110, DIPA, Cotonou. 80 p.

Koffie-Bikpo CY (2012) Côte d'Ivoire, 50 ans d'indépendance : permanence, mutation et, ou, évolution des territoires. l'Harmattan, Paris.

Konan A (1998) Co-management in Aby Lagoon, Côte d'Ivoire. Proceedings of the International Workshop on Fisheries Co-management, Fisheries Project, Aby Lagoon, Abidjan. 36 p.

Kouadio B (2009) From stability to insurgency: the root and proximate causes of the September 2002 civil war in Côte d'Ivoire. FIU Electronic Theses and Dissertations, Florida International University, Miami. 115 p.

Kouame K and Enoh M (2011) Rapport sur la dynamique de la consommation alimentaire en Côte d'Ivoire.3, Michigan State University. 98 p.

Laë R (1992) Les pêcheries artisanales lagunaires ouest-africaines: échantillonnage et dynamique de la ressource et de l'exploitation. MSc thesis, ORSTOM, Université de Bretagne Occidentale, Brest, Paris. 205 p.

Laë R (1997) Does overfishing lead to a decrease in catches and yields? An example of two West African caostal lagoons. Fisheries Management and Ecology 4(1997): 149-167.

Lankester K, Diouf P and Sane K (2001) Fisheries Access in West Africa. The promotion of sustainable and equitable fisheries access agreements. WWF, Saly Portudal, Senegal. 216 p.

Lassarat A (1957) La pêche du thon en Côte d'Ivoire. Science et Pêche 44: 1-6.

Lassarat A (1958) La pêche en Côte d'Ivoire. Revue des Travaux de l'Institut des Pêches Maritimes 21(1): 31-63.

Mabawonku A (1990) The role and effect if subsidies on fisheries development in West Africa (Nigeria, Côte d'Ivoire, The Gambia and Senegal). CECAF/ECAF Series 90/53, FAO, Rome. Available at: http://www.fao.org/docrep/003/U1990E/U1990E00.htm#TOC [Accessed: 09/12/2013].

Manning P (2011) Support to the implementation of the FCWC regional plan of action on IUU fishing. Project ref. N°CU/PE1/SN/11/011. ACPFish II, Brussels. 43 p.

Ménard F, Fonteneau A, Gaertner D, Nordström V, Stequert B and Marchal E (2000) Exploitation of small tunas by a purse-seine fishery with fish aggregating devices and their feeding ecology in an eastern tropical Atlantic ecosystem. ICES Journal of Marine Science 57: 525-530.

Menard F, Hoëpffner J, Nordström V, Joanny T and Konan J (2001) A Database for the industrial trawl fishery of Côte d'Ivoire. Naga, the ICLARM Quaterly 24.

Morric MacLean L (2004) Mediating Ethnic Conflict at the Grassroots: the Role of Local Associational Life in Shaping Political Values in Côte d'Ivoire and Ghana. The Journal of Modern African Studies 42(4): 589-617.

N'Goran Y (1990) Statistiques de pêche en Lagune Aby (Côte d'Ivoire). La pêche à l'épervier (1988). Arch. Sci. Cent. Rech. Oceanogr. XIII, Centre de Recherche Océanographique d'Abidjan, Abidjan. 10 p.

Njock J and Westlund L (2010) Migration, resource management and global change: Experiences from fishing communities in West and Central Afria. Marine Policy 34(2010): 752-760.

Nunoo FKE, Asiedu B, Amador K, Belhabib D, Lam VWY, Sumaila UR and Pauly D (2014) Marine fisheries catches in Ghana: historic reconstruction for 1950 to 2010 and current economic impacts. Reviews in Fisheries Science & Aquaculture 22(4): 274-283.

Oceana (2004) European trawlers are destroying the oceans. Oceana, Brussels. 77 p.

OECD (2000) Review of fisheries in OECD countries. Volume I Policies and summary statistics. Organisation for Economic Co-operation and Development, Paris.

Pauly D, Belhabib D, Blomeyer R, Cheung WWWL, Cisneros-Montemayor AM, Copeland D, Harper S, Lam VWY, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2013) China's distant-water fisheries in the 21st century. Fish and Fisheries doi: 10.1111/faf.12032.

Pérez-Ruzafa A and Marcos C (2012) Fisheries in coastal lagoons: An assumed but poorly researched aspect of the ecology and functioning of coastal lagoons. Estuarine, Coastal and Shelf Science 110(0): 15-31.

Pigeaud F (2012) En Côte-d'Ivoire, la criée au désespoir. Liberation Terre 27 Aout 2012.

Postel E (1950) La pêche en Côte d'Ivoire. La Pêche Maritime 870, Abidjan. 180 p.

Rey H (1993) L'économie des pêches maritime ivoiriennes. pp. 551-577 In Le Loeuff P, Marchal E and Amon Kothias J (eds.), Environnement et ressources aquatiques de Côte d'Ivoire. ORSTOM, Paris.

Romagny B, Menard F, Dewals P, Gaertner D and N'Goran Y (2000) Le «faux-poisson» d'Abidjan et la pêche sous DCP derivants dans l'Atlantique tropical Est: circuit de commercialisation et role socio-economique pp. 634-652 In Cayre P, Le Gall J and Taquet M (eds.), Pêche thonière et dispositif de concentration de poissons. Colloque Caraibe-Martinique, Trois-Ilets, 15-19 Octobre 1999. Institut de recherche pour le developpement, Institut français de recherche pour l'exploitation de la mer, Ecole nationale supérièure agronomique de Rennes 38. Editions Quae.

Shep H, Traore F and Konan K (2011) Programme régional de renforcement de la collecte de données statistiques des pêches dans les états membres et de la création d'une base de données régionale de renforcement de collecte de données. Enquête cadre-Côte d'Ivoire. Programme Régional UEMOA–Consortium, Ouagadougou. 19 p.

SIF (2010) Sometimes teaching a man to fish is not enough. Stop Illegal Fishing, London. 5 p.

Troadec J, Barro M and Bouillon P (1969) Pêche au chalut sur la radiale de Grand Bassam (Côte d'Ivoire) (mars 1966–fevrier 1967). Doc. Scient. Prov. Centre Rech. Océanogr. Abidjan 33, Centre de Recherche Océanographique d'Abidjan, Abidjan. 14 p.

Troadec J and Garcia S (1979) Les ressources halieutiques de l'Atlantique Centre-Est. première partie: les ressources du Golf de Guinée de l'Angola à la Mauritanie. FAO Document Technique sur les Pêches 186, FAO, Rome. 172 p.

UNDP (2011) The conflict in Côte d'Ivoire and its effect on West African countries: A perspective from the ground UNDP, New York. 8 p.

Valdmanis R and Akam S (2010) Illegal fishing plunders and strains West Africa. ENVIRONMENT, Freetown. 3 p.

Verdeaux F (1981) L'Aizi Pluriel. Chronique d'une ethnie lagunaire de Côte d'Ivoire. Office de la recherche scientifique et technique outre-mer, Abidjan. 303 p.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	14,600	52,700	5,900	41,200	5,200	356
1951	14,223	54,100	7,200	41,000	5,500	481
1952	18,263	57,300	9,900	40,900	5,700	840
1953	17,902	61,300	13,400	40,700	5,900	1,319
1954	17,535	66,600	18,000	40,500	6,100	1,964
1955	17,412	67,800	18,800	40,400	6,300	2,295
1956	20,847	70,000	21,000	40,200	6,500	2,303
1957	26,521	72,600	21,600	41,800	6,800	2,343
1958	26,174	77,200	24,100	43,300	7,100	2,665
1959	29,780	86,500	30,700	44,800	7,300	3,625
1960	34,123	88,200	30,500	46,400	7,600	3,732
1961	35,283	98,000	37,200	47,900	7,800	5,137
1962	36,427	101,500	38,600	49,300	8,100	5,421
1963	36,729	102,300	37,600	50,800	8,300	5,466
1964	45,386	105,200	38,600	52,300	8,600	5,750
1965	47,197	107,200	39,400	52,800	8,800	6,207
1966	44,535	121,200	51,100	53,300	9,000	7,800
1967	44,545	120,100	50,000	53,700	9,200	7,168
1968	47,819	119,200	48,900	54,500	9,400	6,442
1969	43,117	113,400	41,400	55,200	9,500	7,284
1970	38,948	105,500	34,500	55,700	9,700	5,631
1971	51,714	119,400	48,600	56,100	9,800	4,872
1972	48,436	125,100	52,800	56,600	9,900	5,811
1973	36,667	111,700	38,500	57,100	10,000	6,165
1974	44,555	113,500	40,700	57,500	10,100	5,289
1975	37,524	111,700	38,900	58,000	9,700	5,201
1976	57,043	114,600	42,600	57,100	9,700	5,152
1977	42,921	124,500	51,300	56,600	10,300	6,254
1978	43,169	120,400	45,200	57,500	11,600	6,056
1979	44,078	111,100	36,500	57,900	11,200	5,514
1980	35,707	116,300	50,200	52,100	8,200	5,784
1981	38,249	122,300	62,800	46,400	7,600	5,466
1982	36,932	121,500	62,300	44,700	9,300	5,180
1983	40,110	125,400	60,100	51,100	9,200	5,011
1984	39,778	87,800	26,200	48,300	9,800	3,478
1985	60,636	110,500	46,400	50,300	9,800	4,008
1986	61,152	108,200	45,100	49,500	9,800	3,792
1987	61,718	104,500	42,200	48,800	9,700	3,842
1988	50,602	95,200	33,700	48,100	9,500	3,853
1989	59,767	98,800	38,300	47,300	9,400	3,744
1990	67,057	107,100	47,300	46,600	9,300	3,918
1991	54,813	110,800	48,600	45,900	9,200	7,059
1992	65,109	127,500	62,700	45,100	9,100	10,599
1993	50,244	124,400	57,500	44,400	9,000	13,485
1994	52,496	125,000	56,900	43,700	8,900	15,524
1995	53,306	130,700	58,500	45,100	8,900	18,245
1996	55,793	144,300	65,100	48,900	9,000	21,222
1997	50,349	147,600	65,600	49,900	9,000	23,174
1998	55,587	152,400	67,300	50,900	8,900	25,333
1999	63,524	157,200	69,000	51,900	8,900	27,506
2000	66,031	160,100	71,200	50,300	8,800	29,763
2001	62,055	161,000	71,600	48,800	8,700	31,943
2002	44,969	148,800	58,800	47,400	8,600	34,016
2003	44,407	146,200	56,500	45,900	8,400	35,361
2004	47,344	150,600	60,100	44,400	8,300	37,787
2005	27,615	155,300	65,500	43,000	8,200	38,652
2006	46,769	148,300	58,900	41,500	8,100	39,859
2007	42,965	151,900	61,400	40,100	7,900	42,451
2008	44,818	155,800	64,300	38,700	7,800	45,015
2009	38,119	159,700	67,200	37,300	7,700	47,610
2010	56,889	167,400	73,800	35,900	7,600	50,205

Appendix Table A2. Reconstructed total catch (in tonnes), by major taxa for Côte d'Ivoire, 1950-2010. 'Others' contain 78 additional taxonomic categories.

Year	*Ethmalosa fimbriata*	*Sardinella aurita*	*Brachydeuterus auritus*	*Sardinella maderensis*	Scombroids	Balistes	*Pentheroscion mbizi*	*Pteroscion peli*	*Elops lacerta*	Others
1950	18,300	18,000	0	0	0	98	79	79	2,640	13,500
1951	18,700	18,300	0	0	0	131	109	109	2,710	14,100
1952	18,700	18,700	0	0	0	223	197	197	2,790	16,500
1953	19,800	20,300	0	0	0	344	316	316	2,860	17,400
1954	21,200	22,400	0	0	0	507	475	475	2,930	18,600
1955	21,300	22,100	0	0	0	591	556	556	3,010	19,700
1956	19,800	23,100	0	0	0	595	557	557	3,080	22,400
1957	21,100	20,600	794	0	0	596	555	555	3,160	25,100
1958	22,300	22,300	856	0	0	677	633	633	3,240	26,500
1959	24,500	22,600	1,740	0	0	918	870	870	3,320	31,600
1960	24,400	21,400	1,531	0	0	945	895	895	3,400	34,700
1961	25,800	24,800	2,481	0	403	1,281	1,227	1,227	3,480	37,300
1962	26,000	24,700	3,300	0	807	1,336	1,279	1,279	3,560	39,200
1963	25,200	23,400	3,114	0	1,210	1,332	1,272	1,272	3,630	41,900
1964	29,600	24,700	2,632	0	1,614	1,388	1,325	1,325	3,710	38,800
1965	28,600	21,500	6,046	0	2,017	1,487	1,421	1,421	3,790	41,000
1966	32,200	20,500	4,668	0	2,420	1,882	1,780	1,780	3,860	52,100
1967	29,400	22,700	3,898	0	2,824	1,714	1,591	1,591	3,930	52,500
1968	28,500	17,600	1,113	0	3,227	1,516	1,387	1,387	4,030	60,400
1969	25,700	20,000	2,551	0	5,959	1,591	1,506	1,506	4,140	50,400
1970	23,500	10,500	349	12,080	8,691	1,062	985	985	4,200	43,100
1971	22,700	10,400	427	18,440	11,423	748	607	607	4,260	49,800
1972	23,300	7,700	1,080	15,020	14,155	828	688	688	4,320	57,300
1973	24,400	2,200	603	13,410	14,155	884	816	816	4,380	50,000
1974	23,400	1,200	623	15,200	14,155	608	525	525	4,430	52,800
1975	25,300	0	887	18,710	14,155	458	393	393	4,420	46,900
1976	21,600	2,400	3,052	14,750	12,115	453	370	370	4,140	55,300
1977	26,000	1,200	4,891	19,110	11,587	530	440	440	4,270	56,100
1978	26,300	3,700	6,238	11,810	11,060	499	433	433	4,550	55,400
1979	25,400	800	3,563	14,790	10,532	468	427	427	4,510	50,200
1980	23,500	2,000	4,214	9,520	10,004	522	421	421	3,340	62,400
1981	19,600	10,200	4,327	10,820	9,476	407	245	245	2,520	64,500
1982	19,100	14,500	3,858	5,750	8,949	362	197	197	2,540	66,000
1983	22,900	19,000	2,169	4,780	8,421	423	260	260	3,410	63,800
1984	19,200	8,000	1,733	4,340	7,893	448	395	395	3,140	42,300
1985	19,000	25,300	1,349	5,520	7,365	577	442	442	3,440	47,100
1986	19,000	28,100	1,922	2,580	6,838	761	618	618	3,360	44,300
1987	18,800	23,600	2,091	3,370	6,310	789	664	664	3,280	44,900
1988	19,700	13,400	3,325	4,110	5,782	790	709	709	3,200	43,400
1989	20,100	12,000	432	4,450	5,254	793	691	691	3,110	51,300
1990	21,700	14,900	7,192	7,370	4,727	875	737	737	3,030	45,900
1991	20,700	21,900	7,730	2,370	4,199	1,901	1,761	1,761	2,950	45,500
1992	21,500	28,300	7,530	1,970	4,199	3,033	2,839	2,839	2,860	52,500
1993	20,200	19,500	7,599	4,420	4,199	3,962	3,792	3,792	2,780	54,100
1994	19,600	14,700	8,562	6,390	4,199	4,704	4,510	4,510	2,690	55,200
1995	19,900	14,700	8,912	3,780	4,199	5,611	5,403	5,403	2,920	59,900
1996	21,000	22,700	9,334	3,080	4,199	6,591	6,352	6,352	3,480	61,200
1997	22,900	13,700	10,747	2,810	2,831	7,363	7,093	7,093	3,420	69,700
1998	21,400	13,800	6,902	2,280	2,831	8,139	7,837	7,837	3,360	78,100
1999	22,400	13,800	9,943	2,050	2,831	8,917	8,583	8,583	3,300	76,900
2000	20,300	20,600	11,584	2,510	3,350	9,698	9,332	9,332	3,230	70,100
2001	19,500	20,500	8,505	3,040	3,350	10,475	10,085	10,085	3,160	72,400
2002	19,100	8,400	10,530	5,260	3,397	11,192	10,839	10,839	3,090	66,200
2003	15,300	8,600	10,053	3,040	3,397	11,766	11,376	11,376	3,020	68,200
2004	12,400	10,600	10,885	8,910	2,312	12,648	12,223	12,223	2,940	65,400
2005	7,700	13,400	14,850	4,650	2,312	12,834	12,422	12,422	2,870	71,900
2006	6,700	8,300	12,126	3,420	2,312	13,370	12,933	12,933	2,500	73,700
2007	7,300	8,300	11,836	4,570	2,312	14,252	13,790	13,790	2,720	73,000
2008	6,600	5,900	12,200	4,450	2,076	15,137	14,648	14,648	2,450	77,800
2009	6,900	4,700	12,754	4,470	2,076	16,021	15,505	15,505	2,570	79,200
2010	3,200	9,600	13,072	4,730	2,076	16,904	16,362	16,362	1,030	84,100

The marine fisheries of Togo, the 'Heart of West Africa,' 1950 to 2010[1]

Dyhia Belhabib[a], Viviane Kutoub[b] and Daniel Pauly[a]

[a] *Sea Around Us, Fisheries Centre, University of British Columbia*
2202 Main Mall, Vancouver, V6T 1Z4, Canada
[b]*USAID, Dakar, Senegal*

d.belhabib@fisheries.ubc.ca; koutubviviane@gmail.com; d.pauly@fisheries.ubc.ca

Abstract

Fisheries catches in the Togolese Exclusive Economic Zone were reconstructed including small scale marine and lagoon fisheries, commercial large scale fisheries, illegal foreign fisheries and discards by both the domestic and foreign sectors. In the last two decades, total domestic catches showed a decrease, in contrast to the positive trend observed in the data supplied to FAO. Moreover, with a total of 2.3 million tonnes compared to 560,000 tonnes between 1950 and 2010, domestic catches were 4.1 times the catch supplied to FAO. This study also shows higher foreign fisheries removals than what is officially reported, with the foreign legal and illegal catch representing almost a quarter of the total reconstructed catch. These catches are masked by the reflagging practices of Togo and the lack of fisheries monitoring and enforcement, which illustrates a general *laisser faire* in the Togolese fisheries policy, and threatens poverty alleviation strategies and food security within local communities trapped between the over-exploitation of fisheries and the anticipated effects of climate change.

Introduction

Togo, a small West African country stretching 600 km from the edge of the Sahel in the North to the coast of the Gulf of Guinea in the South, where it has a width of 56 km, consequently has an extremely small Exclusive Economic Zone (EEZ), and an even smaller shelf (Figure 1).

Unmonitored and uncontrolled, freshwater and coastal lagoon fisheries of Togo generate relatively high yields, but remain largely understudied. Marine fisheries, which apparently generate higher yields, are given more importance in the few studies that are available for Togo. In fact, these fisheries, similar to those of Benin, are mostly mentioned *en passant* in reviews of the Gulf of Guinea fisheries (Écoutin *et al.* 1993; Guiffre 1993; Horemans 1993, 1994, 1995).

Here, we try to overcome this by assembling all the information that we could obtain on the Togolese fisheries, and particularly on their catches since 1950, using early 'grey literature' gathered during a short stay in that country (by DP in Oct. 1971), as well as from the more recent peer-reviewed and report literature, both on and offline, with particular emphasis to colonial and 'development' sources in German and French.

Togo, was known under various names highlighting a rich historical past. Its coast, used as a slave trading platform, earned Togo the name of 'Slave Coast'; as a German colony from 1884 to 1918, it became 'Togoland', before it was transferred to France as part of the French colonial empire in West Africa, to finally gain independence in 1960.

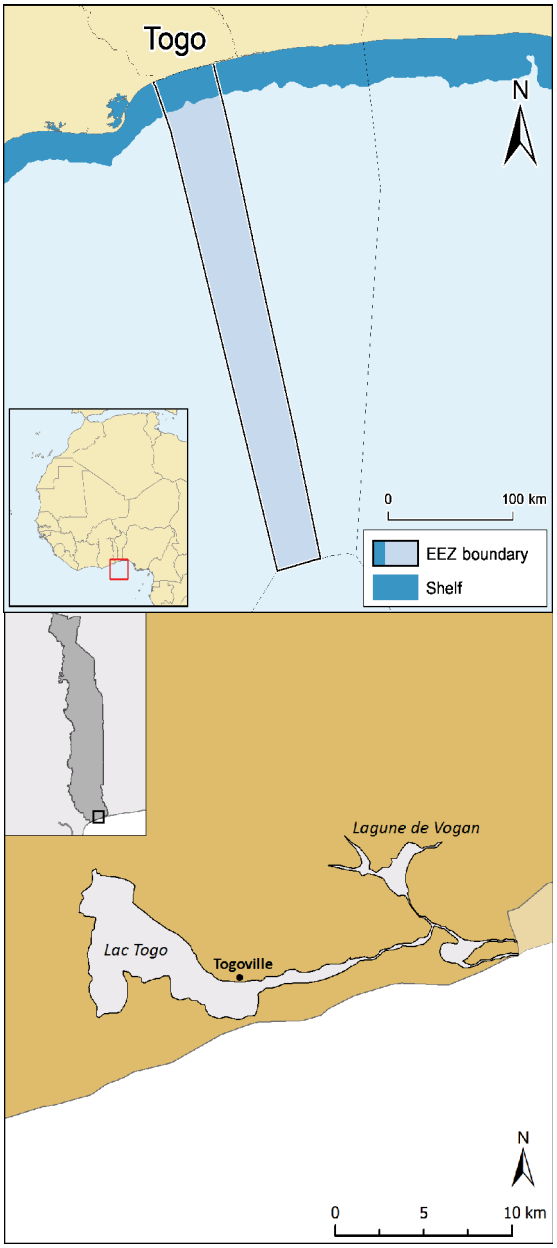

Figure 1. a) Map of Togo showing the Exclusive Economic Zone of Togo, and b) showing the coastal lagoons of Togo.

[1] Cite as: Belhabib, D., Kutoub, V. and Pauly, D. (2015) The marine fisheries of Togo, the 'heart of West Africa,' 1950 to 2010. pp. 37-50. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

However, the ties which Togo retained to Germany where instrumental for the decade-long marine fisheries development project initiated in the mid-1960s, which brought industrial fishing, specifically bottom trawling, onto the Togolese shelf (Karger and und Steinberg 1969).

This development was meant to complement the existing small-fisheries, but these were soon seen as competitors to the trawl fisheries, if mainly because their beach seines and other gear tended to exploit the juvenile stages of species potentially exploitable as adults further offshore by the newly supplied trawler (Beck 1974, 1977). These dynamics still exists, in Togo and elsewhere, though as rather typical competition between foreign trawlers and local small-scale fishers (Pauly 2006), the implantation of a locally-based industrial fishery having failed. These dynamics, and the foreign element that they entail, are also the reason why the catches of the marine fisheries of Togo, despite their small size, are difficult to disaggregate into subsectors.

Methods

The majors sources of information used here are peer reviewed and grey literature along with media reports; the data they contained we analyzed using the catch reconstruction methods in (Zeller *et al.* 2007), which, in the main, consists of:

1) Using the available catch estimate as 'anchor points', between which linear interpolations were used to provide preliminary catch estimates for years without data;

2) Using demographic data to extrapolate estimates of small-scale fisher numbers (incl. beach seine operators) to years for which such estimates were lacking; and

3) Generally: provide (conservative) estimates where there was evidence of a non-zero catch.

The procedure used for the various subsectors was a follows:

Small-scale fisheries

Small scale fisheries include two major sectors, subsistence fisheries operated in (brackish-water) coastal lagoons (freshwater fisheries are not considered here), and marine artisanal fisheries conducted from beaches (beach seines and set nets) or by pirogues.

Lagoon subsistence fisheries

The statistics on lagoon fisheries are included in the continental water component, and the fisheries are not monitored (FAO 2007). Thus the catch data supplied to FAO pertains mostly to freshwater species. Most lagoon fishery catches in Togo are for personal consumption and are not marketed (Laë 1992), which differs from neighboring Ghana, where the catch of lagoon fishers are mostly sold (Pauly 1976). They are operated by mostly occasional and seasonal fishers who practice agriculture at the same time (Laë 1992). Therefore, this fishery is considered a subsistence fishery. Coastal lagoons in Togo, as elsewhere along the gulf of Guinea are exploited either traditionally or by means of extensive ranching systems called *acadjas*.

Traditional fishing

The mapping by Weigel (1985) for Lac Togo, which despite its name is a coastal lagoon, in 1960 revealed 19 villages over a total of 37, where 700 pirogues are active operated by 2.5 fishers at average (de Surgy 1966; Bama 1984). Considering a total of 37 villages and 5,300 permanent fishers (Alsopp 1966), i.e., 51 pirogues per villages and 143 fishers, the remaining 18 villages not covered by Weigel (1985) would shelter 2,574 fishers and 918 additional pirogues in 1960. Thus the total number of fishers for 1960 is estimated at 4,324 fishers. These numbers are conservative because they do not include part time and seasonal fishers, and children (de Surgy 1966). For 1978, Dioury (1983) estimated the number of pirogues at 2,000, with 2.5 fisher per pirogue (Bama 1984), i.e., a total of 5,000 fishers. Laë (1992) reported a total number of 1,800 fishers in 1984 for 33 villages, i.e., 2,372 fishers in 37 villages in total. The number of pirogues was estimated at 1,000 in 1985 (Weigel 1985), 1,100 in 1989 (Sedzro and Kusiaku 1999), 793 in 2007 (IRD 2011) and assumed constant thereafter. Assuming a constant number of fishers per pirogue at 2.5, we estimated the number of fishers at 2,500 in 1985, 2,750 in 1989, 1,586 in 2007 onwards, then we performed a series of linear interpolations to complete the time series. The CPUE per fisher declined from 1.7 $t \cdot year^{-1} \cdot fisher^{-1}$ in the mid-1960s to 0.53 $t \cdot year^{-1} \cdot fisher^{-1}$ in the mid-1980s (Laë 1997). Given the strong decline in lagoon catches and the over-exploitation already reported in the 1960s (de Surgy 1966), we assumed the CPUE in 1950 was 20% higher than in 1965 (2.05 $t \cdot year^{-1} \cdot fisher^{-1}$). Pérez-Ruzafa and Marcos (2012) estimated a CPUE of 0.59 $t \cdot year^{-1} \cdot fisher^{-1}$ in 2012. Thus we interpolated linearly CPUE estimates and multiplied these by the total number of fishers to estimate the traditional lagoon catch in Togo from 1950 to 2010.

Acadja catches

Acadjas are extensive ranching techniques that rely on wild fish being concentrated in "dense masses of branches planted in the muddy bottom" (Welcomme 1972), in which they find shelter and food. *Acadjas* were introduced in Togo in the mid-1950s (King 1993), and because of their uncontrolled proliferation, which created conflicts between traditional fishers and fishers using this new technique, and also because of the deforestation they induce, they were prohibited in 1975 (Weigel 1985). However, the higher productivity (Kapetsky 1981) and the lack of control is undoubtedly encouraging an illegal use that is still common in Togolese lagoons (SOFRECO 2011). Weigel (1985) estimated a total number of 133 *acajda* systems in Togo of 0.7 ha each and a productivity of 5 $t \cdot ha^{-1}$ from 1969 to 1972. The resulting catch would be the product of the number of *acadja* systems, the average surface and the productivity, i.e., 451 t from 1969 to 1972. We assumed catches induced by *acadjas* in 2010 were half the catch of 1972, i.e., 226 in one hand because of the unenforced prohibition but mostly because of over-exploitation and pollution. We interpolated catches from 0 t in 1954 right before the introduction of the *Acadja* technique to Togo, to 451 t in 1969 and then from 541 t in 1972 to 226 t in 2010.

Table 1. Species composition of lagoon catches

Scientific name	Common name	%
Clarias gariepinus	North African catfish	2.3
Heterotis niloticus	African bonytongue	0.5
Parachanna obscura	African snakehead	0.8
Hepsetus odoe	Kafue pike	0.2
Schilbe mystus	African butter catfish	0.1
Pellonula leonensis	Smalltoothed pellonula	0.4
Chrysichthys spp.	Bagrid catfishes	14.0
Gerres spp.	Silver biddies	1.4
Hemichromis fasciatus	Banded jewelfish	1.3
Sarotherodon melanotheron	Blackchin tilapia	57.9
Tilapia guineensis	Guinean tilapia	7.6
Ethmalosa fimbriata	Bonga shad	1.2
Liza falcipinnis	Sicklefin mullet	1.9
Pomadasys jubelini	Sompat grunt	0.1
Elops lacerta	West African ladyfish	0.4
Polydactylus quadrifilis	Giant African threadfin	0.1
Callinectes amnicola	Bigfisted swimcrab	7.6
Farfantepenaeus notialis	Southern pink shrimp	2.1

Traditional lagoon and *acadja* catches are overwhelmingly dominated by the blackchin tilapia *Saratherodon melanotheron* and the Guinean tilapia *Tilapia guineensis* (50-70%), the rest consisting of a near equal mix of coastal marine and continental (freshwater) species (Laë 1994). We applied the species disaggregation provided by Laë (1994) to traditional and acadja lagoon catches (Table 1).

Artisanal marine fishery

Land based fishing

Coastal population data was extracted from the Center for International Earth Science Information Network (CIESIN 2012) for 1990, 2000 and 2010 (Table 2) within a range of 10 km of the coast from, and total population data was extracted from Populstat (www.populstat.info [2012]) and the Worldbank (www.worldbank.org [2012]) databases from 1950 to 2010 (Table 2). We estimated the proportion of coastal population over the total population at 19% for 1990, 2000 and 2010. We assumed this rate was constant from 1950 to 2010, and thus could estimate the annual coastal population in Togo (Table 2). In 1965, fishers used 345 cast nets the majority of which were operated by individual land-based fishers (80%), 135 beach seines, half of which uses at average 30 fishers on land and 36 handlines (de Surgy 1966). Thus the total number of land-based fishers in 1965 was estimated at 2,334 permanent land based fishers, and 2,000 seasonal land-based fishers (de Surgy 1966) working 42% less (Laë 1992), which translates to 1,164 permanent working fishers. The total number of land based fishers is the sum of the two categories (3,170 in 1965). This number represented 1.08% of the coastal population in 1965. Using the same method, based on the data by IRD (2011), 208 handlines, 2,146 nets of which we conservatively assumed 20% were operated from land by individual fishers, 62 beach seines, i.e., 930 land based fishers. Thus the total number of land-based fishers for 2010 was estimated at 1,567, i.e., 0.14% of the coastal population. We assumed the rate was constant from 1950 to 1965 and interpolated from 1.08% in 1965 to 0.14% in 2010. Then we applied these rates to the coastal population data per year and estimated the number of artisanal land-based fishers from 1950 to 2010 (Table 2). We assumed the CPUE per fishers working on a pirogue was similar to the CPUE of a land based fisher since the two categories operate in similar areas and use similar gears. The number of fishers per pirogue increased from an average of 4.75 in the 1950s and 1960s (de Surgy 1966) to 8.43 fishers per pirogue in 2010 based on the estimates of the number of pirogues and the number of pirogue based fishers by (IRD 2011). We performed a linear interpolation and estimated the land based catch as the product of the CPUE per fishers, i.e., CPUE per pirogue (estimated in artisanal fishing above) divided by the number of fishers per pirogue, and the total number of land based fishers.

A detailed analysis of the catch composition of the beach seine catch in 1973 was presented by Beck (1974, 1976), documenting a catch consisting of most of the groups making up the "shallow water" community, dominated by croakers (Family Sciaenidae; Longhurst and Pauly 1987, p151). We used this description to break down land based catches onto taxonomic groups (Table 3).

Table 2. Total population, coastal population and land based fishers estimates in Togo. Interpolations are italicized.

Year	Total population (x 10^3)	Coastal population (x 10^3)	Land based fishers as percentage of coastal population (%)	Number of land based fishers
1950	1,212	230	1.08	2,488
1951	1,241	236	1.08	2,548
1952	1,267	241	1.08	2,601
1953	1,291	245	1.08	2,650
1954	1,316	250	1.08	2,702
1955	1,343	255	1.08	2,757
1956	1,372	261	1.08	2,816
1957	1,404	267	1.08	2,882
1958	1,437	273	1.08	2,950
1959	1,450	276	1.08	2,977
1960	1,444	274	1.08	2,964
1961	1,482	282	1.08	3,042
1962	1,520	289	1.08	3,120
1963	1,613	306	1.08	3,311
1964	1,655	314	1.08	3,397
1965	1,704	324	1.08	3,498
1966	1,760	334	1.06	3,540
1967	1,822	346	1.04	3,592
1968	1,889	359	1.02	3,649
1969	1,955	371	1.00	3,698
1970	1,962	373	0.97	3,633
1971	2,013	382	0.95	3,648
1972	2,066	393	0.93	3,661
1973	2,119	403	0.91	3,671
1974	2,174	413	0.89	3,680
1975	2,231	424	0.87	3,687
1976	2,289	435	0.85	3,692
1977	2,348	446	0.83	3,694
1978	2,409	458	0.81	3,694
1979	2,473	470	0.79	3,693
1980	2,554	485	0.77	3,713
1981	2,615	497	0.74	3,697
1982	2,770	526	0.72	3,806
1983	2,890	549	0.70	3,856
1984	2,960	562	0.68	3,831
1985	3,028	575	0.66	3,799
1986	3,144	597	0.64	3,819
1987	3,248	617	0.62	3,816
1988	3,381	642	0.60	3,837
1989	3,507	666	0.58	3,841
1990	3,638	694	0.56	3,855
1991	3,761	717	0.53	3,834
1992	3,899	744	0.51	3,819
1993	4,026	768	0.49	3,783
1994	4,010	765	0.47	3,607
1995	4,085	779	0.45	3,511
1996	4,230	807	0.43	3,467
1997	4,345	829	0.41	3,387
1998	4,458	850	0.39	3,297
1999	4,567	871	0.37	3,195
2000	5,019	951	0.35	3,290
2001	5,153	977	0.32	3,174
2002	5,051	958	0.30	2,910
2003	5,170	980	0.28	2,773
2004	5,288	1003	0.26	2,626
2005	5,408	1025	0.24	2,471
2006	5,530	1048	0.22	2,307
2007	5,653	1072	0.20	2,133
2008	5,777	1095	0.18	1,951
2009	5,902	1119	0.16	1,758
2010	6,028	1143	0.14	1,567

Pirogue fishing

The number of pirogues was documented since 1962, and remained relatively constant since then (Table 4). We assumed conservatively that the number of pirogues was 20% lower in 1950 than in 1962 (Table 4), since evidence suggests the number of pirogues increased slightly to 'chase' sardinella and sardine stocks going further from the coast, migration caused by industrialization and over-exploitation of coastal areas (Welcomme 1972). Thereafter, we interpolated the number of pirogues between the anchor points from 1950 to 2010 (Table 4). As for the catch per unit of effort, in 1978, based on a catch of 12,003 $t \cdot year^{-1}$ and an effort of 346 pirogues (Amégavie 1979), we estimated a CPUE of 34.69 $t \cdot year^{-1} \cdot boat^{-1}$. Because of the over-exploitation pattern of coastal areas in Togo, constrained by a higher motorization rate in 2010, we assumed the CPUE in 2010 was 10% lower than the CPUE in the mid-1970s. Similarly in 1950, because of a consequent lower motorization (0%; Welcomme 1972), we assumed the CPUE in 1950 was 20% lower than in 1983. We then interpolated linearly from 27.75 $t \cdot year^{-1} \cdot boat^{-1}$ in 1950 to 34.69 $t \cdot year^{-1} \cdot boat^{-1}$ in 1978, and then to 31.22 $t \cdot year^{-1} \cdot boat^{-1}$ in 2010. Thereafter, we multiplied the yearly number of pirogues by the corresponding CPUE to estimate the pirogue based marine artisanal catches in Togo from 1950 to 2010.

We applied a species disaggregation using the 1991-1995 catch data from Denke (1997) converted to rates, then averaged (Table 5) and then applied on the artisanal catches from 1950 to 2010.

Recreational fisheries

While growing up in Togo, V.K did not observe significant recreational fishing activities; however a few recreational fishing clubs were created by expatriates, notably during the last 16 years. Three clubs were documented, the first in 1997, the second in 2004 and the third in 2007 (FAO 2007)[1]. These clubs often sell their catches to restaurants. We assumed that the number of fishers per club was 20, i.e., that they was a total of 20 fishers in 1997, 40 fishers in 2004 and 60 fishers in 2007. We extrapolated the trend and estimated the number of recreational fishers at 68 for 2010. We assumed the number of trips to be 4 per month (i.e., one day per week end) during six months of the year corresponding to the dry season (24 trips·fisher^{-1}·year^{-1}). We estimated the CPUE based on four YouTube videos posted by recreational fishers/clubs from Togo, which showed the species caught and the number of recreational fishers (5). We approximated the weight for each species, then estimated the mean CPUE as 13.6 kg·fisher^{-1}·trip^{-1}. We multiplied the number of fishers by the number of trips and the CPUEs and obtained a catch of 6.5 t for 1997, 13.1 t for 2004, 19.6 t for 2007 and 22.2 t for 2010. We interpolated linearly assuming recreational fishing began after the last *coup d'état* in 1967, which was followed by a certain political stability. We obtained the species breakdown by averaging the total catch by species by the total for all species (by all fishers), i.e., 515 of wahoo (*Acanthocybium solandri*), 21% of groupers (Fam. Serranidae), 7% of Carangidae, 7% of Muraenidae, 7% of dolphinfish (*Coryphaena hippurus*) and 7% of other species.

Table 3. taxonomic composition of the beach seine (land-based) fishery (Beck 1976)

Scientific name	Common name	%
Albula vulpes	Bonefish	0.1
Ilisha africana	West African ilisha	1.4
Sardinella rouxi	Yellowtail sardinella	5.1
Sardinella aurita	Round sardinella	0.9
Sardinella maderensis	Madeiran sardinella	40.7
Engraulis encrasicolus	European anchovy	4.3
Lagocephalus laevigatus	Smooth puffer	0.1
Hemirhamphus balao	Balao halfbeak	1.4
Sphyraena afra	Guinean barracuda	4.8
Galeoides decadactylus	Lesser African threadfin	3.6
Lutjanus fulgens	Golden African snapper	0.1
Pomadasys jubelini	Sompat grunt	0.1
Brachydeutrerus auritus	Bigeye grunt	16.2
Gerres melanopterus	Flagfin mojarra	1.0
Pteroscion peli	Boe drum	0.2
Pseudotolithus senegalensis	Cassava croaker	0.3
Trachinotus ovatus	Pompano	0.1
Uraspis secunda	Cottonmouth jack	<0.1
Decapterus punctatus	Round scad	1.1
Selar crumenophtalmus	Bigeye scad	1.2
Caranx hippos	Crevalle jack	0.2
Caranx crysos	Caranx crysos	2.2
Caranx senegalus	Senegal jack	0.2
Chloroscombrus chrysurus	Atlantic bumper	11.2
Vomer setapinnis	Atlantic moonfish	2.4
Pseudupeneus prayensis	West African goatfish	0.2
Sparus ehrenbergi	Pagrus caeruleostictus	0.1
Orcynopsis unicolor	Plain bonito	0.5
Solea spp.	Soles	0.1
Cephalopoda	Cephalopods	0.1
Penaeus spp.	Shrimps	0.1

Large-scale fisheries

Industrial

Industrial fishing in Togo is conducted by visibly reflagged fleets to Togo (mostly), vessels under joint ventures, and vessels operating under agreements. Thus here, the 'Togolese' fleet is comprised of ostensibly Togolese vessels, i.e., vessels whose origin we couldn't trace. The number of industrial vessels in Togo was reported by different sources (Table 6), and the origin of vessels was reported in a few instances (Table 6); thus using these numbers, we performed a series of linear interpolation and completed the effort time series per country of origin, the difference between the total number of industrial vessels as documented by the literature and the sum of the interpolated effort per country of origin, is in the category other origin (Table 6). The CPUE was estimated by Beck (1976) at 235 t·year^{-1}·boat^{-1} in 1973 and we assumed this CPUE was constant since the introduction of industrial fishing to Togo in 1965. In the 2000s, vessels were larger, with 1,416 GRT (www.grosstonnage.com) on average compared to around 200 GRT in the 1970s (Beck 1976), i.e., increased by a factor of 7. We assumed the CPUE increased proportionally however at a lower extent given evidence of over-exploitation, i.e., by a factor of 5, resulting in a CPUE of 1,175 t·year^{-1}·boat^{-1}. We performed a linear interpolation to complete the CPUE time series and multiplied the CPUEs by the estimated effort per country.

Table 4. Anchor points of artisanal pirogues and the corresponding CPUE, italics indicate interpolations. Data were interpolated for the missing years.

Year	Number of pirogues	Motorized (%)	Reference	CPUE (t·year^{-1}·boat^{-1})
1950	370[a]	-	-	27.75[b]
1962	463	-	Alsopp (1966)	*30.74*
1966	255	23	Amégavie (1979)	*31.73*
1967	388	16	Amégavie (1979)	*31.98*
1968	386	24	Amégavie (1979)	*32.23*
1969	416	24	Amégavie (1979)	*32.47*
1970	237	41	Amégavie (1979)	*32.72*
1971	545	24	Amégavie (1979)	*32.97*
1972	559	28	Amégavie (1979)	*33.22*
1973	550	31	Amégavie (1979)	*33.47*
1974	540	41	Amégavie (1979)	*33.71*
1975	603	42	Amégavie (1979)	*33.97*
1976	218	62	Amégavie (1979)	*34.21*
1977	409	79	Amégavie (1979)	*34.46*
1978	346	85	Amégavie (1979)	*34.69*[c]
1979	603	70	Dioury (1983), Bama (1984)	*34.60*
1992	510		Horemans (1994)	*33.19*
1996	403	45	Sedzro and Kusiaku (1999)	*32.75*
2002	407	40	Segniagbeto and Waerebeek (2010)	*32.10*
2003	400		Anon. (2010)	*31.99*
2007	407		IRD (2011)	*31.56*
2010	407		Assumed constant	31.22[d]

a) assumed to be 20% lower than the number of pirogues in 1962, year of first survey;
b) assumed to be 20% of the CPUE in 1978;
c) based on the estimate of the catch and effort by Amégavie (1979);
d) assumed to be 10% lower than the CPUE in 1978.

The catch composition of trawlers (Table 7) provided by Beck (1977) is dominated by species of the shallow water Haemulidae-dominated community (reaching down to about 40 m) and represented by the bigeye grunt *Brachydeuterus auritus* and of the species from bellow the thermocline, i.e., the species of the Sparidae community (Longhurst and Pauly 1987). While pelagic catches were assumed to include 70% of Sardinella and 30% of other unidentified taxonomic groups, since seiners in Togo target mostly sardinellas (Bama 1984).

Table 5. Catch composition of the artisanal pirogue fishery in Togo

Scientific name	English name	Local name	%
Engraulis encrasicolus	Anchovy	Anchois	68.41
Sardinella spp.	Sardinella	Sardinelle	5.75
Sardinella maderensis	Madeiran sardinella	Hareng	2.38
Scomber japonicus	Chub mackerel	Maquereau	1.50
Carangidae	Jacks and pompanos	Chinchard	1.90
Caranx hippos	Crevalle jack	Carangue	4.85
Euthynnus alletteratus	Little tunny	Bonite	2.66
Pagellus bellottii	Red pandora	Pageot	1.21
Ilisha africana	West African ilisha	Rasoir	0.84
Sphyraena spp.	Barracuda	Brochet	0.64
Selene dorsalis	African moonfish	Vomer	0.06
Tylosurus crocodilus crocodilus	Hound needlefish	Orphie	0.28
Boops boops	Bogue	Bogue	0.29
Galeoides decadactylus	Lesser African threadfin	Hormose	0.29
Drepane africana	African sicklefish	Disque	0.05
Trichiurus lepturus	Largehead hairtail	Ceinture	0.04
Dactylopterus volitans	Flying gurnard	Poisson volant	1.29
Hemiramphus balao	Balao halfbeak	Demi-bec	0.01
Elops lacerta	West African ladyfish	Faux mulet	0.04
Pseudotolithus	Croakers	Bar	0.47
Xiphias gladius	Swordfish	Espadon	0.13
Brachydeuterus auritus	Bigeye grunt	Friture	0.42
Centrophorus granulosus	Gulper shark	Requin	0.08
Scombridae	Tunas	Thon	0.34
Lutjanus spp.	Lutjanus (Snappers)	Lutjanus	1.03
Dentex spp.	Dentex	Dorade rose	1.23
Lethrinus atlanticus	Atlantic emperor	Dorade grise	0.11
Epinephelus spp.	Grouper	Merou	0.45
Pomadasys jubelini	Sompat grunt	Pristipoma	0.03
Coryphaena equiselis	Pompano dolphinfish	Cameleon	0.03
Palinurus spp.	Spiny lobster	Langouste	0.01
Penaeus spp.	Shrimps	Crevette	0.01
Umbrina spp.	Drums	Ombrine	0.02
Raja spp.	Rays	Raie	0.08
Polydactylus quadrifilis	Giant African threadfin	Capitaine	0.09
Balistes capriscus	Grey triggerfish	Baliste	0.02
Pseudupeneus prayensis	West African goatfish	Rouget	0.03
Solea spp.	Sole	Sole	0.04
Psettodes belcheri	Spottail spiny turbot	Turbot	<0.01
Sepia spp.	Cuttlefish	Seiche	0.12
Dentex macrophthalmus	Large-eye dentex	Gros yeux	0.01
Carlarius heudelotii	Smoothmouth sea catfish	Poisson chat	<0.01
Paraconger notialis	Guinean conger	Congre	<0.01
Lagocephalus laevigatus	Smooth puffer	Peroquet	0.01
Marine fishes not identified	Marine fishes not identified	Divers	2.74

Discards

To estimate discards by the domestic fleet, we used the average discard rate between the neighbouring Ghana and Benin, i.e., 0.9% of landed catches (Kelleher 2005). This low rate is explained by the use of bycatch for 'African mix', a popular product in West Africa; thus the low-value bycatch is landed and transformed. Using the same source, we estimated an average discard rate of 14.9% of the landed catch between Spain (30%), Ghana (1.3%), Greece (32.8%), Cyprus (0.1%), and Guinea (0.5%), which we applied on the catch by each foreign country operating in Togo.

Discarded species include mostly undersized commercial species and other species not identified. Therefore, we applied the same species disaggregation than for the trawl catches.

Illegal industrial fisheries

Illegal catches are catches by unauthorized foreign vessels in the Togolese EEZ. MRAG (2005) estimated the Illegal Unregulated Unreported (IUU) catch as 32% of the total catch in Togo in the 2000s, consequently we interpolated from zero in 1985 prior the declaration of the EEZ to 32% of the total catch (47% of the reconstructed catch) from 2005 to 2010. We then applied these rates to the reconstructed catch including industrial and small-scale marine catches. We then applied the same species disaggregation as for the legal fishery, assuming the same countries' contributions. Although rates of illegal fishing were documented, countries responsible for illegal fishing in Togolese waters were not always identified. In two instances, we found media reports of trawlers as being "mostly from Asia" (Anon. 2012a), China based in Ghana and Ghanaian canoes operating illegally (Anon. 2012b). Ghanaian canoes, although artisanal in nature, due to their size can travel long distances for fishing[2]. Therefore, we assumed illegal catches to be 70% Chinese (more efficient industrial vessels) and 30% by Ghanaian canoes, which are here considered 'industrial' because they operate internationally. We then applied the same species disaggregation than for industrial legal fleets.

[2] Given the definitions built in the database of the *Sea Around Us*, Ghanean Fanti canoes are labelled as 'industrial' because they operate outside their own national waters, i.e., Ghana's EEZ.

Table 6. Number of pelagic and demersal fishing vessels in Togo by country of origin. Interpolation are indicated in italics.

		Country of origin										Pelagic	Source
Year	Total	Togo	Germany	Greece	Italy	Cyprus	Spain	Guinea	Ghana	Other[a, b]	China	Togo	
1950-1964	0	0	0	0	0	0	0	0	0	0	0	0	
1965	**2**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	**0**	Beck (1974)
1966	*2*	0	*2*	0	0	0	0	0	0	0	0	*1*	
1967	*2*	0	*2*	0	0	0	0	0	0	0	0	*1*	
1968	*2*	0	*2*	0	0	0	0	0	0	0	0	*2*	
1969	*2*	0	*2*	0	0	0	0	0	0	0	0	*3*	
1970	*2*	0	*2*	0	0	0	0	0	0	0	0	*3*	
1971	*2*	0	*2*	0	0	0	0	0	0	0	0	*4*	
1972	*2*	0	*2*	0	0	0	0	0	0	0	0	*4*	
1973	**2**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	*5*	Beck (1976)
1974	*2*	0	*2*	0	0	0	0	0	0	0	0	*6*	
1975	*2*	0	*2*	0	0	0	0	0	0	0	0	*6*	
1976	**7**	***0***	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	0	**7**	Bama (1984)
1977	**4**	***0***	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	0	**10**	Dioury (1983), Bama (1984)
1978	**10**	***1***	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**7**	0	**11**	Bama (1984)
1979	**12**	***1***	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**8**	0	**11**	Dioury (1983)
1980	**2**	***1***	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**0**	0	**4**	Bama (1984)
1981	**3**	***1***	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**0**	0	**13**	Bama (1984)
1982	**7**	***1***	**0**	**1**	**0**	**0**	**0**	**0**	**4**	**1**	0	**11**	Dioury (1983), Amégavie (1986)
1983	**5**	**2**	**0**	**2**	**0**	**1**	*0*	*0*	*4*	**0**	0	**4**	Amégavie (1986)
1984	**1**	**1**	**0**	**3**	**0**	*1*	*1*	*0*	*4*	**0**	0	*4*	Amégavie (1986)
1985	**4**	**1**	**0**	**3**	**1**	***1***	***1***	***0***	***3***	**0**	0	*4*	Amégavie (1986)
1986	4	1	0	3	1	*1*	*2*	*0*	*3*	**0**	0	*4*	
1987	5	1	0	3	1	*1*	*2*	*0*	*3*	**0**	0	*3*	
1988	5	0	0	2	1	*1*	*2*	*0*	*3*	**0**	0	*3*	
1989	5	0	0	2	1	*1*	*3*	*0*	*3*	**0**	0	*3*	
1990	6	0	0	2	2	*1*	*3*	*1*	*3*	**0**	0	*3*	
1991	6	0	0	2	2	*1*	*4*	*1*	*3*	**0**	0	*3*	
1992	**6**	**0**	**0**	**2**	**2**	*1*	**4**	*1*	*2*	**0**	0	*3*	Oceana (2011)
1993	**7**	**0**	**0**	**2**	**2**	*1*	**4**	*1*	*2*	**0**	0	*3*	Oceana (2011)
1994	**7**	**0**	**0**	**2**	**2**	*1*	**4**	*1*	*2*	**0**	0	*2*	Oceana (2011)
1995	**7**	**0**	**0**	**2**	**2**	*1*	**4**	*1*	*2*	**0**	0	*2*	Oceana (2011)
1996	**8**	**0**	**0**	**2**	**2**	*1*	**4**	*1*	*2*	**0**	0	*2*	Oceana (2011)
1997	**8**	**0**	**0**	**2**	**2**	*1*	**4**	*1*	*2*	**0**	0	*2*	Oceana (2011)
1998	**9**	**0**	**0**	**2**	**2**	*1*	**4**	*1*	*2*	**0**	0	*2*	Oceana (2011)
1999	9	1	0	**2**	**2**	**0**	**4**	*1*	*1*	**0**	0	*2*	Segniagbeto and Waerebeek (2010), Oceana (2011)
2000	*9*	**1**	**0**	**2**	**2**	**0**	**4**	*1*	*1*	**0**	0	*1*	Oceana (2011)
2001	*10*	1[c]	0	2	2[c]	0	4[c]	*1*	*1*	**0**	0	*1*	
2002	*10*	1[c]	0	2	2[c]	0	4[c]	*1*	*1*	**0**	0	*1*	
2003	*11*	1[c]	0	2	2[c]	0	4[c]	*1*	*1*	**0**	0	*1*	
2004	*11*	1[c]	0	2	2[c]	0	4[c]	*2*	*1*	**0**	4[c]	*1*	
2005	*12*	1[c]	0	2	2[c]	0	4[c]	*2*	*1*	**0**	4[c]	*1*	
2006	*12*	1[c]	0	2	2[c]	0	4[c]	*2*	*0*	**1**	4[c]	*1*	
2007	*13*	1[c]	0	2	2[c]	0	4[c]	*2*	*0*	**1**	4[c]	*0*	
2008	*13*	1[c]	0	2	2[c]	0	4[c]	*2*	*0*	**2**	4[c]	*0*	
2009	*13*	1[c]	0	2	2[c]	0	4[c]	*2*	*0*	**2**	4[c]	*0*	
2010	**14**	**1**	**0**	**2**	**2**	**0**	**4**[c]	**2**	**0**	3	4[c]	0	IRD (2011), SOFRECO (2011)

a) France and Switzerland are among the unidentified flags;

b) Represents the difference between the sum of trawlers and the total provided by the literature. When the estimated total number of trawlers was higher than the estimate given by the literature, we assumed these vessels were simply not reported by the literature since a number of trawlers using the Togolese flag in the Togolese EEZ were not reported by the literature (Segniagbeto and Waerebeek 2010);

c) assumed constant.

Results

Small-scale catches

Small-scale catches, including artisanal marine and subsistence lagoon catches, totalled 2.24 million tonnes between 1950 and 2010. Catches increased slightly from 33,200 t in 1950 to a peak of 48,700 t in 1975, and then decreased to less than 19,700 t in 2010 (Figure 2).

Table 7. Catch composition of the industrial trawl fishery in Togo (Beck 1976)

Scientific name	Common name	%
Pagellus coupei	Red pandora	10
Dentex spp.	Dentex	10
Lethrinus atlanticus	Atlantic emperor	10
Brachydeuterus auritus	Bigeye grunt	29
Trachurus trecae	Cunene horse mackerel	2
Caranx hippos	Crevalle jack	4
Chloroscombrus chrysurus	Atlantic bumper	2
Pseudupeneus prayensis	West African goatfish	7
Epinephelus aeneus	White grouper	3
Pomadasys jubelini	Sompat grunt	2
Pseudotolithus spp.	Croakers	2
Marine fishes not identified	Marine fishes not identified	20

Artisanal catches

Artisanal catches increased from 24,816 t in 1950 to a peak of 43,100 t in the 1975 and then decreased again to be at 18,600 t in 2010, their historical minimum (Figure 3). Artisanal marine catches totalled 1.97 million tonnes between 1950 and 2010, of which over half (56%) was generated by marine land-based fisheries, i.e., 1.1 million tonnes

(Figure 3). Land based fisheries represented over 60% of the total artisanal marine catch between the 1950s and the late 1970s, then declined to represent 32% of the total artisanal marine catch in 2010 (Figure 3).

Lagoon subsistence fisheries

Lagoon catches totalled 271,000 tonnes between 1950 and 2010 (Figure 4a), which is the equivalent of 14% of the artisanal marine catch. Lagoon catches, mostly tilapias (Figure 4b) and considered here subsistence, increased slightly from 8,400 t in 1950, to around 9 ,100 t in 1963 of which 300 t were generated in the *acadja* systems. Lagoon catches declined rapidly to 2,000 t in 1983, with the *acadja* systems contributing to around 400 t, the kept on decreasing but with a lower slope to 1,100 t in 2010 when the catch generated by the *acadja* systems was estimated at 230 t (Figure 4).

Recreational catches

Recreational catches were estimated at 287 t between 1950 and 2010. Recreational catches increased from zero in 1967 to 22 t in 2010 and included mostly wahoo, carangids and groupers (Figure 5).

Industrial catches

Domestic catches

Industrial domestic catch for Togo was estimated at 101,496 t between 1966, when the domestic industrial fishery was launched and 2010. Of these catches, 81% were captured by the pelagic fleet (81,925 tonnes) (Figure 6). Industrial catches by Togo increased rapidly since their introduction from zero in 1965 to 6,100 t in 1982, then decreased to less than 1,200 t in 2010 (Figure 6).

Foreign trawl catches

Foreign catches started at low levels when the trawl fishery was introduced by Germany in Togo in the mid-1960s, 540 t·year^{-1}, and picked up in 1978 with the increase in the number of trawlers (Figure 7). Catches increased thereafter, to reach at average 15,000 t·year^{-1} in the early 1990s, and then increased rapidly with the introduction of the agreement between Togo and China in the 2000s to a historical maximum catch of around 41,000 t in 2010, of which a quarter was Chinese (Figure 7). Of a total industrial trawl catch estimated at 678,000 tonnes between 1950 and 2010, 13.7% was Spanish, 36.4% was Chinese, 9.6% was Greek, 20.9% was caught by the neighbouring Ghana, 7.8% by Italy, 5% by Guinea, 2.2% by Cyprus, 1% by Germany in the 1970s, and the remaining by other countries including Portugal and Russia (Figure 7).

Discards

Discard were estimated at 38,500 tonnes between 1950 and 2010. Discards by the trawl fleet increased following the same pattern than industrial trawl catches increasing from 70 t in 1965, when industrial fishing begun, to a historical maximum of around 2,300 t in 2010 (Figure 8), twice, the Togolese domestic industrial catch.

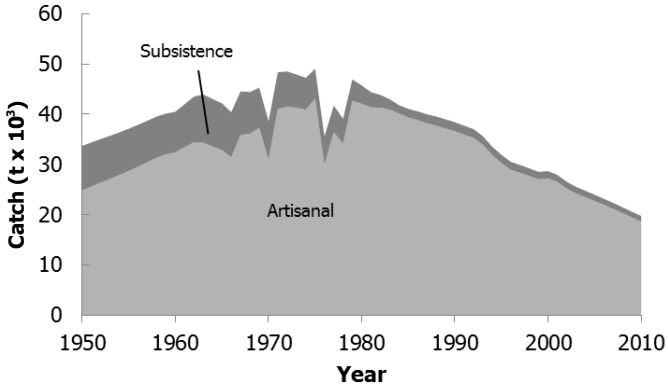

Figure 2. Estimated small scale catches for Togo, 1950-2010.

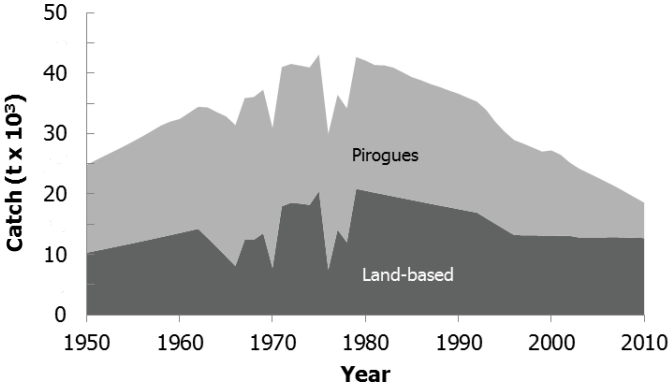

Figure 3. Estimated artisanal catches for Togo, 1950-2010.

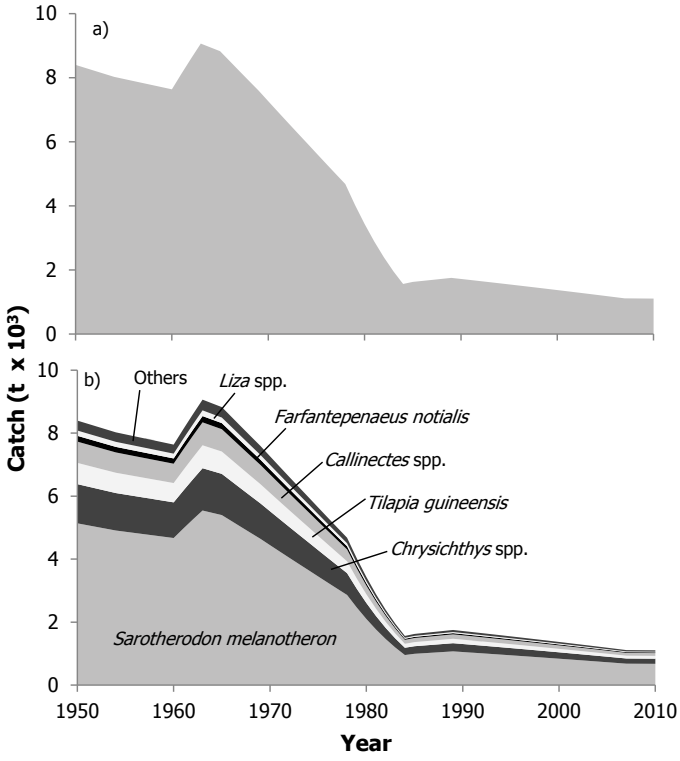

Figure 4. Estimated lagoon catches for Togo (a) subsistence sector and (b) by major taxonomic group, 1950-2010.

Illegal catches

Illegal catches increased from zero in 1985 at the declaration of the Togolese EEZ –unregulated catches already considered in legal catches – to a peak of 20,300 t in 2005, then decreased slightly to about 19,300 t in 2010 (Figure 9). Illegal catches totalled around 289,500 tonnes in less than 30 years which was the slightly higher than the legal (but not all reported) industrial catch.

Total catches

The total marine extractions from the Togolese EEZ were here estimated at over 3 million tonnes between 1950 and 2010 including 2.3 million tonnes from domestic catch and 678,000 tonnes from foreign and visible reflagged vessels. This is compared to the total of 563,400 tonnes supplied to the FAO on behalf of Togo during the same period (Figure 10). Total domestic catches increased from around 33,200 t in 1950 compared to 1,900 t supplied to FAO, to a peak of 51,600 t in 1979, eleven times the catch supplied to FAO, then gradually decreased to be 20,900 t in 2010, compared to 20,000 reported to the FAO (Figure 10). Although this is slightly lower than the data supplied to the FAO, the latter includes catches by foreign vessels landed in Togo, which when considered as domestic resulted in higher catches comparatively to the landing data supplied to the FAO. Foreign (reflagged, joint venture and under agreement) catches increased from 540 t in 1965 to 5,436 t in 1979, the increased constantly to 41,533 t in 2010 (Figure 10).

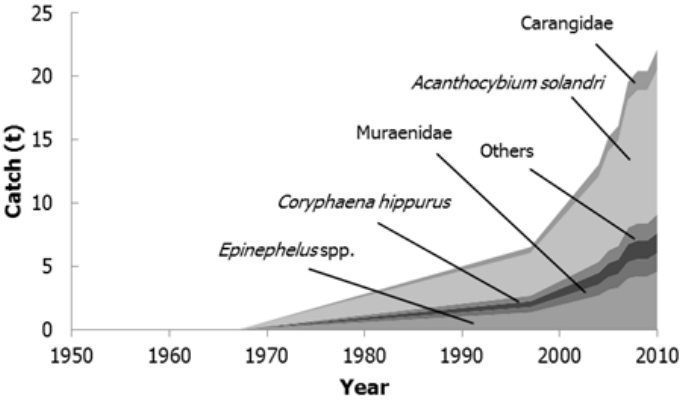

Figure 5. Estimated recreational catches for Togo, 1950-2010.

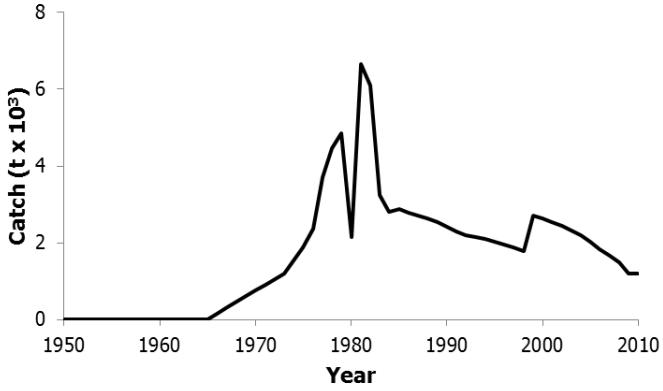

Figure 6. Reconstructed total domestic industrial catch in Togo EEZ, 1950-2010.

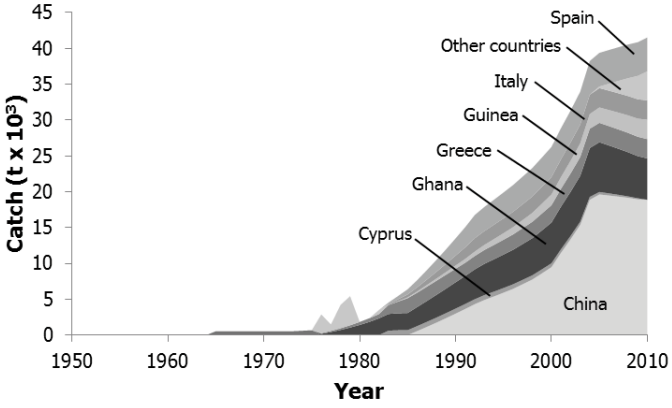

Figure 7. Reconstructed total foreign industrial catch in Togo's EEZ, 1950-2010.

Discussion

The present report presents a historical overview of the Togolese fisheries catch for the 61 years since 1950. It shows reconstructed catches 4 times higher than the figures supplied to the FAO by Togo, with over 3 million tonnes reconstructed compared to 563,000 tonnes supplied to FAO. Artisanal catches represented the bulk (72%) of the reconstructed catch. The pirogue-based artisanal fisheries, dominated by Ghanaian migrant fishers, were driving the variation of domestic catches, also strongly influenced by the political history of Togo. A few examples of inter-annual variations could be related to political-historical events in Togo, like the *coup d'état* of 1963 when, because of the prevailing insecurity, artisanal fishing effort and consequently catches declined. The 'Aliens Compliance Order' decree by the government of Ghana in 1969–forcing all immigrants without proper documentation to leave Ghanaian towards Togo and other neighbouring countries (Bump 2006)–certainly generated an increase in artisanal fishing in Togo, reflected in an increase in artisanal catches in 1970. Another example is provided by the sharp decline in the artisanal catch in the mid-1970s, when the 'Togoland Liberation Movement' and the 'National Liberation Movement for Western Togoland' were seeking separation from Ghana, and threatened it with a guerilla war. This has contributed to increasing insecurity of migrant fishers notably from Ghana, and thus reduced artisanal fishing and catches.

Subsistence lagoon catches represented 10% of the total reconstructed catch. Although subsistence catches do not seem to be high, they contribute towards supplying around 20% of the Togolese population with around 8 kg per capita per year. This further highlights the importance of small-scale fisheries, forgotten by official data, to coastal populations and for food security. Indeed, Togo has been struggling to meet its fish protein demand, with around 65% of the fish supply supplied by imports (FAO FishStat).

On the other hand, the large scale sectors, including industrial legal fisheries and illegal fisheries generated only 8% and 9% of the catch respectively, and discarded 1% of the total catch. The industrial sectors, particularly the foreign fleets show a sharp increase, which contrasts with the pronounced decline of the small-scale fisheries. This further highlights the negative link between industrial (trawl) sectors and small-scale fisheries and questions the usefulness of exclusive 'artisanal fishing zones' in a country where monitoring is barely existent. This adds to the problems of subsistence fishers and poor communities where fishing remains the last resort for poverty alleviation, especially because agriculture is facing increasing climatic challenges (Njock and Westlund 2010).

The decrease in the domestic catch has been compensated by the reflagging practices of Togo since the late 1970s, keeping the total catch in the Togolese EEZ relatively constant since then, at an average of around 48,000 t·year^{-1} ± 2,000 t·year^{-1} despite the increasing effort, particularly by the industrial fleet. This trend is very different from the increasing catch trend shown by the data supplied to FAO, and is explained by an over-exploitation by both the lagoon fisheries (de Surgy 1966; Weigel 1985; Laë 1992) and the artisanal and demersal fisheries (FAO 2006). Since the mid-1970s, droughts constitute another aspect of the decline in the Togolese fishery, because they increase the pressure by farmers who are shifting their activities to fishing, a pattern occurring in many countries (Pauly 2006).

The decrease of domestic industrial catches is due to the collapse of the industrial companies launched in the early 1970s, and the common reflagging practices of Togo here considered in the foreign segment of industrial catches. The so-called 'Togolese fleet' includes vessels from Guinea and Cyprus, vessels from Spain, Italy, China, Ghana, Portugal and Germany in the earlier time periods. Herein, catches by France, Switzerland and other unknown countries where not included, implying that our reconstruction is a conservative, but realistic estimate of catches in Togolese waters. Rather than investing in a truly Togolese fleet, Togo–a Flag of Convenience (FoC) country and also 'a cheap registry that does not require VMS (EJF 2012)–offers the Togolese flag to an increasing number of foreign fleets, and gains a fairly high compensation when doing so (Österblom *et al.* 2010). For example during the last decade, 7 to 15 vessels flagged to Togo (mostly of Spanish origin) were operating in the area covered by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) area illegally and in Australian, Malaysian and French waters (Gianni and Simpson 2005). And thus, as Real (2013) points out, with a lack of control over these 'domesticated' fleets from the EU, Togo was recently classified in the EU blacklist of the countries fishing irresponsibly

Acknowledgments

This is a contribution of the *Sea Around Us*, as scientific collaboration between the University of British Columbia, The Pew Charitable Trusts and the Paul G. Allen Family Foundation.

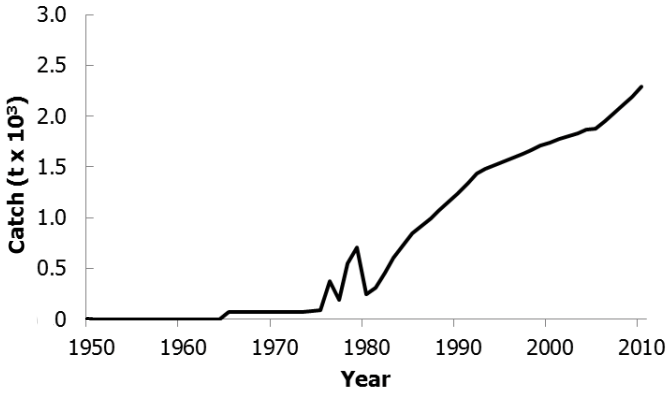

Figure 8. Estimated industrial discards in Togo EEZ, 1950-2010.

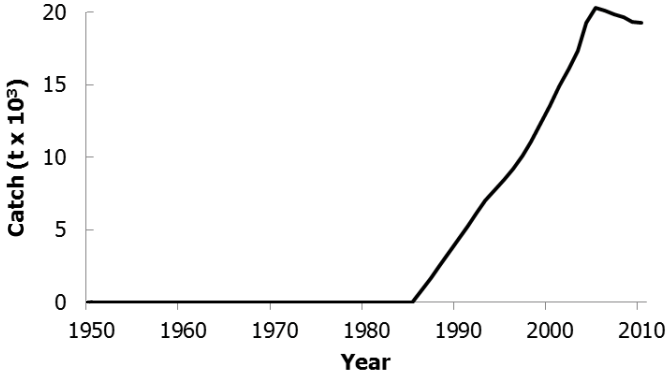

Figure 9. Estimated illegal catches by the foreign fleet from Togo EEZ, 1950-2010.

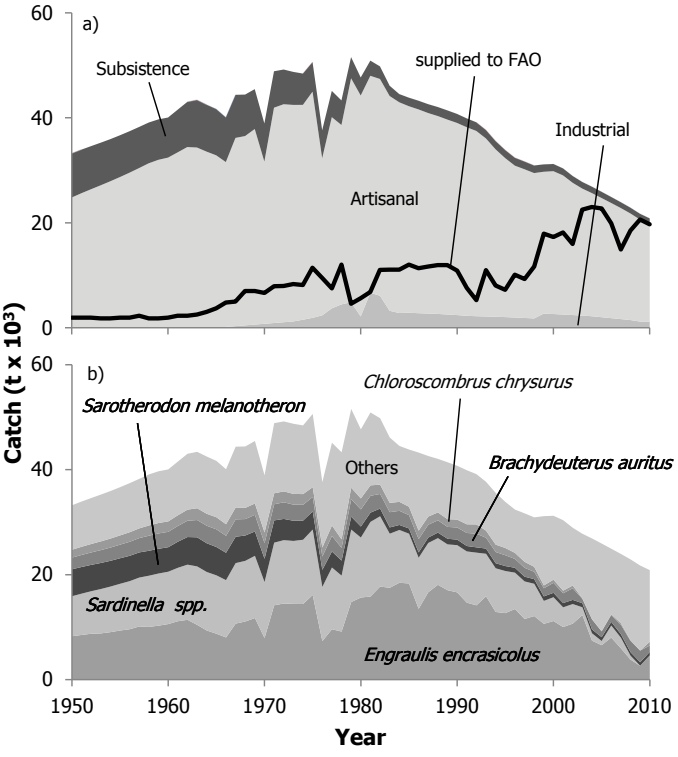

Figure 10. Reconstructed total catch for Togo for 1950 to 2010, by a) sector, with official reported data overlaid as line graph, and b) by major taxa, with 'Others' consisting of 103 additional taxonomic categories.

References

Alsopp WHL (1966) Rapport au Gouvernement du Togo sur le développement et l'organisation de l'industrie des pêches. 2148, FAO, Rome. 19 p.

Amégavie K (1979) Rapport sur la pêche togolaise. *In* COPACE (ed.) Rapport du groupe de travail spécial sur l'évaluation des stocks démersaux du secteur Côte d'Ivoire–Zaïre. COPACE, Rome.

Amégavie K (1986) Les pêches démersale du Togo. p. 200 *In* FAO (ed.) Report of the CECAF *Ad hoc* working group on the demersal and shrimp resources of the central Gulf of Guinea division (34.3.5). FAO, Rome.

Anon. (2010) Togo marine fisheries. Stop Illegal Fishing. 2 p. Available at: www.stopillegalfishing.com/togo.php [Accessed: 1/06/2012].

Anon. (2012a) 5ème Conférence ministérielle du CPCO à Lomé. Le Togo et ses voisins s'attaquent enfin à la pêche illicite. L'Union pour la patrie 558(14 Décembre 2012): 3.

Anon. (2012b) Pendant que le pays disait manquer de moyens, le Togo averti par la Commission européenne contre la pêche pirate. L'Union pour la patrie 551(20 Novembre 2012): 4.

Bama BB (1984) Contribution à l'étude de la pêche maritime au Togo. University of Université de Dakar, Faculté de Médecine et de Pharmacie, Dakar. 134 p.

Beck VU (1974) Bestandskundliche Untersuchungen an einigen Fischarten der Grundschleppnetzfischerei auf dem Schelf vor Togo (Westafrika). Diplomarbeit, Universität Hamburg, Hamburg. [Stock assessments of some fish species caught by the bottom trawl fishey on the shelf of Togo, Master's thesis, Hamburg University],126 p.

Beck VU (1976) Die Zuammensetzung der Erträge aus der Küstenfischerei Togos. 25, Institut für Hydrobiologie und Fischereiwissenschaft der Universität Hamburg, Hamburg. [Composition of the landings of the coastal fisheries of Togo; in German with English abstract], 37-45 p.

Bump M (2006) Country profiles. Ghana: Searching for opportunities at home abroad. Institute for the Study of International Migration, Georgetown University Georgetown. Available at: http://www.migrationinformation.org/USFocus/display.cfm?ID=381 [Accessed: 02/05/2013].

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). NASA Socioeconomic Data and Applications Center (SEDAC), Palisades, NY. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3 [Accessed: 29/10/2012].

de Surgy A (1966) La pêche traditionnelle sur le littoral Evhé et Mina (de l'embouchure de la Volta au Dahomey). Groupes de Chercheurs Africanistes, Paris. 157 p.

Denke A (1997) Enquête cadre et socio-economique sur la pêche artisanale maritime au Togo. 102, DIPA, Cotonou. 96 p.

Dioury F (1983) Monographie de la pêche dans douze pays riverains d'Afrique de l'Ouest, de la Mauritanie au Benin, Bruxelles: s.n. 409 p.

Écoutin JM, Delaunay K and Konan J (1993) Les pêches artisanales maritimes. pp. 537-549 *In* Le Loeuff P, Marchal E and Amon Kothias JP (eds.), Environnement et ressources aquatiques de Côte-d'Ivoire. IRD.

EJF (2012) Pirate fishing exposed: the fisght against illegal fishing in West Africa abd the EU. Environmental Justice Foundation, London. 32 p.

FAO (2006) Report of the fourth Session of the scientific sub-committee. FAO Fisheries Report 800, Food and Agriculture Organization, Rome. 52 p.

FAO (2007) Togo fishery country profile. FAO, Rome. 2 p.

Gianni M and Simpson W (2005) The changing nature of high seas fishing: How flags of convenience provide cover for illegal, unreported and unregulated fishing. Australian Department of Agriculture, Fisheries and Forestry, International Transport Workers' Federation, and WWF International, Canberra, Australia. 83 p.

Guiffre P (1993) Togo: Pêche, l'espoir des eaux interieures. Marchés tropicaux et méditerranéens 1993(2498): 2371-2372.

Horemans B (1993) La situation de la pêche artisanale en Afrique de l'Ouest en 1992. Rapport technique 47, FAO, Cotonou. 36 p.

Horemans B (1994) La situation de la pêche artisanale en Afrique de l'Ouest en 1992. Rapport technique 54, FAO, Cotonou. 39 p.

Horemans B (1995) The state of artisanal fisheries in West Africa in 1994. Technical Report 69, FAO, Cotonou. 39 p.

IRD (2011) Atelier régional de formation et d'harmonisation des méthodes de collecte des données statistiques des pêches dans les états membres de l'UEMOA. IRD, Cotonou. 26 p.

Kapetsky JM (1981) Some considerations for the management of coastal lagoon and estuarine fisheries. Technical paper 218, FAO, Rome. 47 p.

Karger S and und Steinberg W (1969) Heckfischkutter für Togo [Stern trawler for Togo]. Fischerblatt 7(6): 94-98.

Kelleher K (2005) Discards in the world's marine fisheries. An update. 470, FAO, Rome. 131 p.

King HR (1993) Aquaculture development and environmental issues in Africa. pp. 116-124 *In* Pullin RSV, Rosenthal H and Maclean JL (eds.), Environment and aquaculture in developing countries. ICLARM, Manila, Philippines.

Laë R (1992) Les pêcheries artisanales lagunaires ouest-africaines : échantillonnage et dynamique de la ressource et de l'exploitation. ORSTOM et Université de Bretagne Occidentale : Brest, Paris. 205 p.

Laë R (1994) Évolution des peuplements (poissons et crustacés) dans une lagune tropicale, le lac Togo, soumise à un régime alternatif de fermeture et d'ouverture du cordon lagunaire. Aquatic Living Resources 7(03): 165-179.

Laë R (1997) Does overfishing lead to a decrease in catches and yields? An example of two West African coastal lagoons. Fisheries Management and Ecology 4(2): 149-164.

Longhurst A and Pauly D (1987) Ecology of the tropical oceans. Academic Press, San Diego. 407 p.

MRAG (2005) Review of impacts of Illegal, Unreported and Unregulated fishing on developing countries. Final report, MRAG, London. 176 p.

Njock J-C and Westlund L (2010) Migration, resource management and global change: Experiences from fishing communities in West and Central Africa. Marine Policy 34(4): 752-760.

Oceana (2011) European trawlers are destroying the oceans. Oceana. 77 p.

Österblom H, Sumaila UR, Bodin Ö, Hentati Sundberg J and Press AJ (2010) Adapting to Regional Enforcement: Fishing Down the Governance Index. PLoS ONE 5(9): e12832.

Pauly D (1976) The biology, fishery and potential for aquaculture of *Tilapia melanotheron* in a small West African lagoon. Aquaculture 7(1): 33-49.

Pauly D (2006) Major trends in small-scale marine fisheries, with emphasis on developing countries, and some implications for the social sciences. MAST 4(2): 7-22.

Pérez-Ruzafa A and Marcos C (2012) Fisheries in coastal lagoons: An assumed but poorly researched aspect of the ecology and functioning of coastal lagoons. Estuarine, Coastal and Shelf Science 110(0): 15-31.

Real N (2013) Parliament approves blacklist of countries fishing irresponsibly. Fish Information and Services. Available at: http://www.fis.com/fis/worldnews/worldnews.asp?monthyear&day=24&id=60349&l=e&special&ndb=1+target [Accessed: 02/05/2013].

Sedzro KM and Kusiaku YKJ (1999) Les pêches togolaises: COURS ACP-UE sur la gestion des pêches et de la biodiversité, Dakar, Sénégal, du 12 au 23 avril 1999. ACP-EU. 12 p.

Segniagbeto G and Waerebeek KV (2010) A note on the occurrence and status of cetaceans in Togo. SC/62/SM11, IWC, Agadir, Morocco. 8 p.

SOFRECO (2011) Formulation d'un document de politique sectorielle sur la pêche et l'aquaculture et préparation d'un plan d'aménagement des pêcheries du lac du barrage de Nangbeto, Togo. Proposition d'une politique sectorielle sur la pêche et l'aquaculture, Togo. European Union, Brussels. 58 p.

Weigel JY (1985) L'aménagement traditionnel de quelques lagunes du golfe de Guinée (Côte d'Ivoire, Ghana, Togo, Benin). FAO circulaire sur les pêches 790, FAO, Rome. 31 p.

Welcomme RL (1972) An evaluation of the acadja method of fishing as practised in the coastal lagoons of Dahomey (West Africa). Journal of Fish Biology 4(1): 39-55.

Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years. Fishery Bulletin 105(2): 266-277.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	1,900	33,200	0	24,800	8,400	0	0
1951	1,900	33,900	0	25,600	8,310	0	0
1952	1,900	34,600	0	26,400	8,210	0	0
1953	1,800	35,300	0	27,100	8,120	0	0
1954	1,800	35,900	0	27,900	8,030	0	0
1955	1,900	36,700	0	28,700	7,960	0	0
1956	1,900	37,400	0	29,500	7,900	0	0
1957	2,300	38,300	0	30,400	7,830	0	0
1958	1,800	39,100	0	31,300	7,770	0	0
1959	1,800	39,700	0	32,000	7,700	0	0
1960	1,900	40,100	0	32,400	7,640	0	0
1961	2,300	41,500	0	33,400	8,130	0	0
1962	2,300	43,000	0	34,400	8,600	0	0
1963	2,500	43,400	0	34,300	9,060	0	0
1964	3,000	42,500	0	33,600	8,950	0	0
1965	3,700	41,700	0	32,900	8,830	0	0
1966	4,800	40,100	156	31,400	8,520	0	0
1967	5,000	44,400	305	35,900	8,210	0	0
1968	7,000	44,400	455	36,100	7,900	0	0
1969	7,001	45,500	604	37,300	7,600	0	0
1970	6,614	38,900	754	30,900	7,270	1	0
1971	7,923	48,900	903	41,000	6,940	1	0
1972	7,944	49,200	1,053	41,500	6,610	1	0
1973	8,334	48,700	1,203	41,300	6,290	1	0
1974	8,151	48,400	1,527	40,900	5,970	2	0
1975	11,421	50,600	1,889	43,100	5,640	2	0
1976	9,471	37,600	2,357	29,900	5,320	2	0
1977	7,497	45,100	3,696	36,400	5,000	2	1
1978	12,014	43,300	4,452	34,200	4,680	2	2
1979	4,597	51,600	4,861	42,700	4,030	3	2
1980	5,634	47,700	2,148	42,100	3,430	3	3
1981	6,826	50,900	6,660	41,300	2,890	3	4
1982	11,031	49,800	6,095	41,300	2,400	3	5
1983	11,058	46,100	3,230	40,900	1,950	3	10
1984	11,048	44,500	2,809	40,200	1,560	4	5
1985	12,045	43,800	2,867	39,300	1,620	4	5
1986	11,325	43,300	2,771	38,800	1,660	4	4
1987	11,676	42,600	2,709	38,200	1,690	4	4
1988	11,956	42,100	2,629	37,700	1,720	5	3
1989	11,946	41,400	2,531	37,100	1,750	5	2
1990	10,880	40,700	2,414	36,600	1,720	5	1
1991	7,605	39,900	2,280	35,900	1,680	5	0
1992	5,252	39,200	2,198	35,300	1,650	5	0
1993	10,965	37,700	2,151	33,900	1,620	6	0
1994	8,054	35,600	2,095	31,900	1,580	6	0
1995	7,206	33,900	2,029	30,300	1,550	6	0
1996	10,101	32,400	1,954	28,900	1,510	6	0
1997	9,293	31,700	1,869	28,300	1,480	7	0
1998	11,659	30,900	1,775	27,700	1,440	7	0
1999	17,926	31,100	2,696	27,000	1,410	8	9
2000	17,279	31,200	2,614	27,200	1,370	9	9
2001	18,165	30,400	2,522	26,500	1,330	10	10
2002	15,947	28,900	2,421	25,200	1,300	11	10
2003	22,487	27,800	2,311	24,200	1,260	12	10
2004	23,013	26,900	2,192	23,500	1,220	13	11
2005	22,745	25,900	2,011	22,700	1,190	15	11
2006	19,879	24,900	1,830	21,900	1,150	16	11
2007	14,905	23,900	1,650	21,200	1,110	20	11
2008	18,500	22,900	1,469	20,300	1,110	20	11
2009	20,604	21,700	1,175	19,400	1,110	20	11
2010	19,729	20,900	1,175	18,600	1,100	22	11

Appendix Table A2: Reconstructed total catch (in tonnes) by major taxa, for Togo, 1950-2010. Others contain 104 additional taxonomic categories.

Year	*Engraulis encrasicolus*	*Sardinella spp.*	*Sarotherodon melanotheron*	*Brachydeuterus auritus*	*Chloroscombrus chrysurus*	Others
1950	8,270	7,620	5,140	2,210	1,500	8,470
1951	8,510	7,870	5,080	2,290	1,560	8,620
1952	8,740	8,100	5,020	2,370	1,610	8,760
1953	8,810	8,450	4,970	2,450	1,660	8,910
1954	9,050	8,690	4,910	2,520	1,710	9,050
1955	9,360	8,900	4,870	2,590	1,760	9,180
1956	9,600	9,160	4,830	2,680	1,820	9,350
1957	10,130	9,320	4,790	2,730	1,850	9,430
1958	10,040	9,760	4,750	2,870	1,950	9,730
1959	10,290	9,940	4,710	2,930	1,990	9,860
1960	10,590	9,970	4,670	2,930	1,990	9,900
1961	11,130	10,180	4,970	3,000	2,040	10,230
1962	11,400	10,510	5,260	3,110	2,110	10,640
1963	10,440	11,130	5,540	3,290	2,240	10,750
1964	9,360	11,150	5,470	3,340	2,280	10,910
1965	8,750	11,120	5,400	3,370	2,300	10,740
1966	8,040	10,920	5,210	3,230	2,210	10,480
1967	10,670	11,530	5,020	3,320	2,260	11,580
1968	11,080	11,560	4,830	3,130	2,130	11,700
1969	11,740	11,850	4,650	3,170	2,160	11,900
1970	7,920	10,660	4,440	2,970	2,040	10,880
1971	14,160	11,940	4,240	3,070	2,080	13,370
1972	14,510	12,070	4,040	3,170	2,080	13,330
1973	14,430	12,000	3,850	3,070	2,040	13,360
1974	14,410	12,240	3,650	3,010	2,040	13,080
1975	16,130	12,470	3,450	2,760	1,860	13,960
1976	7,340	10,320	3,250	2,530	1,720	12,450
1977	9,600	11,760	3,060	2,960	1,990	15,760
1978	9,150	10,670	2,860	2,430	1,620	16,590
1979	14,780	13,810	2,470	3,320	2,190	15,010
1980	15,640	11,430	2,100	3,250	2,100	13,160
1981	15,840	14,220	1,770	3,210	1,990	13,890
1982	17,730	13,390	1,470	2,790	1,770	12,660
1983	17,500	10,310	1,190	2,900	1,770	12,460
1984	18,460	10,060	950	2,700	1,710	10,660
1985	18,320	9,490	990	2,540	1,590	10,900
1986	13,500	9,730	1,010	2,550	1,610	14,870
1987	16,650	9,390	1,030	2,450	1,550	11,530
1988	18,070	8,900	1,050	2,340	1,510	10,200
1989	17,040	8,730	1,070	2,260	1,470	10,840
1990	16,620	9,000	1,050	2,310	1,510	10,250
1991	14,670	9,760	1,030	2,480	1,650	10,310
1992	14,150	10,040	1,010	2,620	1,750	9,580
1993	15,880	8,110	990	2,060	1,360	9,300
1994	12,890	8,320	970	2,130	1,410	9,860
1995	12,670	8,020	950	2,060	1,380	8,790
1996	13,460	6,930	920	1,690	1,150	8,250
1997	11,560	7,160	900	1,690	1,140	9,240
1998	12,110	6,150	880	1,400	940	9,430
1999	10,630	4,370	860	1,540	550	13,200
2000	11,170	4,540	840	1,900	600	12,170
2001	10,020	3,760	820	1,860	500	13,430
2002	10,670	3,730	790	2,210	520	11,010
2003	12,300	1,490	770	820	120	12,300
2004	7,420	1,400	750	1,900	50	15,380
2005	6,560	800	730	1,110	30	16,710
2006	8,020	2,290	700	1,310	120	12,500
2007	5,970	2,020	680	1,790	300	13,190
2008	3,820	740	680	2,150	100	15,410
2009	2,620	30	680	2,210	0	16,210
2010	4,600	20	680	1,210	730	13,640

Benin's fisheries: a catch reconstruction, 1950-2010[1]

Dyhia Belhabib and Daniel Pauly

Sea Around Us, Fisheries Centre, University of British Columbia
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.belhabib@fisheries.ubc.ca; d.pauly@fisheries.ubc.ca

Abstract

Total marine fisheries catches from the Exclusive Economic Zone of Benin and its coastal lagoons were estimated between 1950 and 2010. The reconstruction considered artisanal and industrial sectors and their discards, subsistence fisheries from the marine and lagoon waters including those generated by women for the first time. Small-scale catch estimates were obtained using catch per unit of effort and per capita catch estimates alongside with the number of fishers and the number of pirogues, while industrial catches were estimated by country using the number of industrial vessels and their catch per unit of effort. Total catches were estimated at 4.0 million t between 1950 and 2010 of which 3.9 million t were domestic (and mainly from lagoon areas) compared to 1.7 million t of catch data supplied to the FAO. Catches showed a decreasing pattern in contrast to the increase observed in official data, which puts in jeopardy the livelihoods of the many fishers relying solely on fisheries.

Introduction

Benin (capital city; Cotonou, 6°28′N 2°36'E) is a small country of Central West Africa with a coast on the Gulf of Guinea, one of the smallest coastlines of Africa (the Gulf of Benin). The country is bordered by Nigeria on the East, Niger and Burkina Faso on the North and Togo on the West.

Historically, Benin held a major role in the slave trade, and hence its previous name of 'Slaves Coast', following the European colonial habit of naming areas of Africa after their major resources, such as the "Pepper Coast" for Côte d'Ivoire (itself another resource name, ivory), or the "Gold Coast" for Ghana (Bouche 1885). The country, known as Dahomey during the French colonization and shortly after independence in 1960, went through a period of political unrest and a major coup d'état in 1972, which triggered the establishment of a Marxist regime. The newly formed government renamed the country the People's Republic of Benin and started a multitude of politically driven initiatives such as nationalization of industries, and taking nuclear waste from the former Soviet Union and France. Ill-founded policies, conflicts and a badly managed economy governed under the "poverty is not fatality" motto contributed to Benin acquiring the reputation of being the "sick child of Africa" (Atti-Mama 1998).

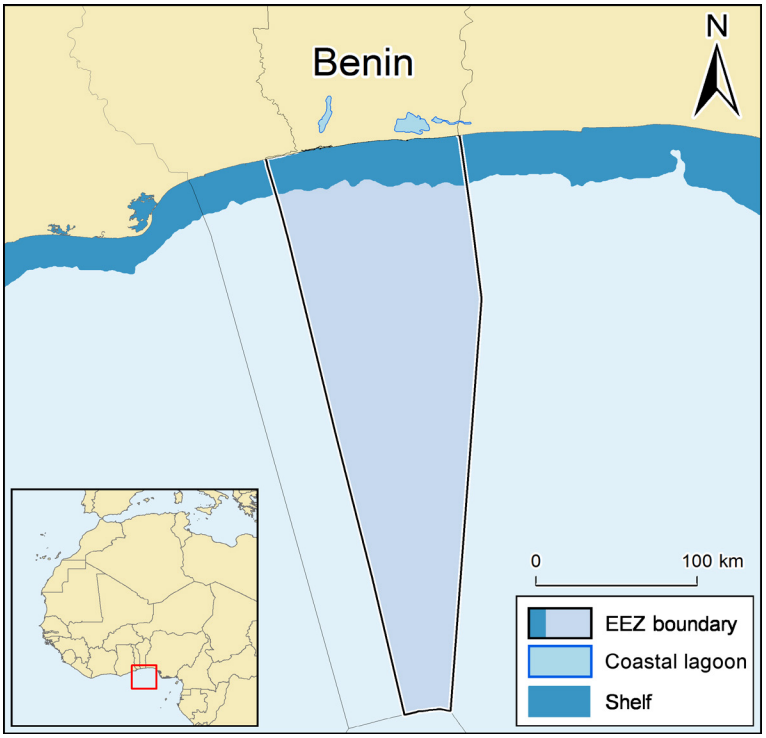

Figure 1. Map of Benin with Exclusive Economic Zone (EEZ).

The availability of fisheries resources within Benin's many lagoons and coastal areas contributed to the importance of this industry as it is the second major source of employment for coastal populations following agriculture (Bouche 1885). Benin has a well-established tradition of fishing as fish was then caught for personal consumption (Bouche 1885).

The absence of major upwelling phenomenon in Benin inshore waters (Djiman 1996; FAO 2007), the short coastline and the large size of the estuarine systems drove the growth of Benin's mostly lagoon-based fisheries, which are small-scale, largely subsistence operations conducted from small canoes. Artisanal and industrial marine fisheries operate in Benin's waters only since the early 1950s. They include small pelagic fisheries, operated by Fanti type pirogues and pelagic trawlers, cephalopod fisheries by industrial vessels flagged to Benin which land their catches in Benin, a demersal fish sector operated either by industrial trawlers reflagged to Benin or artisanal boats which land their catches in Benin (Senouvo 1990b; Chaboud and Charles-Dominique 1991; Ecoutin *et al.* 1993), and a shark fishery (Anon. 2010).

[1] Cite as: Belhabib, D. and Pauly, D. (2015) Benin's fisheries: a catch reconstruction, 1950 to 2010. pp. 51-64. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

Although new fisheries regulations were introduced in the 1990s, they faced serious challenges in effectively regulating these fisheries sectors, particularly in the face of the well-established implemented traditional system such as the one found in lagoons (Stoop *et al.* 2013).

Traditional systems of fisheries management built around animist beliefs ('*Voodoo*') were efficient in the past as fishers adhered to fishing rules, as they were those of their own villages and/or communities. For example, violation of fisheries regulations set up by villages was considered a sacrilege and therefore an animal sacrifice was required at the cost of the offender (Iroko 2005). Voodoo sanctions ranged from fines and confiscation of fishing gear to public flagellation and even death sentences (Briones Alonso *et al.* 2013). Measures to prevent overfishing or to allow fish to multiply went from prohibiting breastfeeding women and women having their periods to approach the water (Iroko 2005) to 'quotas'. Interestingly in Benin, even today, these quotas, i.e., definite quantities of fish to be taken, as set by villages, are traditionally defined by the customs of the two ethnic groups Houedah and the Xwlâ, exist. Although they have no scientific basis, and are based exclusively on tradition, they are believed to be efficient. Some other measures included fishing bans, release of bycatch and a feast day for the deities of the sea, when fishing was forbidden (Vogt *et al.* 2010). These rules are now slowly disappearing from among young fishers (Vogt *et al.* 2010) and destructive fishing techniques are increasingly used as the traditional system loses power to 'modern', but ineffective systems. Ironically, as noted by Vogt *et al.* (2010), while artisanal fishers observe strict rules, the 'deities' of the sea, a.k.a., illegal fishing vessels, are feasting upon the fish which small-scale fishers allow to rest, which creates more conflicts between the small-scale sector and the industrial sector.

Benin lacks the capacity to monitor its fisheries effort and catches, which often results in a lack of data and a lack of scientific knowledge leading to inadequate management (FAO 2007). However, data wise, the sampling techniques that were used were described as "efficient"–at least in the past for part of the fishing industry, at the dawn of FAO development projects in the 1970s (FAO 2007). On the other hand, some authors argue that large fractions of the catch were never registered, and that those that were recorded are unreliable. Furthermore "it has to be noted that even the national fishing authority does not have data on fishing quantities at its disposal." (Vogt *et al.* 2010). For example, industrial catches are unreliable as the FAO data for the industrial sector was in the past significantly higher than the national data presented by the Direction de Programmation et de Prospective (DPP), the latter likely being under-estimated given the high number of trawlers (Vogt *et al.* 2010).

Fisheries in Benin shifted from a time of abundance, waste and carelessness when "dried fish was even used to replace the cattle cake normally used in making fire" (Iroko 2005), to fisheries depletion, social disparities created by the use of 'acadja' systems (see below), as early as the 1960s (Iroko 2005) and raising conflicts with the industrial marine fleet, which ultimately led to piracy.

Herein, we reconstruct Benin marine and lagoon fisheries catches to have a realistic idea of total fisheries removals from Benin in contrast to officially ill-documented data.

Methods

Data on fisheries landings are collected and compiled by the Centre de Recherche Halieutique et Océanographique du Benin (Fisheries and Oceanographic Research Centre of Benin, CRHOB); these are then submitted to the Fisheries Directorate. Monitoring of marine artisanal fisheries is based on ARTFISH stratified sampling technique, which was introduced by FAO in 1976 at the launch of the Technical Cooperation Programme (TCP). Between 1987 and 2002, the Fisheries Directorate counted daily the number of dugout canoes in the port of Cotonou. Monitoring decreased after 2003 for economic reasons. One of the particularities of Benin however, is that marine fishers were actively involved in data collection as they received a financial compensation from the Fisheries Directorate for their work. The program stopped in 2007 and fisheries monitoring shrunk again to cover only the Port of Cotonou (FAO 2007). The industrial fleet is dominated by foreign vessels, notably bottom trawlers, onboard of which no observers were taken. Similarly, there is hardly any control on the mesh size or the fishing grounds of these fleets (FAO 2007).

Herein we reconstruct total catches from Benin EEZ for the artisanal marine and lagoon sectors notably catches taken by acadja systems, subsistence fisheries catches, domestic and industrial foreign catches and their discards (including legal and illegal sectors).

Coastal population

Coastal population, i.e., rural and urban population living within the 10 km strip of the coast was given for 1990, 2000 and 2010 (CIESIN 2012). We extracted total population estimates from the WorldBank database (www.worldbank.org) from 1960 to 2010, and completed these using data from www.populstat.com from 1950 to 1960. We divided the coastal population estimate for 1990 by the total population estimate for the same year and obtained a percentage of coastal population for 1990. We assumed this percentage was constant between 1950 and 1990 and multiplied it by the total population for the same time period to obtain coastal population of Benin between 1950 and 1989. We interpolated between coastal population estimates between 1990 and 2010 to fill in the gaps (Figure 2).

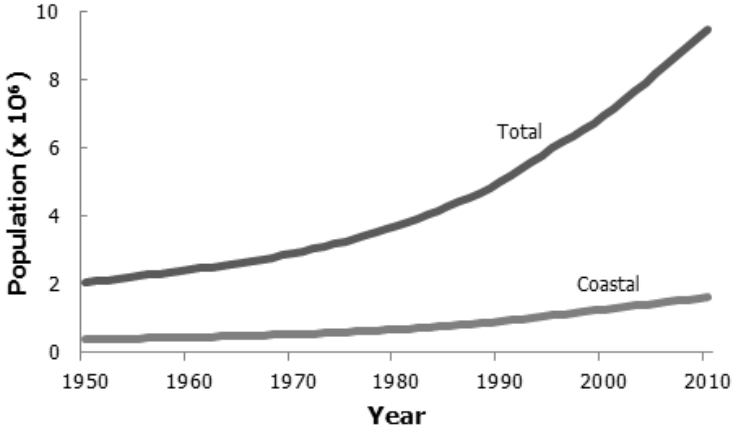

Figure 2. Total and coastal population of Benin, 1950-2010.

Artisanal catches

Although artisanal catches in Benin are relatively unknown, they seem to be important particularly in the lagoons (Boëly and Fréon 1979). Data are often referred to as "patchy" which is explained by the fact that to the 80 landing sites are difficult to monitor properly (Turay and Verstralen 1997).

Marine catches

To reconstruct artisanal marine catches, we multipled the catch per unit of effort by the effort (number of pirogues). Literature documented the number of marine pirogues for a certain number of years for the years 1983, 1985, 1986, 1987, 1988, 1992, 1993, 1994, 1997 and 1999 (Senouvo 1990a, 1990b; Ssentongo 1990; Gbaguidi and Meyizoun 1994; Horemans and Jallow 1997; Turay and Verstralen 1997; FAO 2007) and the number of marine fishers for the early 1980, 1983, 1992, 1993, 1994, 1997, 1999 and 2010 (Chaboud and Charles-Dominique 1991; Ecoutin *et al.* 1993; Horemans 1994; Horemans and Jallow 1997; Turay and Verstralen 1997; FAO 2007; Njock and Westlund 2010; Dessouassi 2011) (Table 1). We estimated the number of pirogues for 1980 by multiplying the number of fishers (2,500) by the number of fishers per pirogue obtained from the first available anchor point documenting both the number of pirogues and the number of fishers, i.e., around 5 fishers per pirogue in 1983. The total number of coastal fishers (lagoon and marine) was estimated at 15,300 for 1960 (Anon. 1964), thus to estimate the number of marine artisanal fishers among these, we first obtained the number of lagoon fishers using the ratio lagoon fishers estimated at 11,000 (Lemasson 1961): Coastal population for 1955 (Figure 2), i.e., 3%, multiplied by the coastal population for 1960 and obtained a number of lagoon fishers of 11,939 for 1960. The difference between the total number of coastal fishers and lagoon fishers is the number of artisanal marine fishers for 1960, i.e., 3,361 for 639 pirogues (assuming 5 fishers per pirogue). Similarly, we obtained the total number of coastal fishers as 4% of the coastal population within the primary sector (80% of the coastal population) as documented by Anon. (1964) for 1950, i.e., 11,925 fishers. We then estimated the number of lagoon fishers for 1950 at 10,061 using the proportion of lagoon fishers for 1955, i.e., 11,000 (Lemasson 1961) over the coastal population for 1955, then multiplied by the coastal population for 1950. We then estimated marine artisanal fishers by subtracting the number of lagoon fishers from the total estimated for 1950 (Table 1), which was then divided by 5 to estimate the number of pirogues. We interpolated to fill in the gaps.

Table 1. Artisanal fishing effort in the marine waters of Benin and its lagoons. Italics indicate interpolations.

	Marine effort			Lagoons fishers		
Year	Pirogues	Fishers	Source	Total	Sources	Using acadjas
1950	354	1,864	Estimated	10,061	Estimated	2,515
1955	*496*	*2,613*		11,000	Lemasson (1961)	2,750
1956	*525*	*2,762*		11,000	Lemasson (1961)	2,750
1957	*553*	*2,912*		11,000	Lemasson (1961)	2,750
1958	*582*	*3,062*		10,000	Buffe (1958)	2,500
1960	639	3,361	Estimated	14,455		3,614
1969	*565*	*2,974*		34,500	Welcomme 2003	8,625
1977	*500*	*2,629*		38,300	Dioury 1983	7,295
1980	475	2,500	Estimated based on the number of fishers (Chaboud and Charles-Dominique 1991)	38,545		7,686
1987	*477*	*4,000*		39,117	Turay and Verstralen (1997)	8,615
1988	*654*	*3,840*		42,619	Turay and Verstralen (1997)	9,513
1989	*657*	3,680		45,292	Turay and Verstralen (1997)	10,245
1990	*660*	*3,520*		50,284	Turay and Verstralen (1997)	11,523
1991	*662*	*3,360*		50,470	Turay and Verstralen (1997)	11,716
1992	665	3,200	Horemans (1994)	47,672	Turay and Verstralen (1997)	11,209
1993	731	3,237	Horemans and Jallow (1997)	50,014	Turay and Verstralen (1997)	11,908
1994	731	3,237	Horemans and Jallow (1997)	48,874	Turay and Verstralen (1997)	11,782
1995	*786*	*3,357*		48,895	Turay and Verstralen (1997)	11,933
1996	840	3,476	Turay and Verstralen (1997)	48,947		12,091
1997	840	3,596	Turay and Verstralen (1997)	49,000	Turay and Verstralen (1997)	12,250
1999	816	4,345	FAO (2007)	52,600		13,150
2002	*804*	*4,524*		58,000	FAO (2007)	14,500
2003	800	4,583	Njock and Westlund (2010)	57,949		14,487
2006	*860*	*4,762*		57,796	Ahouandjogbe *et al.* (2013)	14,449
2009	*919*	*4,940*		58,000	Anon. (2010)	14,500
2010	939	5,000	Estimated based on the number of fishers (Dessouassi 2011)	59,217		14,804
2012				61,650	Ahouandjogbe *et al.* (2013)	

Surveyed catches by gear type and the number of artisanal boats were obtained from Turay and Verstralen (1997) for 1995 and 1996, which were used to calculate an average CPUE of 14.26 t·pirogue^{-1}·year^{-1} for 1995 and 1996. Given the over-exploitation pattern (Stoop *et al.* 2013), we assumed this CPUE was slightly higher (10%) in 1950, and lower in 2010 (10%). We interpolated and then multiplied the estimated number of pirogues by the CPUE.

Lagoon catches

Non-*acadja* catches

There are three main lagoons in Benin, Porto Novo, Lake Aheme and Lake Nokoué, which in contrast to what their names suggest, are two of the most important lagoon systems in Benin. Literature suggests Benin lagoons contribute the most to artisanal fisheries in the country (Iroko 2005; FAO 2007). Data on the number of artisanal fishers were available and completed by a series of linear interpolations (Table 1). Some of these fishers use acadjas, i.e., "artificial systems aimed at enhancing fish production by providing additional substrata for development of plants and animals upon which the fish will feed" (Niyonkuru and Lalèyè 2010), to aggregate, then catch fish. Since these systems are well documented, we reconstructed their catches separately. We first estimated the number of fishers not using acadjas by subtracting the number of those using acadjas from the total number of artisanal lagoon fishers. We obtained the proportion of fishers using acadjas over total lagoon fishers by dividing the number of fishers using this technique for Lake Aheme and Porto-Novo Lagoon (3,500) by the total number of fishers provided for both lagoons for 1997 (14,025), i.e., 25% (Turay and Verstralen 1997; SOFRECO 2002). Given that acadjas are mainly on inheritance basis and new entries are restricted (Vogt *et al.* 2010), we assumed the rate remained constant over time except for the time when the acadjas were prohibited in Lake Aheme between 1970 and 1976. Thus, we assumed the proportion of acadja fishers over total number of fishers for 1976 was 25% lower than that of 1997, i.e., 9%. We assumed this proportion was 25% between 1950 and 1970, when acadjas were prohibited in Lake Aheme, interpolated to 9% in 1976, and then interpolated to 25% in 1997, kept constant thereafter. We multiplied these rates by the total number of lagoon fishers (Table 1) and then subtracted the result from the total number of lagoon fishers to obtain the number of lagoon fishers not using acadjas (Table 1).

We estimated the CPUE using the total non-acadja observed catch divided by the number of fishers for 1960, i.e., 22,500 t by 11,000 fishers (Lemasson 1961), and we assumed that this CPUE was constant between 1950 and 1960. We divided the CPUE by 2 for 1983 (Dioury 1983). Similarly, we estimated the CPUE based on catch and effort data by Turay and Verstralen (1997) at 1.1 $t \cdot fisher^{-1} \cdot year^{-1}$. Ahouandjogbe *et al.* (2013) surveyed lagoon catches per trip, the number of trips and the number of pirogues by lagoon in Benin for 2012, which allowed to estimate a weighted average CPUE for all coastal lagoons, and excluded 25% of it as being taken by acadjas, i.e., 1.65 $t \cdot pirogue^{-1} \cdot year^{-1}$ or 1.2 $t \cdot fisher^{-1} \cdot year^{-1}$ (with 1.37 fishers per pirogue). Pérez-Ruzafa and Marcos (2012) estimated a lower CPUE of 0.99 $t \cdot fisher^{-1} \cdot year^{-1}$ for the same year, of which we removed 25% as taken from acadja systems and obtained 0.74 $t \cdot fisher^{-1} \cdot year^{-1}$. We averaged the previous CPUE estimates and obtained 0.98 $t \cdot fisher^{-1} \cdot year^{-1}$ for 2012. Anon. (2010) documented that the CPUE declined by a third during the last 20 years. Therefore, we assumed the CPUE in 1989 was 33% higher than the CPUE in 2012, i.e., 1.3 $t \cdot fisher^{-1} \cdot year^{-1}$. These declines of CPUE are illustrated throughout the literature and surveys, where catches per trip and fish sizes were declining (Atti-Mama 1998; Niyonkuru and Lalèyè 2010), and fish stocks decreasing (Stoop *et al.* 2013) in lagoons which were previously known to be abundant in fish (Bouche 1885). We interpolated between the CPUE estimates and multiplied the resulting annual values by the estimated number of fishers to obtain lagoon non-acadja catches.

Acadja catches

Acadjas were introduced in Benin through Lake Nokoué and Porto Novo lagoons in the beginning of the 20th century (Lalèyè 2000). They quickly became an effective way of aggregating and catching large amounts of wild fish within lagoons. However, this technique is controversial since it tends to aggregate wild fish otherwise caught by non-acadja users. Furthermore, the area occupied by acadjas is often high enough, i.e., 35% of Lake Nokoué for example, to produce spatial conflicts (Niyonkuru and Lalèyè 2010). These conflicts and inequalities have led to a moratorium in 1970 in Aheme lagoon (Weigel 1985; Dangbégnon 2000; Cofad and Gut 2002). The total surface area of acadjas was estimated at 433 ha in 1959 (Welcomme 1972), 156 ha after the prohibition in 1970 (Welcomme 1972) and at 6,691 ha for 1996 (Gbaguidi and Djanato 1997). We estimated the surface areas of acadjas for 1950 at 414 ha (by estimating the surface area per fisher for 1959 obtained by dividing the surface area by the estimated number of acadja fishers; Table 1). We applied the same method to estimate the surface area between 1960 and 1969, prior to the prohibition acadjas in Lake Aheme and assumed the surface area was constant between 1971 and 1976 because of the prohibition in place. We estimated the surface area of acadjas for 2010 by dividing the surface area for 1996 by the number of fishers for the same year, then multiplying the resulting rate by the number of acadja fishers for 2010 and obtained a surface area of 8,192 ha for 2010. We interpolated between the estimates to fill in the gaps.

Catches per hectare were obtained from Buffe (1958) for the period between 1955 and 1958, Welcomme (1972) for 1959 and 1970 and Lalèyè (2000) for 1980 and 1998. We also estimated the CPUE for 1994 based on the survey by Anon. (1994) estimating the catch for 12 ha of different acadjas, over 93 fishing days and 33 fishers, at 13.8 $kg \cdot ha^{-1} \cdot day\text{-}1$, i.e., 4.14 $kg \cdot ha^{-1} \cdot year^{-1}$ assuming 300 fishing days. We assumed the CPUE was constant between 1950 and 1955 and that it declined by 10% between 1998 and 2010 to account for overexploitation despite an increase in catches since 1976 (Ajao 1999). We interpolated between the CPUE estimates and multiplied them by the surface area of acadjas to obtain total artisanal acadja catch.

Subsistence catches

Acadja catches

Acadja catches per trip were surveyed by Anon. (1994) and accounted for commercial catches, consumption, donations and stolen fish. These would not be landed and therefore not accounted for in artisanal catches or surveys targeting artisanal catches. Consumption (including personal consumption, donations and stolen fish) was estimated at 1.5 kg·fisher^{-1}·day^{-1}, i.e., 451 kg·fisher^{-1}·year^{-1} for 1994. We assumed this consumption was 20% higher between 1950 and 1969 prior to the prohibition of acadjas in Lake Aheme. Given evidence of a decrease of retained catches for personal consumption (Vogt *et al.* 2010), we assumed consumption in 2010 was 15% lower than that of 1994. Similarly, we assumed consumption during the acadja prohibition period (between 1970 and 1976) was 15% lower than in 1994. We interpolated and multiplied the estimated consumption by the number of fishers using acadjas.

Other marine and lagoon subsistence catches

Subsistence marine catches were estimated as the equivalent of 17% of artisanal catches for 2010, part of which is the taken home portion of the artisanal catch (Vogt *et al.* 2010), i.e., 1,939 t·year^{-1} for 2010. This converts into a consumption rate of around 48 kg·capita^{-1}·year^{-1} for fishers and their households of 8 members (Ijff and Tempelman 1990). For 1990, Ijff and Tempelman (1990) estimated a consumption from subsistence fishing of 54 kg·capita^{-1}·year^{-1} which, when multiplied by the number of fishers and their households, provides a subsistence catch of 1,521 t·year^{-1} for 1990. Given the evidence of declining subsistence consumption (Vogt *et al.* 2010), we extrapolated the previous consumption rates per capita backwards and estimated a consumption rate of 65.1 kg·capita^{-1}·year^{-1} for 1950, i.e., 970 t·year^{-1} when multiplied by the number of marine artisanal fishers and their household in 1950. We then interpolated linearly between the three anchor points and estimated marine subsistence catches.

Table 2. Reconstructed number of industrial fishing vessel operating in Benin per country (Dioury 1983; Ssentongo 1990; Turay and Verstralen 1997; SOFRECO 2002; Anon. 2010). Interpolations are indicated in italics.

Year	Total	Benin	Nigeria	Cameroon	Sudan	Greece	China	Spain	France	Italy	Portugal
1950-1957	-	-	-	-	-	-	-	-	-	-	-
1958	1	-	-	-	-	-	-	-	-	1	-
1959	1	-	-	-	-	-	-	-	-	1	-
1960	2	-	-	-	-	-	-	-	-	1	1
1961	2	-	-	-	-	-	-	-	1	1	-
1962	2	-	-	-	-	-	-	-	1	1	-
1963	3	-	-	-	-	-	-	-	1	1	1
1964	6	-	-	-	-	1	-	-	1	2	2
1965	6	-	-	-	-	1	-	-	1	2	2
1966	5	-	-	-	-	1	-	-	1	2	1
1967	7	1	-	-	-	1	-	-	2	2	1
1968	7	1	-	-	-	1	-	-	2	2	1
1969	7	1	-	-	-	1	-	-	2	2	1
1970	9	2	-	-	-	1	-	-	3	2	1
1971	11	2	-	-	-	1	-	-	3	3	2
1972	12	3	-	-	-	1	-	-	3	3	2
1973	11	2	-	-	-	1	-	-	3	3	2
1974	19	3	-	-	-	1	-	-	10	3	2
1975	8	2	-	-	-	1	-	-	2	2	1
1976	6	2	-	-	-	1	-	-	2	1	-
1977	6	2	-	-	-	1	-	-	2	1	-
1978	4	1	-	-	-	1	-	-	1	1	-
1979	4	1	-	-	-	1	-	-	1	1	-
1980	16	3	1	1	1	1	-	1	4	2	2
1981	9	2	1	1	1	1	-	1	2	1	1
1982	1	1	-	-	-	-	-	-	-	-	-
1983	1	1	-	-	-	-	-	-	-	-	-
1984	5	1	-	1	1	-	-	-	-	-	-
1985	6	1	1	2	1	-	-	-	-	-	-
1986	6	2	1	1	1	-	-	-	-	-	-
1987	*7*	*2*	*1*	*1*	*1*	*1*	-	*1*	*1*	-	-
1988	*7*	*2*	*1*	*1*	*1*	*1*	-	*1*	*1*	-	-
1989	*8*	*2*	*1*	*1*	*1*	*1*	-	*1*	*1*	-	-
1990	*8*	*3*	*1*	*2*	*1*	*1*	-	*1*	*1*	-	-
1991	*9*	*3*	*1*	*2*	*1*	*1*	-	*1*	*1*	-	-
1992	*9*	*3*	*1*	*2*	*1*	*1*	-	*1*	*1*	-	-
1993	*10*	*3*	*1*	*2*	*1*	*1*	-	*1*	*1*	-	-
1994	9	3	1	2	1	1	-	1	1	-	-
1995	7	3	1	1	-	-	-	1	1	-	-
1996	7	3	1	1	-	-	-	1	1	-	-
1997	7	3	1	1	-	-	-	1	1	-	-
1998	9	3	1	1	-	-	1	1	1	-	-
1999	10	*3*	*1*	*2*	*1*	-	*3*	*1*	*1*	-	-
2000	12	*2*	*1*	*2*	*1*	*1*	*4*	*1*	*1*	-	-
2001	13	*2*	*1*	*3*	*1*	*1*	*5*	*1*	*1*	-	-
2002	15	*2*	*1*	*3*	*2*	*1*	*7*	*1*	*1*	-	-
2003	14	*3*	*1*	*2*	*1*	*1*	*6*	*1*	*1*	-	-
2004	13	*3*	*1*	*2*	*1*	*1*	*6*	*1*	*1*	-	-
2005	12	*4*	-	*1*	*1*	-	*5*	*1*	-	-	-
2006	11	*4*	-	*1*	-	-	*5*	*1*	-	-	-
2007	10	5	-	-	-	-	4	1	-	-	-
2008	14	4	1	1	1	1	6	1	1	-	-
2009	18	3	1	1	2	1	8	1	1	-	-
2010	20	3	8	-	-	-	8	-	-	-	-

We applied the same method for lagoon non-acadja subsistence catches, where for 2010 the equivalent of 17% of artisanal catches were for subsistence (Vogt *et al.* 2010), i.e., 7,476 t·year^{-1} or 21.04 kg·capita^{-1}·year^{-1}, and for 1990, a consumption rate of 38.33 kg·capita^{-1}·year^{-1} was estimated (Ijff and Tempelman 1990), i.e., a catch of 11,884 t·year^{-1}. We extrapolated the previous consumption rates backwards and estimated a consumption rate of around 73 kg·capita^{-1}·year^{-1} for 1950, i.e., 4,401 t·year^{-1}. We interpolated linearly lagoon non-acadja subsistence catches.

Women catches

Literature documenting women fishing in Benin is scarce, most reviews refer to their role in fish processing. Yet, to improve their financial situation, women along the coast tend to have other activities such as financing fishing gear, or fishing for crabs and oysters along the lagoons (Gnakadja 2000). In Benin, these women fish for cash sale (Trottier 1987). Capo-Chichi (2006) estimated the number of these women at 9,724 for 2006, which is the equivalent of 16% of the total number of male lagoon fishers. Since these women are most likely relatives of male fishers themselves and directly or indirectly related to them, we assumed this percentage was constant over the 1950-2010 time period and multiplied it by the total number of lagoon male fishers to obtain the total number of female fishers. We assumed the same CPUE than for the acadja subsistence catch and multiplied the CPUE by the number of female fishers.

Industrial

Most of the industrial fleet that is operating and holds legal agreements to fish within Benin is either foreign owned, foreign flagged or under joint venture and thus based in Benin (Dioury 1983). This situation did not change over time as in the 2000s, and most vessels operating within Benin legally were foreign owned, targeting demersal stocks notably shrimps (Turay and Verstralen 1997; FAO 2007). It is also widely recognized that industrial foreign vessels do not land their catches in Benin (Allegre and Dupret 2010), nor do they have observers onboard and therefore their catches, reflected by low numbers in official data, are mostly unknown. This situation worsened after the 1972 coup d'état, when French, Italian and Greek fishing vessels based in Cotonou left Benin ports because of the fear of nationalization (NOAA 1981), which makes catch data collection even more difficult. We reconstructed the total number of industrial shrimp trawlers within Benin using different literature sources and then allocated these number to a nationality based on the available literature (Table 2). For example, the Chinese fleet, particularly the Kelly fleet (see below), operate in Benin since 2002 and has been increasingly reflagging to the country since then (Vogt *et al.* 2010). The number of these boats was given at –at least – 4 for 2007, and therefore we assumed the number of Chinese vessels in the following years was at least 4 plus part of the number of vessels flagged to Benin. CPUEs estimated were given by the literature from 1958 to 1988 (Dioury 1983; Ssentongo 1990). We performed a linear extrapolation to model the CPUE between 1950 and 2010, then multiplied the resulting CPUE estimates by the estimated number of boats per country.

Discards

The discard rate for the domestic fleet was estimated by Kelleher at 0.5% for 2005, a low rate that is due to increasing retention and landing of bycatch by the domestic demersal fleets. This rate was assumed constant between 2005 and 2010. In the early 1960s, trawl surveys within fishing areas revealed that over the total catch, 15% of species were non-commercial and thus discarded species (Crosnier and Berrit 1964). We assumed this percentage was constant between the 1950s and 1969 and then interpolated to 0.5% in 2005. We multiplied discard rates by the domestic catch to obtain discarded bycatch.

To estimate foreign discards, we used the percentage of discards provided by Kelleher (2005) for Spain (30%) and Greece (32%) between the 1950s and 2010 and then applied them to Spanish and Greek catches. We averaged the previous discard rates and applied them to the industrial catch by France, Portugal, Italy and China. For Nigeria, Cameroon, and Sudan, we applied the domestic discard rates given that these fleets are likely landing their bycatch for local markets.

Table 3. Artisanal marine catch composition (Ssentongo 1990; Djiman 1996) in %.

Percentage of total catch	20	80
Pseudotolithus spp.	13.7	9.7
Galeoides decadactylus	13.9	7.3
Pentanemus quinquarius	0.1	-
Arius spp.	-	-
Brachydeuterus auritus	0.4	-
Drepane africana	0.5	-
Belonidae	2.4	-
Chloroscombrus chrysurus	14.3	-
Trichiurus lepturus	3.4	-
Others	51.3	-
Dentex spp.	-	2.5
Sphyraena spp.	-	6.2
Lutjanus spp.	-	2.9
Illisha africana	-	50.0
Pomadasys spp.	-	0.8
Polydactylus quadrifilis	-	0.6
Pagellus spp.	-	0.3
*Sardinell*a spp.	-	8.6
Scombromorus tritor	-	11.2

Illegal

Illegal fishing in Benin is operated by Nigerian flagged Chinese vessels and particularly the 'Kelly Company's fleet', whose incursions to the artisanal fishing area often results in loss of gear and conflicts with artisanal fishers (Vogt *et al.* 2010). MRAG (2005) estimated illegal, unreported and unregulated catches to be the equivalent of 12% of the legal reported catch, but it is unclear to which category these catches belong. The available information suggests that illegal tuna fishing was most likely offshore (FAO 2007). Trawl illegal fishing referred to in the literature considers the unregulated activities of the Kelly fleet and vessels that are Nigerian flagged holding legal right to operate in Benin, but use illegal mesh size and often operate within areas reserved for artisanal fishers. Herein, we did not reconstruct illegal catches as these might be already included in the industrial component.

Species disaggregation

To disaggregate artisanal and subsistence marine catches we combined the taxonomic breakdown by Ssentongo (1990), who provided the species disaggregation for demersal catches, i.e., 20% of total catches, and Djiman (1996), who documented the species breakdown for the rest of the catch (Table 3).

Similarly, we used the species breakdown provided by (Ssentongo 1990) and Djiman (1996) between 1965 and 1993, completed with a series of linear interpolations and assuming that the same species breakdown since 1993.

It should be noted that the *Sea Around Us* is solely focused on marine and brackishwater fisheries catches. Therefore, once the species disaggregation of the lagoon catches was complete, the catch of purely freshwater species was removed and all analysis was performed on marine and brackish water species only. Herein, artisanal and subsistence lagoon catches refer exclusively to the marine/brackish water species estimates.

RESULTS

Artisanal catches

Artisanal catches from the marine and estuarine waters of Benin were estimated at about 3.1 million t between 1950 and 2010, mainly taken from lagoons (81.6%). Artisanal marine catches increased from 5,600 t·year^{-1} in 1950 to a first peak of around 10,000 t·year^{-1} in 1960 and then decreased after independence due to a series of socio-political events to their historical minimum of 6,200 t·year^{-1} in 1985 then increased to a peak of 12,000 t·year^{-1} in 1996 to remain relatively constant despite an increase in the effort later on (Figure 3).

Artisanal lagoon catches increased from 15,400 t in 1950 to a first peak of 35,000 t in 1969, to decrease thereafter to 28,000 t·year^{-1} in the mid-1970s after the 1972 coup d'état that triggered insecurity (Figure 3). Catches increased thereafter to their historical maximum of 67,000 t in 1993, before declining to 58,000 t·year^{-1} in the late 2000s and then remaining relatively constant despite an increasing number of fishers (Figure 3). The data set does not separate artisanal catches into acadja/non-acadja catches.

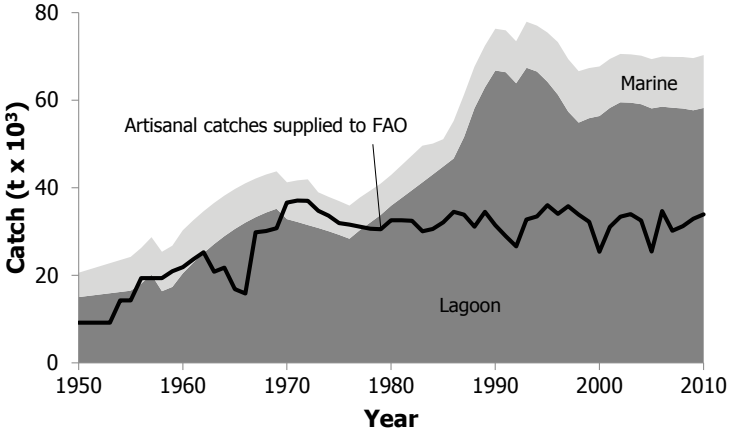

Figure 3. Artisanal reconstructed catches within marine and lagoon waters of Benin, 1950-2010. Black line indicating FAO reported values has been adjusted to remove freshwater catches from lagoons.

Subsistence catches

Subsistence catches were estimated at around 800,000 t between 1950 and 2010, most of which taken from the lagoons (538,000 t). Subsistence marine catches increased with the coastal population from around 1,000 t·year^{-1} in 1950 to around 2,100 t·year^{-1} in 2010 (Figure 4). The lagoon subsistence catches of male fishers increased from around 4,400 t·year^{-1} in 1950 to a peak of 12,000 t·year^{-1} in 1990, mainly taken as consumption from the acadja fishery (60%), before declining to 8,100 t·year^{-1} in 2010 (Figure 4). Women catches increased from 1,000 t·year^{-1} on average in the 1950s to a peak of around 3,000 t·year^{-1} in 1969 right after decreasing because of increasing insecurity in the early 1970s (Figure 4). Catches increased gradually thereafter to reach a peak of 4,100 t·year^{-1} in 2002, before decreasing to around 3,800 t·year^{-1} in 2010 (Figure 4).

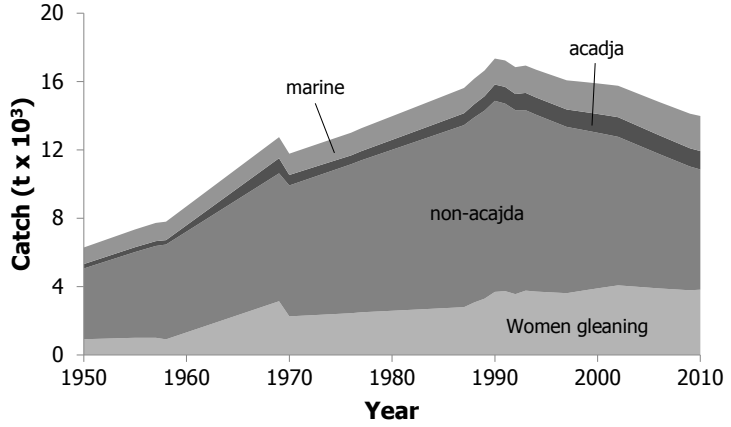

Figure 4. Subsistence reconstructed catches within coastal and lagoon waters of Benin, 1950-2010.

Industrial catches

Industrial domestic catches increased from 240 t in 1959 to a first peak of 1,100 t·year^{-1} in 1974 and declined rapidly to less than 400 t·year^{-1} in the late 1970s (Figure 5). Industrial catches peaked again in 1980 at 1,100 t·year^{-1} before declining to less than 400 t·year^{-1} in 1984. Industrial catches varied later on but reached a peak of 1,600 t·year^{-1} in 2007 before declining drastically due to the decline in the number of industrial domestic vessels (Figure 5).

Foreign catches, on the other hand, reached a historical peak of around 7,800 t·year^{-1} in 1974, after which the departure of vessels from Benin translated into a drastic decline in industrial foreign legal catches, dropped to around 1,100 t·year^{-1} in 1978, mostly by French, Italian, Greek and Sudanese vessels (Figure 5). Catches peaked again in 1980 with the increase in the number of industrial vessel at 5,900 t, before declining to very low levels in 1982 (0 from 1982-1983) (Figure 5). Catches increased again thereafter to reach a peak of 2,500 t·year^{-1} in the early 1990s, when industrial fleets were dominated by African flagged vessel (Cameroon, Nigeria, Sudan) and European vessels (Figure 5). Catches increased to around 5,800 t·year^{-1} in 2002, dominated by Chinese catches, decreased slightly before reaching 5,900 t·year^{-1} in 2010; they were dominated by China and Greece (Figure 5).

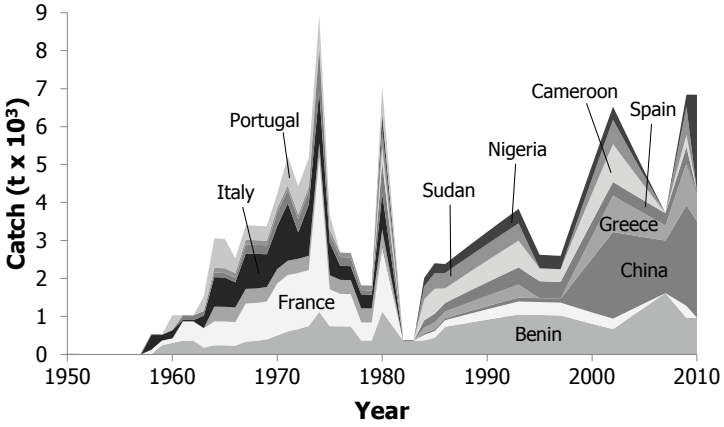

Figure 5. Industrial domestic and foreign reconstructed catches from Benin, 1950-2010.

Discards

Discards were estimated at around 29,100 t between 1950 and 2010. Discards increased gradually from low levels in the mid-1950s to a peak of 1,900 t·year^{-1} in 1974, due to high discarding rates. Discards lowered with the decline of the industrial fleet to low levels in 1983 before increasing gradually to around 800 t·year^{-1} in 2010 (Figure 6).

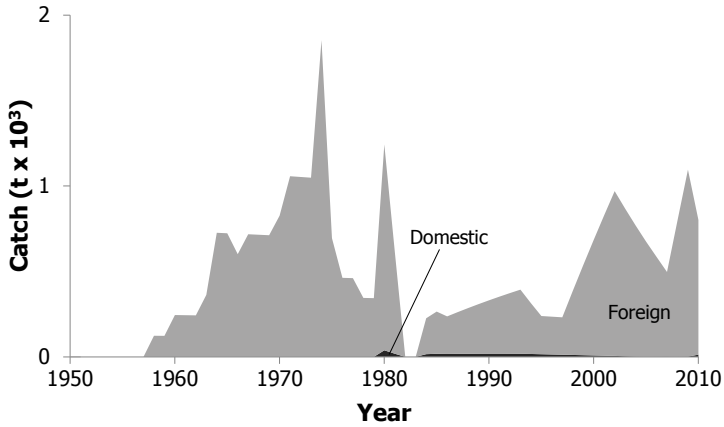

Figure 6. Industrial domestic and foreign reconstructed discards from Benin, 1950-2010.

Reconstructed total catches

Total removals from Benin waters were estimated at 4.0 million t between 1950 and 2010, of which 76 % were taken from the lagoons of Benin, and less than 4 % by the foreign fleets operating in Benin. Domestic catches were estimated at 3.8 million t, of which only 1.7 million t were reported to FAO[2] on behalf of Benin. Domestic catches increased to 26,900 t in 1950 compared to 9,200 t reported to FAO, to 56,900 t in 1969, contrasted to the 31,000 t reported to FAO. Catches declined during the 1970s before increasing to a peak of over 94,000 t·year^{-1} in the early 1990s, almost three times what was reported to the FAO (Figure 7a). Catches decreased thereafter to 85,000 t in 2010, while landing data reported to FAO increased to 35,000 t (Figure 7a).

Taxonomically, blackchin tilapia (*Sarothoredon melanotheron*) dominates catches with approximately a third of total reconstructed catches (38%) followed by Perciforms (11.5%). However the contribution of the two previous taxa to total catches has been declining and slowly replaced by bonga shad (3.8%) in the most recent periods (Figure 7b). 'Others' contain 91 additional categories and composed 25.7% of reconstructed total catches.

DISCUSSION

Domestic and foreign fishing fleets caught around 4.5 million t between 1950 and 2010. Only 41% of the catches taken domestically were reported to the FAO on behalf of Benin. The under-reporting component remained relatively constant over time and then increased during the recent time periods, which shows a lack of improvement in the monitoring system. Furthermore, while official data shows stagnation to a slight increase in the recent years, the

[2] 1.7 million t represents the adjusted FAO baseline, after the removal of freshwater species.

reconstructed data suggest catches are decreasing despite (or rather because of) an increase in effort, which explains over-exploitation perceived by small-scale fishers. This overexploitation causes increasing conflicts with industrial fishing fleets. Furthermore, marine catches including artisanal, industrial catches and the discards they generate are above Maximum Sustainable Yield (MSY), estimated to be between 8,000 and 10,000 t·year^{-1} (Anon. 2010).

The decline of fisheries and the increasing number of conflicts (Vogt *et al.* 2010) threatens small-scale fishers' livelihoods. Indeed, more than a tradition, fisheries are often in Benin the only available occupation for a large number of people as it remains a more profitable activity than agriculture (Atti-Mama 1998). Yet, the economic situation of fishers is increasingly deteriorating (Vogt *et al.* 2010), which suggests increasing presence of industrial vessels and increasing use of acadjas. Although some authors argue that acadjas contribute to increasing fish sizes and repopulating lagoons (Atti-Mama 1998), these large brush parks remain controversial since they "physically impede fishing in the waters they occupy and, as they attract fish from a wider area, they also reduce the stocks available to capture fisheries to some extent" (Cofad and Gut 2002).

Fisheries are also affected by socio-political conditions. For example, the 1972 coup d'état triggered insecurity in the country which resulted in a decline in small-scale catches on one hand, and the departure of formerly Benin-based foreign fleets fearing nationalization (NOAA 1981) by the newly implemented Marxist regime, on the other hand. As a result, when the livelihoods of fishers are threatened, the traditional rules aimed at the sustainable use of fisheries resources via bans, periods of rest, restricted gear and entry to the fishery, are overcome by short term high yields (Vogt *et al.* 2010), resulting in further over-exploitation of fisheries. This decline is also shown by the decrease in discarding rates leading to previously discarded species and juvenile fish increasingly appearing in local markets (Vogt *et al.* 2010). This, along with climate-change induced sea level rise and a low adapting capacity (Dossou and Glèhouenou-Dossou 2007) dangerously challenges of the management approaches aimed at development in Benin.

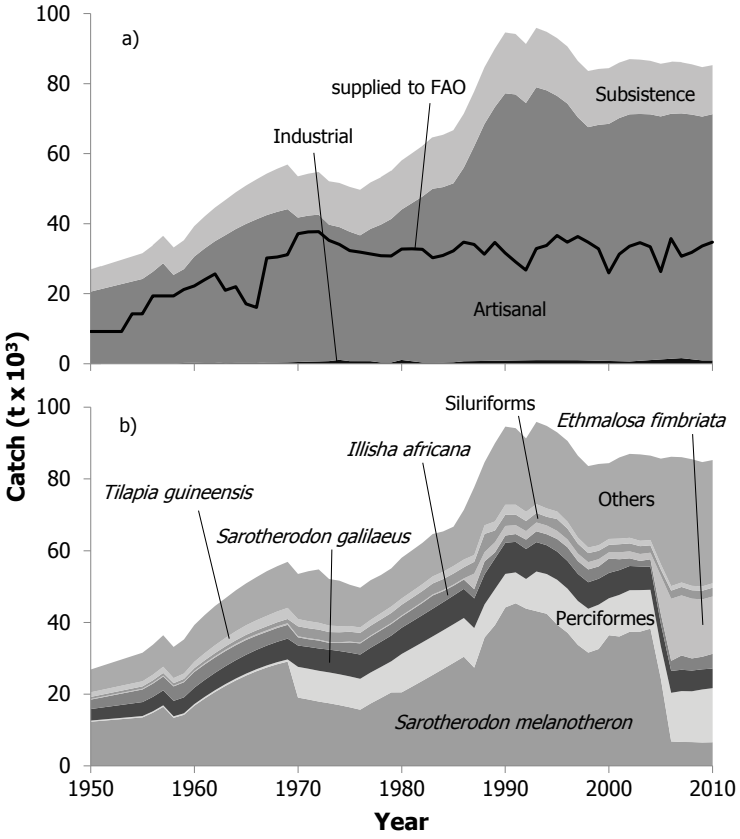

Figure 7. Reconstructed total catches from Benin EEZ by a) sector, with the solid line representing the adjusted FAO reported baseline after the removal of freshwater species; and b) by taxonomic composition, 1950-2010. 'Others' contain 91 other taxonomic categories.

Another dangerous aspect of the decline in Beninese fisheries is that 90% of fisheries and related activities involve "the exchange of sexual favors or transactional sex which is highly related to HIV and AIDS" (Allison and Seeley 2004). The decline in fisheries may have severe implications for exacerbating the HIV/AIDS pandemic.

As fish catch decline, the growing desperation of fishers could intensify catch effort and capacity, hence placing additional pressures on both marine and lagoon resources. The expansion of fishing territory, which further increases competition (Vogt *et al.* 2010) and the lack of management measures to control foreign industrial fleets, have led to the increasing spread of piracy and violence in the Gulf of Guinea. This was prevalent in 2007, when Chinese trawlers sailing under the Benin flag were attacked by local fishers (Gletton-Quenum 2010). By reconstructing the total marine catches of Benin, the severity of the current state of the fisheries and the stark implications for Benin fishers becomes apparent.

Acknowledgements

We acknowledge the support of the *Sea Around Us*, a scientific collaboration between the University of British Columbia, The Pew Charitable Trusts and the Paul G. Allen Family Foundation.

References

Ahouandjogbe S, Didavi Y, Gangbazo K and Gnitassoun D (2013) Rapport National. Enquête cadre en pêche continentale 2012. Ministère de l'Agriculture, de l'Elevage et de la Pêche, Cotonou. 124 p.

Ajao E (1999) Sustainable management of water bodies for small-scale fisheries resorces research and development, 13th Annual Conference of the Fisheries Society of Nigeria (FISON), 3-8 November 1996. Fisheries Society of Nigeria, New Bussa, Nigeria. 6 p.

Allegre J and Dupret G (2010) Assistance au secteur industriel de la pêche au Bénin pour l'harmonisation du système de production avec la réglementation UE (IND020BEN). Amélioration de l'état sanitaire des produits de la pêche dans les pays ACP/PTOM 8ACPTPS137. Module 3: de la conformité des industries de pêche aux conditions sanitaires d'exportation., European Union, Brussels. 41 p.

Allison EH and Seeley JA (2004) HIV and AIDS among fisherfolk: a threat to 'responsible fisheries'? Fish and Fisheries 5(3): 215-234.

Anon. (1964) Enquete Démographique au Dahomey 1961. Résultats définitifs. I.N.S.E.E Service de Cooperation, Paris. 336 p.

Anon. (1994) Production halieutique 1994 de la pêche continentale au Benin. Direction des Pêches, Service Statistique et Projet Pêche Lagunaire, Cotonou. 17 p.

Anon. (2010) Revue des pêche SFW Benin. Revue des Pêches SFW, FAO–SFW, Rome. 8 p.

Atti-Mama C (1998) Co-management in continental fishing in Benin: the case of Lake Nokoué. Hydraulic Department, Cotonou. 29 p.

Boëly T and Fréon P (1979) Les ressources pélagiques côtières. pp. 13-74 *In* Troadec J and Garcia S (eds.) Les ressources halieutiques de l'Atlantique centre-est : première partie : les ressources du Golfe de Guinée de l'Angola à la Mauritanie. Document Technique de Pêches 186 (1). FAO, Rome.

Bouche P (1885) Sept ans en Afrique Occidentale. La Côte des Esclaves et le Dahomey. E. Plon, Nourrit et Cie, Paris.

Briones Alonso E, Verpoorten M and Houssa R (2013) Voodoo and fishing in a changing world: The role of traditional religion and modern institutions in managing the inland fisheries of Benin. Licos, Cotonou, 46 p.

Buffe I (1958) Les pêcheries en branchages "Acadja" des lagunes du Bas-Dahomey. Revue Bois et Forêts des Tropiques 59(Mai-Juin 1958): 19-24.

Capo-Chichi Y (2006) Monographie de la commune de Grand-Popo. Afrique Conseil, Cotonou. 46 p.

Chaboud C and Charles-Dominique E (1991) Les pêches artisanales en Afrique de l'ouest : état des connaissances et évolution de la recherche. pp. 99-141 In Durand J, Lemoalle J and Weber J (eds.), La recherche face à la pêche Artisanale, Symp. Int. ORSTOM-IFREMER, Montpellier France, 3-7 juillet 1989, t. 1, ORSTOM, Paris.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). Center for International Earth Science Information Network (CIESIN)/Columbia University. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3 [Accessed: 29/04/2013].

Cofad G and Gut R (2002) Back to basics. Traditional Inland Fisheries Management and Enhancement Systems in Sub-Saharan Africa and their Potential for Development. Natural Resource Management, GTZ, Eschborn. 203 p.

Crosnier A and Berrit G (1964) Fonds de pêche le long des côtes des républiques du Dahomey et du Togo. Office de la Recherche Scientifique et Technique Outre-Mer, Pointe-Noire 146 p.

Dangbégnon C (2000) Governing Local Commons: What can be learned from the failures of Lake Aheme's Institutions in Bénin? Paper presented at the Eighth biennial conference of the IASCP in Bloomington, Indiana, USA, May/June 2000. 25 p.

Dessouassi C (2011) La pêche artisanale au Sud Benin face aux défis des chagements climatiques. Direction des Pêches, Cotonou. 21 p.

Dioury F (1983) Monographie de la pêche dans douze pays riverains d'Afrique de l'Ouest, de la Mauritanie au Benin. [s.n.], Bruxelles. 409 p.

Djiman R (1996) Fisheries potential evaluation and probable upwelling phenomenon off the Benin Coast. pp. 25-30 *In* Summaries of contributions presented at the workshop on West African fisheries organized during the advanced course on upwelling systems (Atlantic Ocean Eastern Boundary). A joint effort from IOC and the European Union MAST Programme, Las Palmas, Gran Canaria, Spain, 9-10 August 1995. Intergovernmental Oceanographic Commission of UNESCO.

Dossou KMR and Glehouenou-Dossou B (2007) The vulnerability to climate change of Cotonou (Benin): the rise in sea level. Environment and Urbanization 19(1): 65-79.

Ecoutin J, Delaunay K and Konan J (1993) L'économie des pêches maritime ivoiriennes. pp. 537-549 *In* Le Loeuff P, Marchal E and Amon Kothias J (eds.), Environnement et ressources aquatiques de Côte d'Ivoire. ORSTOM, Paris.

FAO (2007) Country inventory fisheries monitoring system, Benin. FAO, Rome. 8 p.

Gbaguidi A and Djanato M (1997) Enquète cadre plans d'eau du Bénin. Direction des pêches, Cotonou. 34 p.

Gbaguidi A and Meyizoun T (1994) Understand the sector to work better for its development. IDAF Newsletter 22 (June 1994): 18-23.

Gletton-Quenum M (2010) Pêche maritime. Le pillage des ressources continue. Adjinakou Newspaper 1506(7).

Gnakadja G (2000) Rapport du consultant national sur les pêches continentales et aquacultures. Ministère du Developpement rural, Cotonou. 46 p.

Horemans B (1994) La situation de la pêche artisanale en Afrique de l'Ouest en 1993. N. 54, Programme pour le développement integre des pêches artisanales en Afrique de l'ouest, Cotonou. 40 p.

Horemans B and Jallow A (1997) Workshop on gender roles amd issues on artisanal fisheries in West Africa. Lomé, Togo, 11-13 December 1996. Technical Report 97, IDAF, Cotonou. 52 p.

Ijff A and Tempelman D (1990) Etude sur les relations entre les captures de poisson et l'etat nutritionnel des communautés des pêcheurs dans la province du Mono, au Benin. N. 16, IDAF, Cotonou. 25 p.

Iroko F (2005) Benin. The hidden face of traditional inland fisheries. SFLP Liaison Bulletin 21 & 22, FAO, Rome. 47-50 p.

Kelleher K (2005) Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper 470, Food and Agriculture Organization, Rome. 131 p.

Lalèyè PA (2000) Acadja fisheries enhancement systems in Benin: their productivity and environmental impacts. p. 51-52. *In* Abban E, Casal C and Falk R (eds.), Biodiversity and sustainable use of fish in the coastal zone. ICLARM Conference Proceedings 63, 71 p.

Lemasson J (1961) Chromique piscicole. La situation de la pêche lagunaire au Dahomey et les interventions qu'elles necessite. Revue Bois et Forêts des Tropiques 76 (Mars-Avril 1961): 62-67.

MRAG (2005) Review of impacts of Illegal, Unreported and Unregulated fishing on developing countries. Final report, MRAG, London. 176 p.

Niyonkuru C and Lalèyè PA (2010) Impact of acadja fisheries on fish assemblages in Lake Nokoué, Benin, West Africa. Knowledge and Management of Aquatic Ecosystems 2010(339): 15.

Njock J-C and Westlund L (2010) Migration, resource management and global change: Experiences from fishing communities in West and Central Africa. Marine Policy 34(4): 752-760.

NOAA (1981) The Fisheries of Benin. Foreign Fishery Development No. 43, NOAA, Washington, DC. 29-31 p.

Pérez-Ruzafa A and Marcos C (2012) Fisheries in coastal lagoons: An assumed, but poorly researched aspect of the ecology and functioning of coastal lagoons. Estuarine, Coastal and Shelf Science 110(0): 15-31.

Senouvo P (1990a) Statistiques de pêches des villages du projet modèle. Annee 1987. DIPA. 33 p.

Senouvo P (1990b) Statistiques des pêches des villages du projet modèle. N. 13, DIPA, Cotonou. 6 p.

SOFRECO (2002) Diagnostic strategique de filieres Agro-industrielles. Rapport Benin. UE / CECEAO, Clichy. 21 p.

Ssentongo G (1990) la pêche demersale en République Populaire du Benin. p. Annexe XII *In* Rapport du groupe de Travail *ad Hoc* sur les stocks demersaux de la région du Golfe de Guinée Ouest (Division Statistique 34.3.4), Centro Costero de Canarias, Santa Cruz de Tenerife, Espagne 23–27 mars 198789/48. FAO, Rome.

Stoop N, Houssa R and Verpoorten M (2013) To fish or not to fish? Resource Degradation and Income Diversification in Benin. LICOS Discussion Paper 328, LICOS Centre for Institutions and Economic Performance, Leuven. 47 p.

Trottier B (1987) Women in Aquaculture Production in West Africa. p.17-28 *In* Nash C, Engle C and Crosetti D (eds.), Women in Aquaculture. Proceedings of the ADCP/NORAD Workshop on Women in Aquaculture, Rome, FAO, 13-16 April 1987 ADCP/REP/87/28. FAO, Rome.

Turay F and Verstralen K (1997) Costs and Earnings in Artisanal Fisheries: Methodology and Lessons Learned from Case Studies. Technical Report 100, DIPA, Cotonou. 60 p.

Vogt J, Teka O and Sturm U (2010) Modern issues facing coastal management of the fishery industry: A study of the effects of globalization in coastal Benin on the traditional fishery community. Ocean & Coastal Management 53(8): 428-438.

Weigel J (1985) Traditional management of some lagoons in the Gulf of Guinea (Ivory Coast, Ghana, Togo and Benin). FAO Fish. Circ. 790, FAO, Rome. 29 p.

Welcomme R (1972) An evaluation of the acadja method of fishing as practiced in the coastal lagoons of Dahomey (West Africa). I. Fish Biol. 4: 39-55.

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

Year	FAO landings[1]	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	9,190	26,900	-	20,600	6,290	-
1951	9,190	27,800	-	21,300	6,500	-
1952	9,190	28,800	-	22,000	6,710	-
1953	9,190	29,700	-	22,800	6,920	-
1954	14,280	30,600	-	23,500	7,130	-
1955	14,280	31,600	-	24,200	7,340	-
1956	19,370	33,800	-	26,200	7,530	-
1957	19,370	36,400	-	28,700	7,720	-
1958	19,370	33,200	-	25,400	7,800	-
1959	21,190	35,300	240	26,800	8,250	-
1960	22,190	39,300	300	30,300	8,700	-
1961	24,010	42,100	360	32,600	9,150	-
1962	25,650	44,600	360	34,600	9,600	-
1963	21,010	46,700	180	36,500	10,050	-
1964	22,010	48,900	240	38,200	10,500	-
1965	17,100	50,900	240	39,700	10,950	-
1966	16,080	52,600	228	41,000	11,400	-
1967	30,160	54,300	336	42,100	11,850	-
1968	30,460	55,700	354	43,000	12,300	-
1969	31,160	56,900	396	43,700	12,740	-
1970	37,100	53,500	499	41,200	11,780	-
1971	37,670	54,300	606	41,700	11,980	-
1972	37,680	54,800	666	41,900	12,190	-
1973	35,250	52,100	749	39,000	12,390	-
1974	34,070	51,600	1,119	37,900	12,600	-
1975	32,290	50,500	743	37,000	12,800	-
1976	31,890	49,700	740	35,900	13,000	-
1977	31,390	51,800	737	37,800	13,270	-
1978	30,880	53,200	367	39,400	13,500	-
1979	30,770	55,100	365	41,000	13,740	-
1980	32,780	58,000	1,091	42,900	13,970	38
1981	32,790	60,100	724	45,100	14,210	18
1982	32,650	62,200	361	47,400	14,440	-
1983	30,250	64,600	359	49,600	14,680	-
1984	30,910	65,400	352	50,100	14,910	16
1985	32,250	66,700	420	51,100	15,150	18
1986	34,690	71,400	709	55,300	15,390	17
1987	34,090	77,700	756	61,300	15,620	18
1988	31,290	84,700	803	67,700	16,170	18
1989	34,660	90,000	850	72,400	16,650	19
1990	31,630	94,600	896	76,300	17,340	19
1991	29,070	94,200	942	76,000	17,230	19
1992	26,750	91,300	987	73,500	16,840	19
1993	32,900	95,900	1,031	77,900	16,930	18
1994	33,750	94,800	1,027	77,000	16,700	17
1995	36,630	93,000	1,022	75,500	16,490	15
1996	34,710	90,600	1,018	73,300	16,280	14
1997	36,350	86,500	1,013	69,400	16,070	13
1998	34,690	83,600	941	66,600	16,010	11
1999	32,820	84,200	868	67,300	15,950	10
2000	25,980	84,400	797	67,700	15,890	8
2001	31,290	86,000	729	69,400	15,820	7
2002	33,560	87,000	660	70,600	15,750	6
2003	34,560	86,800	854	70,500	15,510	3
2004	33,380	86,500	1,046	70,200	15,280	2
2005	26,350	85,700	1,237	69,400	15,040	1
2006	35,720	86,200	1,425	70,000	14,800	-
2007	30,720	86,100	1,612	69,900	14,570	-
2008	31,830	85,500	1,283	69,900	14,340	1
2009	33,660	84,700	958	69,600	14,120	2
2010	34,690	85,300	953	70,300	13,980	13

[1] For the purposes of *Sea Around Us*, freshwater species catch have been removed from reported FAO landings, yielding an adjusted baseline.

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxa for Benin, 1950-2010. 'Others' contain 91 additional taxonomic categories.

Year	*Sarotherodon melanotheron*	Perciformes	*Sarotherodon galilaeus*	*Ilisha africana*	*Ethmalosa fimbriata*	Siluriformes	*Tilapia guineensis*	Others
1950	12,300	317	3,210	2,620	189	569	1,300	6,340
1951	12,600	329	3,350	2,800	193	587	1,330	6,660
1952	12,800	341	3,490	2,980	196	605	1,350	6,990
1953	13,100	353	3,620	3,150	200	623	1,380	7,310
1954	13,300	365	3,760	3,330	204	641	1,400	7,630
1955	13,500	377	3,900	3,510	207	659	1,430	7,950
1956	14,800	394	4,030	3,680	227	699	1,560	8,350
1957	16,500	413	4,170	3,860	253	747	1,730	8,780
1958	13,400	410	4,310	4,030	206	693	1,410	8,690
1959	14,300	425	4,440	4,210	218	725	1,500	9,480
1960	16,800	448	4,580	4,380	257	795	1,770	10,250
1961	18,800	468	4,720	4,330	287	852	1,980	10,640
1962	20,600	487	4,850	4,280	315	906	2,180	10,950
1963	22,300	506	4,990	4,220	341	957	2,360	11,060
1964	23,800	524	5,120	4,170	364	1,005	2,520	11,400
1965	25,200	541	5,260	4,120	385	1,049	2,670	11,670
1966	26,400	558	5,400	3,960	403	1,089	2,800	12,020
1967	27,500	574	5,530	3,830	418	1,127	2,910	12,450
1968	28,300	589	5,670	3,850	432	1,160	3,010	12,610
1969	29,100	603	5,810	3,840	443	1,191	3,090	12,830
1970	19,100	8,568	5,940	2,290	290	2,778	2,030	12,570
1971	18,500	8,576	6,080	2,140	282	2,778	1,970	13,920
1972	17,900	8,585	6,220	2,200	273	2,778	1,910	14,870
1973	17,500	8,592	6,350	1,870	259	2,765	1,810	12,980
1974	16,900	8,600	6,490	2,220	244	2,752	1,710	12,670
1975	16,300	8,607	6,630	2,850	230	2,738	1,610	11,500
1976	15,700	8,616	6,760	3,110	214	2,725	1,500	11,070
1977	17,400	8,639	6,900	3,160	232	2,756	1,620	11,070
1978	18,900	8,658	7,040	3,210	246	2,780	1,710	10,660
1979	20,500	8,681	7,170	3,240	259	2,804	1,800	10,620
1980	20,500	10,694	7,310	3,160	253	3,002	1,750	11,350
1981	22,100	10,717	7,450	3,280	265	3,022	1,830	11,430
1982	23,700	10,735	7,580	3,410	277	3,041	1,910	11,500
1983	25,400	10,753	7,720	3,690	288	3,059	1,980	11,800
1984	27,000	10,756	7,860	3,060	299	3,074	2,050	11,240
1985	28,700	10,777	7,990	2,740	308	3,088	2,110	10,950
1986	30,400	10,791	8,130	2,590	318	3,100	2,170	13,830
1987	27,400	11,034	8,270	2,570	4,336	3,291	1,900	18,910
1988	35,800	9,214	8,400	3,590	2,569	5,096	2,390	17,580
1989	39,300	10,027	8,540	1,680	2,840	3,269	2,540	21,790
1990	44,200	9,342	8,680	2,010	2,681	3,136	2,770	21,780
1991	45,300	8,605	8,510	2,180	2,483	2,936	2,750	21,340
1992	43,900	8,263	8,350	2,620	2,371	2,808	2,580	20,470
1993	43,100	11,054	8,190	3,020	2,462	2,665	2,460	22,910
1994	42,400	11,070	8,030	3,070	2,440	2,419	2,340	22,990
1995	39,400	12,519	7,870	3,490	2,272	3,291	2,110	22,070
1996	37,100	12,281	7,710	3,820	2,182	3,019	1,930	22,510
1997	33,700	12,252	7,550	3,560	2,097	2,771	1,700	22,820
1998	31,600	12,228	7,390	3,570	2,023	2,532	1,550	22,710
1999	32,600	12,365	7,230	3,420	2,028	2,341	1,540	22,670
2000	36,400	10,318	7,070	3,990	1,744	2,082	1,650	21,130
2001	36,100	11,602	6,910	3,020	1,936	2,248	1,570	22,620
2002	37,400	11,592	6,740	2,130	1,945	2,217	1,570	23,390
2003	37,400	11,577	6,580	1,550	1,933	2,183	1,500	24,080
2004	38,300	10,827	6,420	2,080	1,838	2,049	1,470	23,540
2005	24,300	9,069	6,260	2,740	10,622	1,733	1,490	29,410
2006	6,800	13,564	6,100	2,820	17,300	2,268	1,270	36,040
2007	6,700	14,181	5,940	3,980	16,751	2,352	1,240	34,930
2008	6,600	14,163	5,780	3,370	16,665	2,337	1,230	35,290
2009	6,500	14,783	5,620	3,500	15,983	2,422	1,210	34,630
2010	6,600	15,079	5,460	4,120	15,979	2,458	1,230	34,340

An overview of the Nigerian marine fisheries and a re-evaluation of their catch from 1950 to 2010[1]

Lawrence Etim[a], Dyhia Belhabib[b] and Daniel Pauly[b]

[a] *Department of Fisheries and Aquatic Environmental Management, University of Uyo, Akwa Ibom State, Nigeria*
[b] *Sea Around Us, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada*

lawrenceetim@uniuyo.edu.ng ; d.belhabib@fisheries.ubc.ca ; d.pauly@fisheries.ubc.ca

Abstract

Nigeria, with more than 250 ethnic groups and a current population of about 170 million inhabitants is the most populous African country. With a crude oil production of 2.5 million barrels per day, Nigeria also ranks as the largest producer of crude oil in Africa and the sixth largest producer in the world. The fisheries sector, which is also important, has grown considerably since the country gained independence from the United Kingdom in 1960. However, government fisheries departments lack officers responsible for field data collection; consequently, catch data are often exaggerated or un-reported. Using standard procedures, we re-estimated (i.e., reconstructed) the Nigerian marine fisheries catches from 1950 to 2010 to account for likely under-reporting and non-reporting of the catch of fish and shrimps trawlers, artisanal and subsistence fishers, foreign legal and illegal fleets and discards. This led to catches of about 34,000 t in 1950, 540,000 t in 2005 and 490,000 t in 2010. Reconstructed domestic catches were about twice the data supplied to the FAO. Taxonomically, sardinellas (*Sardinella* spp.) represented the largest contribution to domestic catches, followed by bonga shad (*Ethmalosa fimbriata*) and croakers (*Pseudotolithus* spp.). Under-reporting is becoming more pronounced over time, thus debunking the myth of massive over-reporting by Nigeria. Increasing illegal and unreported catches by foreign vessels constitute a growing threat to the sustainability of the stocks. In all, while catches are under-reported, the marine fisheries of Nigeria are overexploited.

Introduction

Fishing activities in the Nigerian marine fisheries sector may be classified into coastal small-scale (artisanal and subsistence), inshore industrial and offshore (distant water) industrial fisheries. The coastal small-scale fishery operates within 5 nautical miles from the coastline and also in estuaries, creeks and lagoons. To reduce conflicts between the industrial and the artisanal sectors, the Nigeria Sea Fisheries (Fishing) Regulation of 1972 assigns exclusive right to the artisanal canoe fisheries to exploit this inshore area. The species exploited include pelagic and demersal fishes such as clupeids, croakers, soles, threadfins, catfishes, sharks, penaeid shrimps, crabs, etc. The artisanal fishery is labour intensive and employs small, traditional and sometimes un-motorized craft and hand-operated gears although planked and dug-out canoes (3 to 13 m long) powered by outboard engines ranging from 15 to 25 hp are increasingly common. Generally, this fishery, which has low capital outlays, employs simple technology and its catches are sold mostly in the local markets. Set gillnets and cast nets are the major fishing gears. The fishery is open access and unregulated (Panayotou 1982).

Figure 1. Nigeria's Exclusive Economic Zone (EEZ; 217,000 km²) and shelf area (to 200 m depth).

The inshore industrial fishery operates from about 5 nautical miles off the coast to the edge of the continental shelf (Figure 1). This industry employs bottom or mid-water trawlers to catch and land a variety of species including croakers (*Pseudotolithus* spp.), soles (*Cynoglossus* spp.), groupers (*Epinephelus* spp.), snappers (*Lutjanus* spp.), bigeyes (*Brachydeuterus* spp.), threadfins (*Polydactilus* spp.), baraccudas (*Sphyraena* spp.), jacks (*Caranx* spp.), horse mackerels (*Trachurus* spp.) and cutlass fishes (*Trichiurus* spp.). The industrial fisheries are capital intensive and utilize large fishing vessels with in-board engines

[1] Cite as: Etim, L., Belhabib, D. and Pauly, D. (2015) An overview of the Nigerian marine fisheries and a re-evaluation of its catch data for the years 1950-2010. pp. 66-76. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

and mechanically operated winches (Ekpo and Etim 1989). They employ small- to medium-sized trawlers ranging in size from 9 to 25 m Length Over All (LOA). About 40 trawling companies, with an average fleet size of four, operate in Nigeria and most are members of the Nigerian Trawlers Owners' Association. Companies with fleet size of more than four are likely to be in partnership with foreign investors (Falaye 2008). Ganapathiraju and Pitcher (2006) noted that there are 36 fishing companies operated in the country, out of which 14 were foreign-owned.

According to FAO (2000), Nigerian flag-registered fishing vessels are allowed to operate in the waters of other African countries under the terms of the bilateral fishing access agreements between Nigeria and the countries in question, or under privately arranged agreements, which must be seen by the Nigerian Federal Department of Fisheries (FDF) as "just and equitable". All the fish catch must be landed at a Nigerian port. The fishing licence issued to such Nigerian-registered flag vessels is classified as Distant-Water Fishing Licence (Category A). Category B license is for vessels which are foreign flag-registered, but are chartered by Nigerian companies or individuals for fishing in the waters of foreign countries. Category C is Distant-Water Fishing Licences usually issued to reefer vessels bringing in frozen fish to Nigeria. Such vessels may be Nigerian or foreign-flag registered.

Falaye (2008) stated that FDF makes about 250,000 US dollars annually from the registration of industrial trawlers, but that the sector contributes less than 5% to total marine fish catches in the country. A salient aspect of this subsector is that parts of its catch, notably shrimps, are exported, which brings in about 20 million US dollars annually to the Nigerian economy (Falaye 2008).

Offshore marine fisheries exploit resources between the continental shelf area and the 200-mile EEZ. Tuna and billfishes are the main target species. The vessels are generally more than 25 m LOA and greater than 150 gross registered tonnage (GRT). Vessels are all wholly owned by Nigerians. The inability of Nigeria to attract foreign investors may be due its non-membership in the International Commission for the Conservation of Atlantic Tunas (ICCAT).

The history of systematic, country-wide fisheries data collection in Nigeria is rather short, as it started in the early 1970s (Ajayi 1991; Etim 1992). Etim (1992) pointed out that the accuracy and authenticity of data collated by FDF is usually doubted by independent authors (e.g., Ssentongo *et al.* 1983; Everett 1986; Ssentongo *et al.* 1986; Anon. 1988). Much of the inaccuracies and deficiencies in the FDF's data are consequences of the inherent bureaucratic problems in government ministries, the fisheries sector and the difficult politics of the country. The various fisheries departments are grossly under-staffed with field officers who are not replaced by new employees upon their retirements. Thus, fewer field officers continue to collect data from an increasing number of landing sites and beaches.

Without adequate funding, they are unable to cover all the landing sites assigned to them and they end up guessing part, or maybe even all, of the data they submit. Indeed, scarcity of operating funds is considered by the Directors of Fisheries to be their greatest problem. The decline in government funding, as the only source of funds, to ministries implies that it is politically more expedient for government to direct scarce funds to community development projects and poverty alleviation programmes than to fix fisheries data collection issues whose usefulness is not immediately visible. Politicians are re-elected based on the "development projects" they can take credit for, and not on the quality of statistical data their ministries compile. Without funds, it is difficult for field officers to reach the numerous fishers scattered in remote villages.

There are inherent competitive tendencies among the states as they try to surpass or even outdo each other as the best producer of one commodity or the other. This explains the suspected or alleged tendencies by state ministries to inflate their production figures to the FDF. According to the Directors of Fisheries of several states, the final data published by FDF are often higher than the ones they submitted. With no vessels, the monitoring and surveillance unit of the FDF suffers from a total lack of vessel monitoring opportunities; the unit is handicapped as it is expected to depend on other agencies (e.g., the Nigeria Navy) for their monitoring and surveillance activities.

Thus, it is clear that fisheries data collection in Nigeria, as in many other developing countries, is fraught with difficulties that make such data deficient, biased or incomplete (Etim 1992; Zeller *et al.* 2007; Zeller and Pauly 2007; Jacquet *et al.* 2010). This is compounded by the multi-gear nature of the fisheries, which makes computation and inter-comparison of some indices (e.g., CPUE) across a range of gears difficult.

A 'catch reconstruction' approach for addressing the anomalies in such data was developed (Zeller *et al.* 2007) and successfully implemented for many countries, e.g., Mozambique and Tanzania (Jacquet *et al.* 2010), Colombia (Wielgus *et al.* 2010) and the US flag-associated islands in the Pacific (Zeller *et al.* 2007). Within this context and in the light of the aforementioned problems, we reconstructed the marine fisheries catches of Nigeria for the years 1950 to 2010, to obtain time series likely to be more complete, comprehensive and hopefully less biased than the extant data.

Methods

The catch reconstruction procedure used in this work entails six basic steps (Zeller *et al.* 2007):

i) Identifying of and sourcing for existing reported catch time series, catch per effort, number of fishers;

ii) Identifying of sectors, time periods, species, gears, etc., not covered by (i) above; that is missing catch data via extensive literature searches;

iii) Search for available alternative information sources to supply the missing catch data in (ii) through extensive literature searches (peer reviewed publications, gray literature and technical reports) and consultations. The first author consulted in-country experts in academia and federal and state government officials, notably, the Directors of Fisheries in all the maritime states, who were either visited or contacted;

iv) Developing of data anchor points in time for missing data items,

v) Interpolation of time periods between data anchor points for total catch, and

vi) Estimation of final total catch time series estimates for total catch, combining reported catches in (i) with interpolated, missing data series in (v) above.

FAO and other data

The Nigerian marine fish catches between 1950 and 2010, as published by FAO on behalf of Nigeria, was extracted from FAO FishstatJ after filtering out unwanted information related to turtles, marine mammals, etc. We carried out extensive literature searches including peer reviewed publications, technical reports and other grey literature[2].

Reconstructed total catch

The catch per unit of effort (CPUE) and the active fishing days were extracted from the relevant literature or obtained from in-country experts. The reconstructed catch data have the following components: a) fish trawl catches, b) shrimp trawl catches, c) artisanal shrimp catches, d) artisanal fish catches, e) shrimp trawl discards, f) subsistence catch by fishers and their families, and g) illegal and unreported foreign fish catches and illegal and unreported foreign shrimp catches. These are addressed individually.

Table 1. Reconstruction of the number of finfish trawlers operating in Nigeria, 1950-2010.

Year	Number of trawlers	Reference
1950	7	Assumed half of the number in 1971
1971	13	Ssentongo *et al.* (1986)
1976	26	Ssentongo *et al.* (1986)
1982	52	Ssentongo *et al.* (1986)
1984	53	Ssentongo *et al.* (1986)
1992	58.2	One fifth of the total trawl fleet (Okon 2010)
2003	50	One fifth of the total trawl fleet (Okon 2010)
2007	38.2	One fifth of the total trawl fleet (Okon 2010)
2008	35	FDF (2008)
2010	30	One fifth of the total trawl fleet (Perouse de Montclos 2012)

Table 2. Reconstruction of the number of shrimp trawlers operating in Nigeria, 1950-2010.

Year	Number of shrimpers	Reference
1950	5	Assumed to be 20% of the 1971 effort
1971	26	Ssentongo *et al.* (1986)
1972	29	Ssentongo *et al.* (1986)
1973	30	Ssentongo *et al.* (1986)
1974	39	Ssentongo *et al.* (1986)
1975	30	Ssentongo *et al.* (1986)
1976	29	Ssentongo *et al.* (1986)
1977	36	Ssentongo *et al.* (1986)
1978	49	Ssentongo *et al.* (1986)
1979	48	Ssentongo *et al.* (1986)
1980	45	Ssentongo *et al.* (1986)
1981	36	Ssentongo *et al.* (1986)
1982	34	Ssentongo *et al.* (1986)
1983	39	Ssentongo *et al.* (1986)
1984	37	Ssentongo *et al.* (1986)
1992	233	See Table 1
1995	235[a]	-
1997	197[a]	-
2003	200	See Table 1
2010	120	See Table 1

[a] http://www.fcwc-fish.org/about-us/member-countries/81-nigeria

a) Fish trawl catches

The total catch from the marine sector was computed from CPUE and fishing effort. The CPUE was estimated at 639 kg·boat^{-1} for 300 fishing days for 1991 (Löwenberg and Künzel 1991), i.e. 110.7 t·boat^{-1}·year^{-1}. We assumed the CPUE was 20% lower in 1950 due to lower capacity and boat size, and 5% lower in 2010 due to prevailing overexploitation (Akankali and Jamabo 2011) but also increasing piracy, which led to an overall decline of the fishing activity (Perouse de Montclos 2012). The number of finfish trawlers was reconstructed from various sources (Table 1), then interpolated to fill in the gaps. We multiplied the interpolated CPUEs by the number of finfish trawlers and estimated their total catches between 1950 and 2010. We then disaggregated catches based on the species composition provided by Ssentongo *et al.* (1986).

b) Shrimp trawl catches

We reconstructed the number of boats between 1950 and 2010 based on various sources (Table 2). Given the the lack of independent empirical scientific reports on the

[2] Some of the earlier reports from the 1960s were obtained during a summer 2013 visit by DP to Alan Longhurst, who has retired in the South of France, but was based in Lagos in the early 1960s, and very active in early Nigerian fisheries research.

shrimp trawl fisheries, we calculated the CPUE by dividing the catch estimated by FDF (2008) by the corresponding effort, i.e., 1,123 t·boat^{-1}·year^{-1} for the 2008-2010 time period (see Table 2 for effort). An assessment by Ssentongo *et al.* (1986) based on reported catch data by shrimping companies allowed to estimate the CPUE of shrimpers at 188.27 t·boat^{-1}·year^{-1} for the early 1980s. Although this value is much lower than that for the late 2000s, increasing shrimper capacity and efficiency, and the increase in the number of their fishing days (Perouse de Montclos 2012), makes such an increase possible. We assumed the CPUE was 20% lower in 1950 to account for increasing capacity. We interpolated linearly the CPUE estimates, then multiplied the latter by the number of shrimpers between 1950 and 2010. We interpolated the resulting catch to fill in the gaps. Shrimp trawler catches consisted of 6% shrimps, 81% croakers, 2% soles, 3% rays, 4% sea catchfishes and 5% other species (Ssentongo *et al.* 1986).

c) Artisanal shrimp catches

The number of artisanal fishing boats was provided by Ssentongo *et al.* (1986) for the period between 1971 and 1984, and the number of full time artisanal fishers was given in FDF (2008). The latter are given for the entire country rather than by sector. Published studies do not contain information by sector either; this may be because local authors consider enumeration of boats and fisher numbers a 'sociological' study, while calculation of CPUE, etc., is 'scientific' and thus worth their while. From the total number of artisanal fishers given in FDF (2008), the number of artisanal boats in the country was estimated at about 45,200, assuming 6 fishers per boat (Uwe-Bassey 1988; Enin *et al.* 1991; Enin 1994). Assuming a 3.5 to 1 ratio between artisanal fishing and artisanal shrimping boats, there were about 35,200 artisanal fishing boats and about 10,000 artisanal shrimping boats in 2008-2010. We kept this ratio constant and disaggregated the total number of artisanal boats (see above) to fish and shrimp boats between 1979 and 1984. We also assumed that the number of artisanal boats in 1950 was 80% of that of 1971. We interpolated linearly the number of boats to complete the time series.

An average CPUE of 75.9 kg·boat^{-1}·day^{-1} (Enin *et al.* 1991) and an active number of fishing days of 200 (Enin 1994) allowed to estimate an annual CPUE of 15.18 t·boat^{-1} for 1991. We assumed this CPUE was 20% higher in 1950 and 5% lower in 2010 for two main reasons: first, the size and motorization rate of the fleet grew only slightly between 1950 and 1991; and second, over-exploitation should have resulted in declining catch per boat between 1991 and 2010. We multiplied the interpolated CPUE by the interpolated fishing effort and estimated total catches by the artisanal shrimp fleet.

d) Artisanal fish catch

A mean CPUE of 36 kg·day^{-1} (Udolisa and Solarin 1979) and an average number of active fishing days of 160 (Uwe-Bassey 1988) allowed to estimate an annual CPUE of 5.76 t·boat^{-1} for 1979. We applied the same method as for artisanal shrimp fisheries described above.

e) Shrimp trawl discards

During their field investigation, Ayaji and Adetayo (1982) observed that fish discards from shrimp trawlers constituted about 43.7% of the total catch of the shrimp trawler in question. Thus, we computed the yearly quantity of discards as 43.7% of the annual total trawled shrimp landings as reported by the FDF.

f) Subsistence catches

Fish is a staple in the diets of Nigerian fishers; consequently, the total amount of fish they consumed is likely to be higher than the national mean. Nevertheless, we assumed a *per capita* fish consumption of 9.7 kg·person^{-1}·year^{-1} (Ekpo and Etim 1989; FDF 2008), which is the national average. We assumed this consumption rate was 20% higher in 1950 compared to the 2000s and interpolated linearly. We also assumed an average fishing family size of six and an average six crew per boat (Uwe-Bassey 1988; Enin *et al.* 1991; Enin 1994). The product of these figures, jointly with our estimated total number of artisanal boats gave an estimate of the total unreported weight of fish consumed by the fishers (crews) and their families. Thus, here we only estimate take-home catch by artisanal fisheres as subsistence catches, and do not account for the potentially large number of non-fishers that may also enage in subsistence fishing.

g) Illegal foreign fish and shrimp catches

According to Falaye (2008), about 30 million dollars' worth of fish is taken from the Nigerian marine waters by illegal activities of foreign fishing vessels. First, we assumed that two-third of this value (i.e., 20 million dollars) is finfish. From the market survey that we conducted, we estimated a mean price of 3.8 USD per kg in Nigerian coastal markets, and estimated the corresponding tonnage at 5,263 t·year^{-1}, which represented 2% of reported catch data. We applied this rate to total reported catches between 1950 and 2010. It is worth noting that such catches were 'unregulated' rather than illegal before the 1982 declaration of the EEZ by Nigeria.

From the 10 million dollars assumed in term of illegal shrimp catch (see above), and a mean price of 15 USD·kg^{-1}, we inferred a shrimp catch of 667 t·year^{-1}, which represented 0.22% of total reported catches. We then applied the same method as for illegal fish catches (see above).

RESULTS

Industrial catches

Industrial catches increased from around 1,800 t·year^{-1} in the early 1950s to a peak of 200,000 t in 2003 (Figure 2). Industrial catches decreased after that to 141,000 t in 2010 (Figure 2) due to over-exploitation and increasing piracy, which led to the decrease in the number of industrial vessels. The sharp rise, which happened in 1980, is attributed to the creation of the Nigerian Shrimping Company and the expansion of the Nigerian economy as a consequence of the increase in crude oil prices.

Artisanal catches

Artisanal catches averaged around 32,000 t·year^{-1} in the early 1950s, and increased gradually to 36,000 t in 1970 (Figure 3). Artisanal catches increased rapidly in the early 1970s, which coincided with the onset of the rapid expansion in Nigerian economy as a consequence of the jump in crude oil prices. Artisanal catches increased with the increase in the number of boats and reached a plateau of around 340,000 t·year^{-1} in the mid-2000s (Figure 3).

Subsistence catches

Subsistence catches followed the same pattern as artisanal catches (Figure 4). Subsistence catches averaged around 1,200 t·year^{-1} in the early 1950s, and gradually increased to around 2,500 t in 1974 (Figure 4). Thereafer, they increased to plateau at of over 13,200 t·year^{-1} in the mid 2000s (Figure 4).

Discards

Discards increased from around 232 t·year^{-1} in the early 1950s to a first peak of 2,200 t in 1990, declined to 1,400 t in 1993 before increasing again to a plateau of 3,100 t in 2001 (Figure 5).

Illegal foreign catches

Illegal catches (considered 'unregulated' before the declaration of the Nigerian EEZ in 1982) increased from 400 t in 1950 to a pleateau of around 3,000 t·year^{-1} between the 1970s and the mid-1980s. Illegal catches increased to a peak of 6,000 t·year^{-1} in the late 1990s, near which they remained (Figure 6).

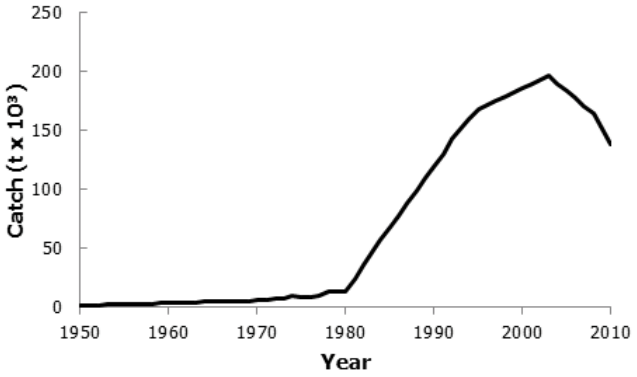

Figure 2. Reconstructed industrial catches from the EEZ of Nigeria, 1950-2010.

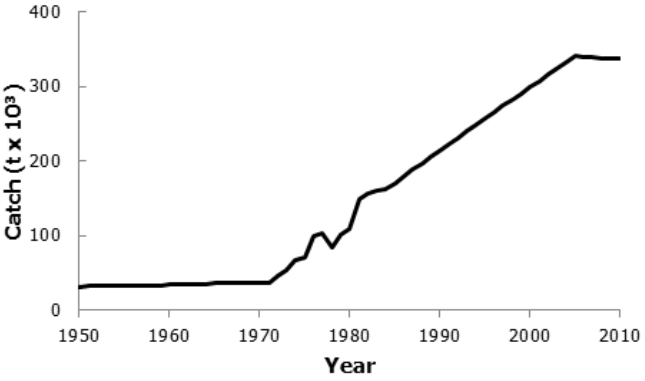

Figure 3. Total reconstructed artisanal catches from the EEZ of Nigeria, 1950-2010.

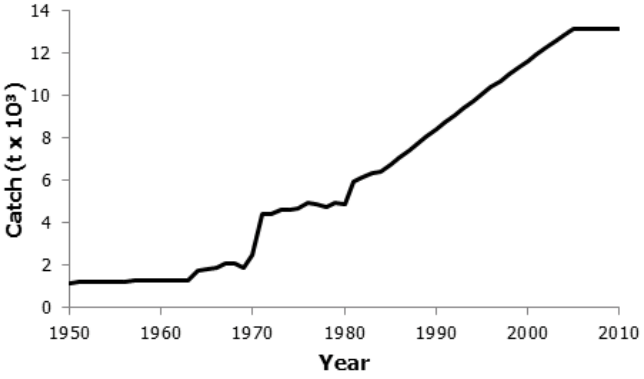

Figure 4. Total reconstructed subsistence catches from the EEZ of Nigeria, 1950-2010.

Total reconstructed catches

Total reconstructed domestic catches were estimated at around 34,000 t in 1950 compared to 22,000 t reported to the FAO on behalf of Nigeria (Figure 7a). Catches increased rapidly in the early 1970s to around 150,000 t·year^{-1} due to (a) the expansion of industrial fisheries, notably those that targeted shrimp and (b) the distant water fishing fleet. Catches increased to a peak of 540,000 t in 2005 compared to 285,000 t reported to the FAO before declining to 490,000 t in 2010. Overall total reconstructed catches were twice as high as the data supplied to the FAO; however under-reporting was higher in the late time periods, which might be due to increasing piracy.

Taxonomically, around 70 taxa are caught within the Nigeria waters; however, catches include mainly croakers (15.4%), sardinellas (11.2%), Bonga shad (6.9%) and scianids (4.1%) (Figure 7b).

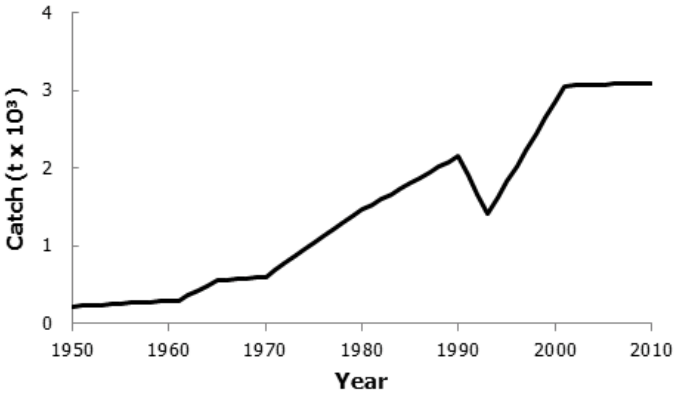

Figure 5. Total reconstructed shrimp trawl discards from the EEZ of Nigeria, 1950-2010.

Discussion

A large part of the catches from the Nigerian marine waters is either poorly accounted for or not accounted for at all. For example, there are at least four categories of fisheries data which are not mentioned at all in the FDF and FAO official statistics, which resulted in our reconstructed catch being twice as high as the catch data supplied to the FAO.

Three historical events in Nigeria translated in a most direct way into downward trends in domestic fish production in the country. These are activities of militants and pirates in the Niger Delta, government economic reform programmes (e.g., the Structural Adjustment Programme, or SAP) and the Nigerian Civil War (1967-1970).

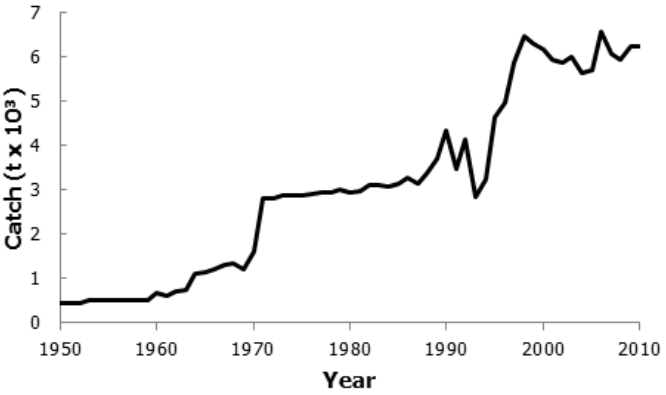

Figure 6. Total reconstructed illegal catches from the EEZ of Nigeria, 1950-2010.

The destructive and violent activities of the pirates in the Niger Delta region (eastern part of Nigeria) exerted a negative impact on fish production in the country. Over a period spanning many years, these militants had consistently and persistently carried out attacks on oil installations mostly in the Niger Delta area with the aim of ensuring that a greater part of Nigeria's petroleum oil revenue goes to the impoverished people of the Niger Delta region from whose lands the oil was taken. The militants engaged in activities like sabotage, theft, property destructions, arson, bombings, guerrilla warfare and kidnapping. The decrease in fish landings, caused by the activities of the militants in the Niger Delta, reached what the FDF (2008) described as an "alarming situation" which resulted in the decline of the number of industrial vessels operating in Nigeria (Perouse de Montclos 2012).

Another event was the implementation of the IMF/World Bank-supported SAP in July 1986. The main components of the SAP entailed the devaluation of the local currency, removal of subsidies on petroleum, liberalization of trade and elimination of price controls (e.g., by scrapping commodity marketing boards), deregulation of bank interest rates and the privatization of government enterprises. The negative impacts of these activities precipitated an uncontrolled inflation, especially as a consequence of currency devaluation. The inflationary rise in cost of fishing inputs (gears, crafts, etc.) together with the increase in pump price of petrol due to subsidy removal had meant that most fishers could not buy new crafts and gears. They also could not service the old ones, nor replace their worn out gears and vessels. This resulted in the decrease in distant water fishing activities by Nigeria.

According to Ekpo and Etim (1989), Nigeria's government fisheries policy objectives could be summarized as follows: (a) increasing domestic fish production, (b) earning foreign exchange through fish exports, (c) developing fishery-based industries, (d) rational management and conservation of the fisheries resources, (e) encouraging local manufacturing of fish products, (f) providing employment, (g) increasing income of local fishers. Measures put in place by government for the realization of these objectives can be grouped into (i) institutional development policy, (ii) direct production policy, (iii) credit policy, (iv) research policy, (v) infrastructure policy, (vi) input provision policy, and (vii) allocation policy. The Federal Government of Nigeria has difficulties implementing these policies, which is not surprising, as several of them are mutually incompatible.

Institutional development policy is vital in enhancing domestic fish catches and ensuring their sustainability. Apart from the Nigerian Institute for Oceanography and Marine Research, which is a federal government agency mandated to conducted research in marine sciences, there is one federal and one state-owned university in each of the maritime states, all of which have a mandate to focus on marine science and fisheries research. However, these institutions are not well funded.

Between 2004 and 2007, there was no budgetary allocation for capital projects in the fisheries subsector by the federal government. The allocation declined from 1.16 billion Naira in 2010 to 750 million Naira in 2012 (1 NGN = 0.006 USD). As observed by Ekpo and Etim (1989) Federal government budgetary allocation to capital projects in fisheries had always been inadequate even in the late 1970s and early 1980s.

The federal government no longer extend credit facilities to fishers because of the policy of discontinuing direct financing of agricultural production. Artisanal fishers lack the necessary collateral to obtain credit from commercial banks. Only owners of commercial trawlers are able to access credit facilities from banks.

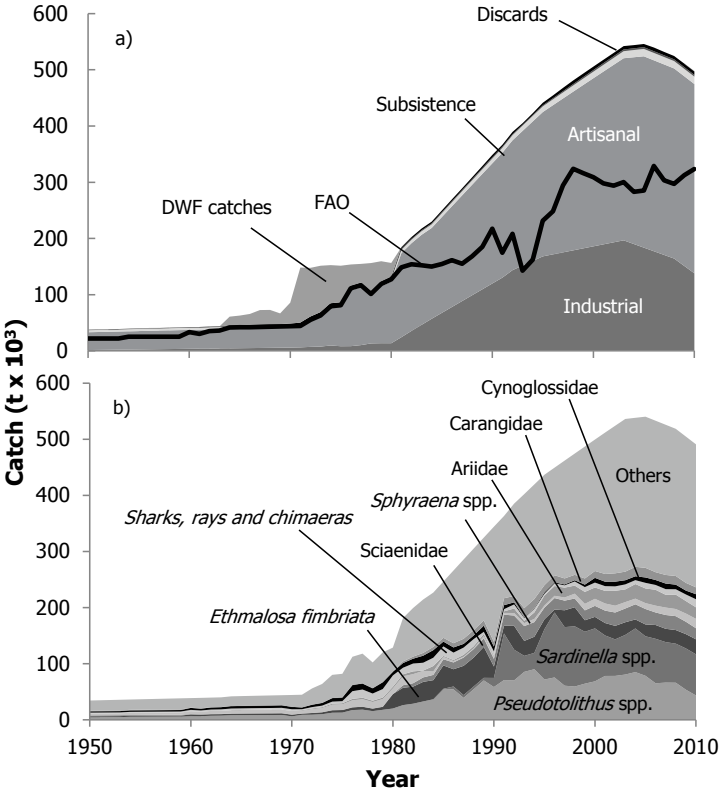

Figure 7. Total reconstructed domestic by Nigeria, by a) sector, with data as reported by FAO overlaid as line graph; and b) taxon, 1950-2010. Distant water fleet (DWF) catches refer to those catches reported to the FAO by Nigeria but that were taken from outside Nigeria within the area comprised between Benin and Cameroon. DWF catches are not included in the taxonomic breakdown.

Except with hook and line and other highly selective gears, by-catch is a natural moiety in fisheries. In some cases, a part or all of the by-catch are thrown back to the sea as discards (Ayaji and Adetayo 1982; Ambrose 2005). In many cases, all the by-catches are sold either separately or as part of the original catch (Löwenberg and Künzel 1991). By-catch is a general problem of shrimp fisheries. Ayaji and Adetayo (1982) observed in commercial shrimp trawlers off Lagos coast (western part of Nigeria) that fish "shovelled overboard measured 18.0 cm or less in total length" and "amounted to 43.68% of the total catch" of the trawler in question. Ambrose (2005) demonstrated that an experimental by-catch reduction device was able to exclude 61% (belonging to length class 4 – 10 cm) and retain 39% (belonging to length class 11–30 cm). Enin *et al.* (1991) and Enin (1994) noted in artisanal shrimp fisheries that by-catch fish (10 cm) and squids constituted approximately 8.5% by weight and 4.7% by number in the sample. These are small compared to 43.7% (Ayaji and Adetayo 1982) and 61% (Ambrose 2005) in trawl shrimp fisheries. Thus, the problem of by-catch in artisanal shrimp fisheries is not as serious as in the trawl fisheries. In Nigeria, by-catch from the artisanal shrimp fisheries is not discarded; all the catches (the targeted shrimps and the fish by-catch) are smoked-dried together and marketed as "crayfish". Nowadays and especially in the eastern part of Nigeria, itinerant buyers use speed boats to follow shrimp trawlers and buy from them whatever would have been discarded. According to E.Ambrose (pers. comm.), who is the pioneer researcher in TED (Turtle Exclusion Device) and BRD (By-catch Reduction Device) in Nigerian marine waters, now "all trawlers carry TED and BRD", but "at sea, 10% use them." Definitely, this is an improvement in the Nigerian fisheries management. Nevertheless, there is still need for a more stringent enforcement of the law.

There are many, though unsubstantiated reports on the illegal activities of foreign vessels in Nigerian waters. Some vessels suspected to belong to China, Korea, Italy, Greece, Russia, Japan, Cameroon and Togo fish in Nigerian waters undeterred (Ganapathiraju and Pitcher 2006; Falaye 2008; Pauly *et al.* 2014). These illegal activities take advantage of the poor monitoring and "lax policing situation (in Nigeria) and land shrimp, lobster, and snapper (among other valuable species) worth over $10,000 per boat per day" or about "30 million US dollars per annum" (Falaye 2008). This is a huge amount compared to about 20 million US dollars per annum which is the amount realized from shrimp as the major fisheries export from Nigeria. In our interview with the Deputy Director of Fisheries in charge of monitoring and surveillance, we learnt that the lack of effective monitoring and policing is because the department has no vessels and fast boats of its own, and is expected to depend on the goodwill of the Nigerian Navy for vessels. Consequently, the department has not been successful in apprehending vessels involved in illegal activities. As pointed out by Falaye (2008), illegal activities are not restricted to Nigeria alone but "continue unabated and unchallenged" throughout the West African region "due to the lack of an adequate monitoring, control and surveillance structure with regards (sic) to both equipment and management systems."

It remains to consider the state of exploitation of the marine fisheries resources in Nigeria vis-à-vis its potential yield. Ajayi and Talabi (1984) gave the potential yield of the Nigerian marine fish resources between 70,000 and 90,000 tonnes, while Ssentongo *et al.* (1986) put the maximum potential yield at "about or slightly less than 150,000 t." Within this context and with a total annual catch of about 390,686 tonnes, the Nigerian marine fisheries resource is overexploited. This is not a new finding: several authors e.g. Nsentip (1983), Moses (1989), Ajayi (1991), Ganapathiraju and Pitcher (2006) and Falaye (2008) had already pointed this out previously.

The challenges this posed are acknowledged by the new Director of the Nigerian Institute for Oceanograpy and Marine Research (NIOMR) Dr. Gbola Akande, who wrote (pers. comm to D.P.) that NIOMR "*is also very much into [food security] research nowadays [which is understandable] when you consider the need for the Government to feed a population close to 170 million people. Fish food security is our priority especially in the artisanal fisheries and aquaculture. The industrial fisheries of course are also in the reckoning, but the first two contributes far more to our national fish production than the industrial fisheries. The justification for procuring the new vessel, RV Bayagbona is essentially to tap into the resources of the deep waters in our 200 mile Exclusive Economic Zone. Our inshore coastal water is currently under pressures with well over 150 fishing/shrimping trawlers struggling to catch from an environment already depleted due to overfishing over the years.*"

Acknowlegements

The work of DB and DP was supported by the *Sea Around Us,* a collaboration supported by The Pew Charitable Trusts and the Paul G. Allen Family Foundation.

References

Ajayi TO (1991) Highlights of achievements in the last 30 years by the Nigerian Institute for Oceanography and Marine Research and its parent research division of the Federal Department of Fisheries, Lagos, 1960-1990. Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos, Nigeria. 23 p.

Ajayi TO and Talabi SO (1984) The potential yield and strategies for optimum utilization of the fisheries resources of Nigeria. Nigerian Insitute for Oceanography and Marine Research Technical Paper 18: 24.

Akankali JA and Jamabo NA (2011) A review of some factors militating against artisanal fisheries development in Niger Delta, Nigeria. Asian Journal of Agricultural Sciences 3(5): 369-377.

Ambrose E (2005) Effects of "fish eye codend" on by-catch reduction in near shore beam trawl shrimp fisheries in Nigeria. Journal of Aquatic Science 20(2): 97-105.

Anon. (1988) Fishing industry–Annual report, Nigeria, 1988. Department of State, Message Reference Number A-9, U.S. Department of State, Washington. 12 p.

Ayaji TO and Adetayo JA (1982) On fish catch and discard of the shrimp fishery of Nigeria. Nigerian Insitute for Oceanography and Marine Research Technical Paper 5: 15.

Ekpo AH and Etim L (1989) The performance of Nigeria's fishery sector: an empirical analysis, 1976 – 85. GeoJournal 18(3): 291-295.

Enin UI (1994) The artisanal shrimp fishery of the outer Cross River Estuary, Nigeria. PhD thesis, University of Calabar, Calabar, Nigeria. 226 p.

Enin UI, Löwenberg U and Kunzel T (1991) The *Nematopalaemon hastatus* (estuarine prawn) fishery in the outer estuarine region of the Cross River Nigeria. Archiv für Fishereiwissenschaft 41(1): 67-68.

Etim L (1992) An integrated approach to the management of the Nigerian fisheries. A case report. Participant Country Reports. Conservation and management of marine resources within the Exclusive Economic Zone. Proceedings of an International Workshop at the International Oceans Institute, Halifax, Canada. 10 p.

Everett GV (1986) An outline of West African small-scale fisheries. IDAF/WP/13. FAO/DANIDA/NORWAY, Food and Agriculture Organization of the United Nations (FAO), Rome. 34 p.

Falaye AE (2008) Illegal, Unreported and Unregulated (IUU) fishing in West Africa (Nigeria and Ghana). A report prepared for the Marine Resource Assessment Group Ltd (MRAG), London. 35 p. Available at: http://www.imcsnet.org/imcs/docs/iuu_fishing_nigeriea_ghana.pdf [Accessed: June 2014].

FAO (2000) Information on Fisheries Management in the Federal Republic of Nigeria. Food and Agriculture Organization of the United Nations (FAO), Rome. Available at: http://www.fao.org/fi/fcp/en/NGA/body.htm [Accessed: June 2014].

FDF (2008) Fisheries Statistics of Nigeria 1995 – 2007. 4th Edition. Federal Department of Fisheries, Abuja, Nigeria.

Ganapathiraju P and Pitcher T (2006) An estimation of compliance of the fisheries of Nigeria with Article 7 (fisheries management) of the UN Code of Conduct for Responsible Fishing. p. 49 + 23 pages *In* Pitcher T, Kalikoski D and Ganapathiraju P (eds.), Evaluations of compliance with the FAO (UN) Code of Conduct for Responsible Fisheries. Fisheries Centre Research Reports 14(2), Vancouver.

Jacquet JL, Fox H, Motta H, Ngusaru A and Zeller D (2010) Few data but many fish: Marine small-scale fisheries catches for Mozambique and Tanzania. African Journal of Marine Science 32(2): 197-206.

Löwenberg U and Künzel T (1991) Investigations on the trawl fishery in the Cross River estuary, Nigeria. Journal of Applied Ichthyology 7: 44-53.

Moses BS (1989) The status of artisanal fisheries and fish resources conservation in south eastern Nigeria. Nigerian Society for Biological Conservation, University of Cross River State, Uyo, Nigeria. 22 p.

Nsentip UN (1983) A review of the commercially exploited marine fishery resources in Nigeria. pp. 35-57 *In* Anon. (ed.), Proceedings of the Second Annual Conference of the Fisheries Society of Nigeria. Fisheries Society of Nigeria (FISON), Calabar, Nigeria, 25-27th January, 1983

Okon EE (2010) Integrating climate change into conservation and management of marine fisheries resources: A study of the sustainable development of marine fisheries in Nigeria. PhD thesis, Aberystwyth University, Department of Law, Aberystwyth, United Kingdom. 308 p.

Panayotou T (1982) Management concept for small scale fisheries: economic and social aspects. FAO Fisheries Technical Paper 228, Rome. 53 p.

Pauly D, Belhabib D, Blomeyer R, Cheung WWL, Cisneros-Montemayor A, Copeland D, Harper S, Lam V, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2014) China's distant water fisheries in the 21st century. Fish and Fisheries 15: 474-488.

Perouse de Montclos MA (2012) Maritime piracy in Nigeria: Old wine in new bottles? Studies in Conflict & Terrorism 35: 531-541.

Ssentongo GW, Ajayi T and Ukpe ET (1983) Report on a resource appraisal of the artisanal and inshore fisheries of Nigeria. FAO/UNDP/FNDP/NIR/77/001, Rome. 43 p.

Ssentongo GW, Ukpe ET and Ajayi TO (1986) Marine fishery resources of Nigeria: a review of exploited fish stocks. CECAF Series 86/40, Food and Agriculture Organization of the United Nations (FAO), Rome. 62 p.

Udolisa REK and Solarin BB (1979) Design characteristics of cast nets and gillnets in Lagos Lagoon, Nigeria. Nigerian Institute of Oceanography and Marine Research Occasional Paper 31: 24.

Uwe-Bassey BU (1988) The catch structure of the artisanal gillnet fishery of the lower Cross River. MSc thesis, University of Calabar, Calabar, Nigeria. 105 p.

Wielgus J, Zeller D, Caicedo-Herrera D and Sumaila UR (2010) Estimation of fisheries removals and primary economic impact of the small-scale and industrial marine fisheries in Colombia. Marine Policy 34: 506-513.

Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years. Fishery Bulletin 105(2): 266-277.

Zeller D and Pauly D, editors (2007) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15(2), University of British Columbia Fisheries Centre, Vancouver. 163 p.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	22,000	34,400	1,359	31,700	1,170	218
1951	22,000	34,900	1,575	31,900	1,180	225
1952	22,000	35,300	1,791	32,100	1,200	232
1953	22,000	35,700	2,008	32,300	1,210	239
1954	25,000	36,200	2,224	32,500	1,220	247
1955	25,000	36,600	2,440	32,700	1,230	254
1956	25,000	37,000	2,656	32,900	1,240	261
1957	25,000	37,500	2,873	33,100	1,250	268
1958	25,000	37,900	3,089	33,300	1,260	275
1959	25,000	38,300	3,305	33,500	1,260	283
1960	33,500	38,700	3,521	33,600	1,270	290
1961	30,000	39,100	3,738	33,800	1,280	297
1962	35,200	39,600	3,954	34,000	1,290	360
1963	36,200	40,100	4,170	34,200	1,300	423
1964	41,345	41,800	4,535	35,500	1,310	486
1965	41,742	42,300	4,758	35,700	1,320	549
1966	42,136	42,700	4,981	35,800	1,330	559
1967	42,525	43,100	5,204	36,000	1,340	570
1968	42,911	43,500	5,427	36,100	1,350	581
1969	43,292	43,900	5,650	36,300	1,360	592
1970	43,670	44,300	5,873	36,400	1,370	603
1971	44,044	44,700	6,096	36,600	1,370	689
1972	55,144	55,900	6,969	46,400	1,750	775
1973	63,087	63,900	7,478	53,600	2,020	861
1974	79,229	80,200	9,483	67,200	2,540	947
1975	80,987	82,000	8,130	70,200	2,660	1,033
1976	111,281	112,400	8,271	99,200	3,770	1,119
1977	116,742	117,900	10,133	102,700	3,910	1,205
1978	101,007	102,300	13,150	84,600	3,230	1,291
1979	118,817	120,200	13,519	101,400	3,880	1,377
1980	127,279	128,700	13,490	109,600	4,190	1,463
1981	148,317	181,200	24,221	149,600	5,920	1,532
1982	154,066	199,300	35,412	156,100	6,180	1,600
1983	152,119	214,500	46,212	160,200	6,340	1,669
1984	150,062	226,800	57,012	161,600	6,390	1,738
1985	154,464	246,500	67,474	170,500	6,740	1,807
1986	161,243	266,200	77,936	179,300	7,080	1,876
1987	155,079	285,800	88,398	188,000	7,420	1,945
1988	167,951	305,300	98,860	196,700	7,760	2,014
1989	185,019	324,800	109,322	205,300	8,100	2,083
1990	217,365	344,200	119,785	213,900	8,430	2,152
1991	174,421	363,300	130,247	222,400	8,770	1,906
1992	208,046	385,300	143,516	231,100	9,100	1,660
1993	142,783	402,200	151,696	239,700	9,420	1,414
1994	162,403	419,600	159,877	248,300	9,750	1,619
1995	231,579	436,800	168,057	256,900	10,070	1,825
1996	248,472	449,400	171,622	265,400	10,390	2,031
1997	294,279	462,000	175,188	273,900	10,710	2,237
1998	324,004	474,600	178,753	282,300	11,020	2,442
1999	316,235	487,100	182,318	290,800	11,330	2,648
2000	309,063	499,500	185,884	299,100	11,640	2,854
2001	297,971	511,900	189,449	307,500	11,950	3,060
2002	293,814	524,100	193,015	315,800	12,250	3,064
2003	300,194	536,200	196,580	324,000	12,560	3,068
2004	282,987	538,300	190,095	332,300	12,860	3,072
2005	285,131	540,300	183,610	340,500	13,150	3,076
2006	328,928	533,100	177,125	339,700	13,150	3,081
2007	303,313	525,900	170,640	339,000	13,150	3,085
2008	296,955	518,700	164,132	338,300	13,150	3,089
2009	312,439	504,800	151,025	337,600	13,150	3,093
2010	323,599	491,000	137,917	336,800	13,150	3,093

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxonomic categories for Nigeria, 1950-2010. 'Others' contain 64 additional taxonomic groups.

Year	*Pseudotolithus* spp.	*Sardinella* spp.	*Ethmalosa fimbriata*	Sciaenidae	*Sphyraena* spp.	Ariidae	Sharks or rays and chimaeras	Cynoglossidae	Carangidae	Others
1950	4,610	0	1,750	1,570	3,390	11	1,520	2,340	1,070	18,100
1951	4,680	0	1,750	1,620	3,390	14	1,520	2,340	1,100	18,400
1952	4,740	0	1,750	1,660	3,390	17	1,520	2,340	1,140	18,700
1953	4,810	0	1,750	1,710	3,390	20	1,520	2,350	1,170	19,000
1954	5,450	0	1,750	1,380	3,850	18	1,750	2,690	940	18,300
1955	5,510	0	1,750	1,430	3,850	21	1,750	2,690	970	18,600
1956	5,570	0	1,750	1,470	3,850	24	1,750	2,700	1,000	18,900
1957	5,630	0	1,750	1,520	3,850	27	1,750	2,700	1,030	19,200
1958	5,700	0	1,750	1,560	3,850	30	1,750	2,700	1,060	19,500
1959	5,770	0	1,750	1,600	3,850	33	1,750	2,700	1,090	19,800
1960	6,920	0	2,690	610	5,150	11	2,340	3,510	420	17,100
1961	6,520	0	2,350	1,080	4,580	24	2,110	3,180	740	18,600
1962	7,230	0	2,690	500	5,380	9	2,460	3,750	340	17,200
1963	7,430	0	2,690	430	5,500	7	2,580	3,870	290	17,300
1964	8,150	0	2,860	0	6,250	0	2,860	4,340	0	17,400
1965	8,280	0	2,900	0	6,320	0	2,900	4,350	0	17,500
1966	8,380	0	2,960	0	6,410	0	2,960	4,440	0	17,600
1967	8,480	0	2,980	0	6,480	0	2,980	4,470	0	17,700
1968	8,570	0	3,010	0	6,540	0	3,010	4,510	0	17,900
1969	8,660	0	3,080	0	6,570	0	3,080	4,580	0	17,900
1970	6,180	0	3,090	0	6,360	247	2,960	4,320	0	21,100
1971	8,890	0	2,250	0	4,920	1,093	1,740	3,190	0	22,700
1972	9,120	0	3,060	0	6,730	1,368	2,370	4,340	0	28,900
1973	10,010	0	3,460	0	7,610	1,502	2,680	4,910	0	33,800
1974	12,630	0	4,500	0	9,850	1,895	3,530	6,380	0	41,400
1975	12,870	0	4,630	0	10,140	1,931	3,700	6,570	0	42,200
1976	17,400	0	4,870	0	12,490	2,610	13,690	11,100	0	50,200
1977	18,130	0	5,200	0	13,350	2,719	14,650	10,740	0	53,200
1978	15,520	0	4,540	0	11,710	2,328	12,730	9,530	0	45,900
1979	17,840	0	5,380	0	13,810	2,676	15,140	12,270	0	53,100
1980	20,150	0	25,750	0	10,040	3,022	20,150	6,620	0	43,000
1981	26,230	0	30,850	4,550	15,860	3,625	11,690	8,370	2,840	77,200
1982	28,730	0	30,460	6,000	16,280	4,898	13,950	8,630	3,740	86,600
1983	32,740	0	34,900	7,930	11,610	629	13,960	12,530	4,950	95,200
1984	36,640	0	34,080	9,330	6,120	9,681	14,770	13,560	5,820	96,800
1985	55,330	0	41,680	10,880	4,380	1,641	16,990	8,520	6,790	100,300
1986	54,280	5,130	30,740	12,090	2,490	1,873	13,190	9,220	7,540	129,600
1987	39,070	5,060	52,110	14,710	1,440	3,464	12,890	6,570	9,170	141,300
1988	54,520	5,000	51,490	15,150	1,420	3,612	12,740	6,480	9,450	145,500
1989	70,230	4,600	55,290	15,150	4,020	3,762	3,830	10,920	9,450	147,600
1990	58,470	16,200	20,350	13,570	4,160	1,730	7,530	8,440	8,460	205,300
1991	70,860	83,090	13,690	19,810	3,130	2,733	3,920	7,110	12,360	146,600
1992	70,230	54,810	42,530	18,280	4,510	8,140	7,200	3,640	11,410	164,600
1993	85,480	28,520	26,600	26,440	5,370	3,937	5,130	1,070	16,490	203,200
1994	90,190	29,050	28,850	26,040	5,670	11,541	6,690	1,040	16,250	204,200
1995	71,810	89,650	17,640	20,760	3,790	17,853	3,280	2,300	12,950	196,800
1996	75,530	115,810	5,260	20,420	4,030	17,402	4,850	1,660	12,740	191,700
1997	60,810	104,400	30,050	17,190	5,590	17,575	4,100	1,570	10,720	210,000
1998	59,330	107,370	33,970	15,530	8,630	14,403	7,410	2,140	9,690	216,100
1999	64,430	92,520	20,510	17,620	11,610	21,324	8,580	4,370	10,990	235,100
2000	68,590	94,380	20,500	19,650	12,600	20,152	8,730	8,400	12,260	234,300
2001	78,200	72,150	22,190	22,080	12,750	22,404	8,480	7,930	13,780	252,000
2002	78,280	65,090	24,090	23,820	12,150	26,557	7,880	8,400	14,860	263,000
2003	80,690	70,640	22,580	24,490	11,430	22,609	8,940	7,420	15,280	272,200
2004	85,060	77,810	16,050	27,000	10,080	25,994	6,930	6,930	16,840	265,600
2005	78,490	70,380	21,130	27,530	10,490	26,142	9,990	9,570	17,180	269,400
2006	65,160	79,250	24,610	22,350	12,150	28,259	8,620	8,810	13,940	269,900
2007	66,330	72,170	23,750	24,590	13,250	22,766	10,070	9,950	15,340	267,700
2008	66,130	69,610	24,260	24,770	12,750	25,621	9,590	8,210	15,450	262,300
2009	53,670	73,570	25,520	22,050	14,620	22,308	11,670	6,960	13,760	260,700
2010	43,350	73,330	26,850	19,680	16,780	20,518	14,420	8,970	12,280	254,800

Reconstructing fisheries catches for Cameroon between 1950 and 2010[1]

Dyhia Belhabib and Daniel Pauly

Sea Around Us, Fisheries Centre, University of British Columbia
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.belhabib@fisheries.ubc.ca; d.pauly@fisheries.ubc.ca

Abstract

Total catches for Cameroon, West Africa, are reconstructed to include sectors that were unaccounted or not properly accounted for, i.e., parts of the artisanal sector, the subsistence sector, bycatch and discards of the industrial sector, as well as illegal foreign fisheries. Reconstructed catches were estimated at 15,000 t in 1950 (compared to 12,000 t reported by the FAO on behalf of Cameroon), increased to a first peak of 89,300 t in 1977, declined to 61,900 t in 1986, then increased again to reach a peak of 115,000 t in 2003 (FAO: 62,800 t), before declining to 80,100 t in 2010 (around 15,100 t higher than the data supplied to the FAO). Overall, there are two main discrepancies between reconstructed data and the data supplied to the FAO: the former are 40% higher than the latter and the trend of the former is consistent with an over-exploitation status of marine fisheries resources of Cameroon, while the FAO data, which shows a pattern of increasing catches, are not. Artisanal fisheries, and thus fish species that are consumed locally, such as sardinellas and bonga shad make up for most catches. This further denotes the relatively important role fisheries play for food security in Cameroon.

Introduction

Cameroon is located in central West Africa, bordered by Nigeria from the north, the Central African Republic and Chad from the east, Gabon from the south and the Atlantic Ocean from the west (Figure 1). The geographic location of Cameroon, facing Bioko Island (Equatorial Guinea) from the West, makes its EEZ relatively small (14,693 km²), smaller than even the tiny EEZs of Benin and Togo. This, despite a relatively large continental shelf, limits economic maritime activities in the country.

Cameroon was colonized by Germany, then, following WWI, by both the U.K. and France. In 1960, 'French' Cameroon obtained its independence, later joined by 'British' Cameroon. Thus, the Federal Republic of Cameroon was born, which, however, maintained strong political and economic ties with France. A civil war gave birth to a repressive dictatorship by the first president of Cameroon, which lasted 22 years, soon followed by a military coup in 1984. The first elections, marred by electoral fraud, were held in 1992 and 1997. Despite major apparent political improvements, there are disputes between the English-speaking southwest region of the country and the French speaking majority in the rest of Cameroon, a colonial legacy that continues to cause problems.

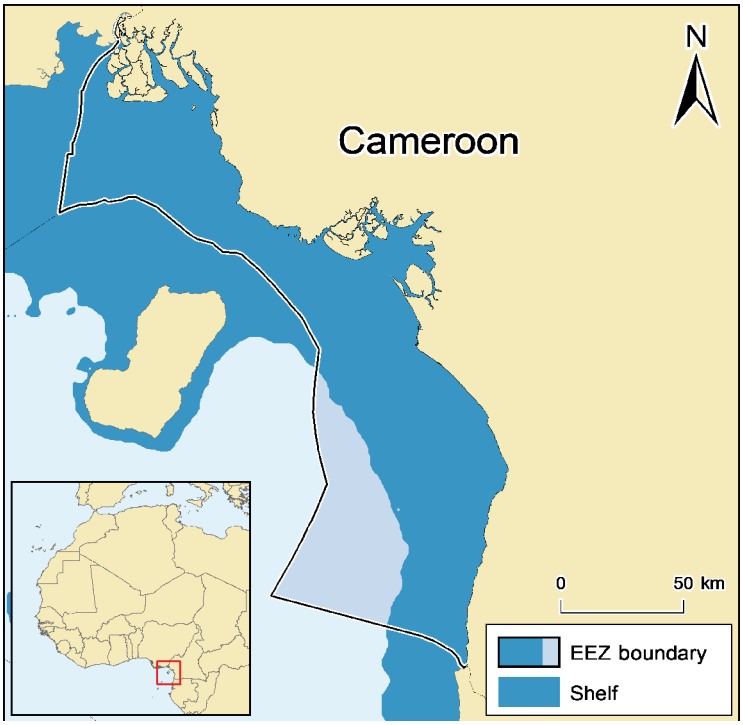

Figure 1. Map of Cameroon and its Exclusive Economic Zone (EEZ).

Cameroon economy relies heavily on extractive industries (oil) and agriculture (cocoa, coffee and cotton). Despite good agricultural conditions and abundant oil reserves, which make Cameroon one of the best primary-commodity economies of Sub-Saharan Africa, political conflicts have contributed to decreasing the GDP by 60% from the mid-1980s to the mid-1990s. Recent reforms, notably in the agriculture and some industrial sectors, have contributed to increasing the GDP. However, many issues still hobble the country, and affect both the general population and the economy, notably major electricity deficits and limited access to safe drinking water (OECD 2007). These issues are amplified by high corruption and rampant abuse of human rights (OECD 2007), which increase the food insecurity of Cameroon's population.

[1] Cite as: Belhabib, D. and Pauly, D. (2015) Reconstructing fisheries catches for Cameroon between 1950-2010. pp. 77-84. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

Fisheries in Cameroon play an important role as fish represents 25.5% of animal protein consumption (Anon. 2009). Moreover, artisanal fisheries alone generate over 119 Billion CFA (240 million USD) per year (Ngok *et al.* 2005). Surprisingly, despite this important role, the fisheries sector is neglected. Indeed, currently in Cameroon there is no data collection system for fisheries. "Existing statistics in the artisanal sector are just vague estimations and extrapolations and the actual volume of fish production in this sector is unknown" and "bycatch [...] is not taken into account in the national statistics, due to lack of log books on vessels." (ENVIREP-CAM 2011). This low monitoring performance is illustrated by the fact that artisanal catches (marine, continental and aquaculture) were reportedly unchanged from 1999 to 2010 (Nnana Noah 2010). The lack of knowledge of the fisheries sector performance and removals has resulted in a severe over-exploitation, documented since the mid-1980s, yet fishing effort has increased drastically since then (Djama and NNa Abo'o 1999). Here, we attempt to address this lack of knowledge by reconstructing catch data for Cameroon, based on a detailed analysis of the existing literature on Cameroon's fisheries.

Methods

Total and coastal population

Total population of Cameroon was extracted from the World Bank database (www.worldbank.org) between 1960 and 2010 and completed using data from www.populstat.info. Coastal population data, i.e. rural population living within 5 km from the coast, for 1990, 2000 and 2010 were obtained from CIESIN (2012), which allowed estimating a percentage of 1.13% of Cameroon's population as coastal. We assumed this percentage for 1950 and obtained the coastal population for the same year. We interpolated to fill in the gaps (Figure 2).

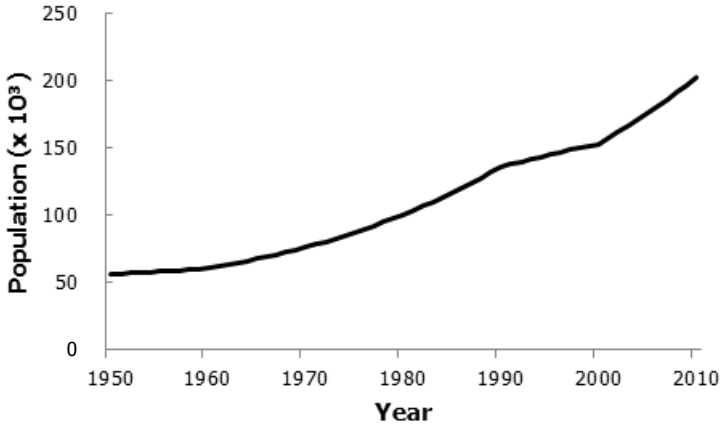

Figure 2. Cameroon's rural population living within a range of 5 km from the coast, 1950-2010.

Subsistence catches

Lagoin and Salmon (1970) documented a survey-based estimate of fish consumption rate ranging between 30 and 48 kg·person^{-1}·year^{-1}, i.e. 39 kg·person^{-1} for 1961. In 1967, 3,048 t were caught and consumed by subsistence fishers. We assumed the consumption rate was constant between 1950 and 1961. We multiplied the consumption rate for 1950 by the coastal population estimated for 1950 and obtained a subsistence catch of 2,178 t. Similarly, we assumed the previous consumption rate from subsistence fishing declined by 70% in 2010, i.e. 11.7 kg·person^{-1} due to increasing fish availability from artisanal fisheries, and we multiplied this rate by the coastal population for 2010. We then interpolated between the previous estimates to complete the time series between 1950 and 2010.

The catch composition of subsistence catches is given as a list with no further indication of the percentage (ENVIREP-CAM 2011): marbled swim crab (*Callinectes marginatus*), African ghost crab (*Ocypoda ippeus*), common cuttlefish (*Sepia officinalis*), sea snail (*Mytilus tenuistriatus*), oysters (*Crassostrea gasar*, *Cypraecassis rufa*), mudskipper (*Periopthalmus hoelferi*), African sicklefish (*Drepana africana*), groupers (*Epinephelus* spp.), Alexandria pompano (*Alectis alexandrina*), Blue runner (*Caranx crysos*), Atlantic bumper (*Chloroscombrus chrysurus*), round scad (*Decapterus punctatus*), bigeye scad (*Selar crumenophthalmus*), greater amberjack (*Seriola dumerili*), African moonfish (*Selene dorsalis*), pompano (*Trachinotus ovatus*), barracudas (Sphyraenidae), bigeye tuna (*Thunnus obesus*), West African Spanish mackerel (*Scomberomorus tritor*), Dasyatidae, brown ray (*Raja miraletus*), and flathead grey mullet (*Mugil cephalus*). In the absence of detailed information, we allocated the same percentage to every taxon.

Artisanal catches

There is no licensing system for artisanal fisheries in Cameroon despite the high percentage (85%) of foreign artisanal fishers (ENVIREP-CAM 2011). This also applies to monitoring of artisanal catches, which is virtually absent (Kamgaing 2009). Estimates of artisanal catch were available through different literature sources for 1967 and 1970 (Laure 1972), 1980 (Ssentongo and Njock 1987), 1987 (Seck 1987), 1990 (Bamou 1997), 2003 (Nnana Noah 2010), 2009 (ENVIREP-CAM 2011) and 2012 (Anon. 2013). We assumed artisanal catches in 1950 were 20% lower than the catch in 1967, given the documented increasing pattern of catches (Lagoin and Salmon 1970). We then interpolated to fill in the gaps between 1950 and 2010. We summed artisanal and industrial landings (see below for industrial landings), and adjusted artisanal landings upwards whenever FAO data were higher than the sum, based on the assumption that the difference is due to under-reporting of artisanal catches.

To disaggregate catches taxonomically, we assumed the same species composition as in the landing statistics presented by FAO on behalf of Cameroon, and disaggregated the "marine fishes nei" group using the species list provided above (see subsistence catches section).

Industrial catches

While industrial fishing in Cameroon began with a failed attempt by a German company in Douala in 1912, it was only in 1951 that first successful industrial fishing operation was conducted (Laure 1972). Industrial fishing in Cameroon is carried out by nationally flagged vessels, mostly targeting demersal resources (Anon. 2010). The main highlights of the industrial fisheries of Cameroon are the shrinking of fishing area when Gabon declared national waters in 1970 (Laure 1972), along with a significant increase in vessel efficiency and size since the 1950s (ENVIREP-CAM 2011) to counter the effects of over-exploitation. We assumed the contribution of catches from Gabon increased linearly from 30% in 1960 to 80% in 1970 before collapsing to zero in 1973. Industrial catch data are collected from Douala port by the National Institute of Statistics (Institut national de la statistique du Cameroun). These data presented on the website of the organization are incomplete.[2] Furthermore, they do not include catches that are exported at sea, landed in Nigeria or those landed in Cameroon's military port of Tiko (ENVIREP-CAM 2011).

We interpolated landings data provided by different literature sources between 1950 and 2010 (Laure 1972; Ssentongo and Njock 1987; Bamou 1997; Djama and NNa Abo'o 1999; Nnana Noah 2010; ENVIREP-CAM 2011). These data serve as a baseline for estimating the under-reported component.

For every kg of shrimp caught by shrimp trawlers there is around 8 kg of bycatch (46% of fish for 6% of shrimp) (ENVIREP-CAM 2011). Although shrimp fishery bycatch are not reported, we herein conservatively assume that only half of the fish bycatch is not reported, i.e., 4 kg of fish for every 1 kg of shrimp. This approach is very conservative since it assumes all shrimp catch by shrimp trawler is reported and all fish catch by demersal trawlers is reported. Similarly, crab catches represent 1.33 times the shrimp catch. We applied this rate to shrimp catches and estimated unreported crab catches.

The demersal fleet of Cameroon comprises Chinese reflagged vessels since the early 2000s, 11 vessels were licenced in 2003 and 8 vessels between 2006 and 2007, which we conservatively assumed constant between then and 2010 (Pauly *et al.* 2013). We estimated the CPUE of demersal boats operating in Cameroon between 2000 and 2010 based on the estimated catch (all trawlers together) and the number of fishing boats provided by the literature (Nnana Noah 2010; ENVIREP-CAM 2011), then we multiplied these by the interpolated number of Chinese vessels to estimate that part of the demersal catch which ownership could be allocated to China. We used data in Lagoin and Salmon (1970) to taxonomically disaggregate the unreported component of industrial catches (Table 1).

Table 1. Composition of the catch of Cameroon's industrial fisheries (Lagoin and Salmon 1970).

Common name	Scientific name	%
Bigeye grunt	*Brachydeuterus auritus*	40.5
Croaker	*Pseudotolithus* spp.*	31.9
Claroteid catfishes	*Chrysichthys* spp.	6.0
Giant African threadfin	*Polydactylus quadrifilis*	5.1
Tongue soles	*Cynoglossus* spp.	4.6
Rays	*Raja* and other genera	2.7
African sicklefish	*Drepane africana*	2.3
Shrimps	Peneidae	1.8
Canary drum	*Umbrina canariensis*	1.1
Marine fishes nei	-	4.0

* including *P. senegalensis* and *P. typus* (see Djama 1988; Djama and Pitcher 1989)

Discards

Around 25% of shrimp trawl catches are discarded (ENVIREP-CAM 2011), i.e. 33% of landings. Herein, we multiplied the estimated industrial shrimp catches by 33% to estimate discards from 1950 to 2010. For demersal trawl, Kelleher (2005) estimated that 0.6% of demersal trawl catches were discarded. Thus demersal trawl discards range between 0.6% and 33%, i.e. 16.8%. We applied this rate to the estimated demersal trawl landings between 1950 and 2010. We assumed the same species disaggregation than for bycatch above.

Illegal catches

Although Cameroon declared an EEZ as late as 2000, there were already "illegal" fishing vessels in 1989, when Cameroon arrested 9 vessels fishing illegally fishing within their waters (ENVIREP-CAM 2011). We assumed that this number corresponded to the number of vessels fishing illegally in Cameroon for that year and multiplied it by a CPUE of 258 t·boat^{-1}·year^{-1} obtained by dividing the total legal industrial (demersal trawl) catch (9,020 t·year^{-1}) by the number of legal boats for the same year, i.e. 35 (Bamou 1997). Chinese illegal vessels caught an estimated 9,500 t in 2009 (Pauly *et al.* 2013). We interpolated to fill in the gaps.

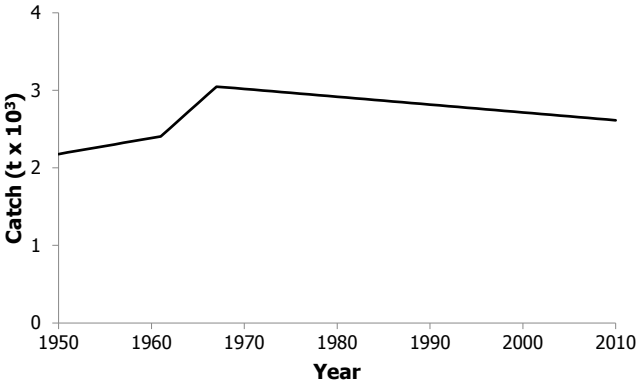

Figure 3. Reconstructed subsistence catches from Cameroon, 1950-2010.

As for the nationality of illegal fishing vessels, we relied upon the profile of illegal fleets from the country that is immediately adjacent to Cameroon, i.e., Equatorial Guinea's Bioko Island. In Equatorial Guinea, illegal catches were taken by Russian fleets between 1980 and 1989 and Chinese fleet between 1985 and 2010 (Belhabib *et al.* 2014). We assumed proportionality and applied the disaggregation to illegal catches from Cameroon waters. We assumed the same species disaggregation than for domestic industrial fisheries above.

[2] http://www.statistics-cameroon.org/manager.php?id=9&id2=53&link=6

RESULTS

Small scale catches

Subsistence catches increased from around 2,200 t in 1950 to 3,000 t in 1967 and then decreased to 2,600 t in 2010 (Figure 3).

Estimated artisanal catches varied between 1950 and 2010, however with a distinct increasing pattern until the mid-2000s. Artisanal catches increased from 12,300 t in 1950 to a peak of 93,200 t in 2003, passing by periods of decline notably between 1958 and 1966 and between 1980 and 1987 dominated by political instability within the country (Figure 4). Catches declined to less than 59,300 t in 2010 (Figure 4).

Industrial catches

Estimated industrial catches increased from 70 t in 1951 to a peak of around 39,000 t in 1971, declined rapidly between then and the early 1980s when the offshore fleet stopped operating in Gabon. Catches kept on declining, although less rapidly, to around 18,000 t in 2010. Chinese reflagged vessels caught less than 600 t in 2001, around 1,000 t in 2008 and less than 1,000 t in 2010 (Figure 5).

Discards

Estimated discards increased from around 10 t in 1951 to a peak of 7,900 t in 1977 following increasing industrial catches from Cameroon, then declined rapidly to 1,500 t in 2010 (Figure 6).

Illegal catches

Estimated illegal catches (considered unregulated until 2000) increased from low levels in the mid-1980s to 2,300 t in 1989 to 9,500 t·year^{-1} in the late 2000s. Illegal catches, as reconstructed here, were overwhelmingly taken by Chinese vessels, with the remainder taken by Russian vessels.

Total catches

Total domestic (and reflagged) catches were estimated at 14,500 t in 1950 compared to 12,000 t reported to the FAO. Catches increased to a first peak of 89,300 t in 1977, following agriculture development policy in Cameroon, and then declined to 61,900 t in 1986 marking a period of political instability in the country. Catches increased later to reach a peak of 115,000 t in 2003 compared to 62,800 t reported to the FAO, before declining to 80,000 t in 2010, around 15,000 t higher than the data supplied to the FAO (Figure 8a). There is also a net discrepancy in trends between the reconstructed data and the data supplied to the FAO. The reconstructed catches shown a steady declining pattern compared to the FAO data, which were relatively constant since the mid-2000s (Figure 8a).

Overall, 68 taxa are caught within Cameroon waters (and caught in Gabon's EEZ, but landed in Cameroon). The artisanal sector dominates with over 71% of total catches and industrial contributing 21% (Figure 8a). Catches include mainly bonga shad (25%) and a declining catch of sardinella (19%), which were previously the prime focus of the little attention Cameroonian fisheries biologists could afford to give to their marine resources (Djama *et al.* 1989a; 1989b; 1990).

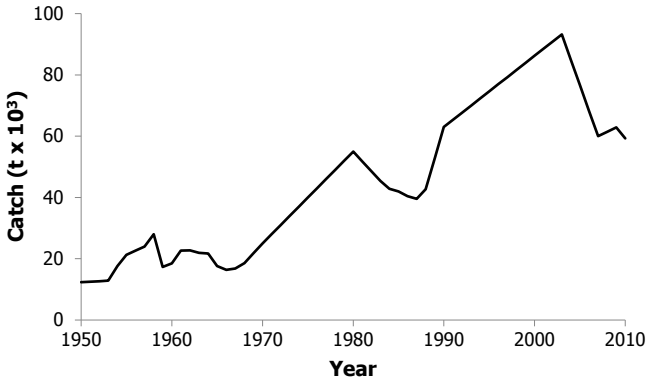

Figure 4. Reconstructed artisanal catches from Cameroon, 1950-2010.

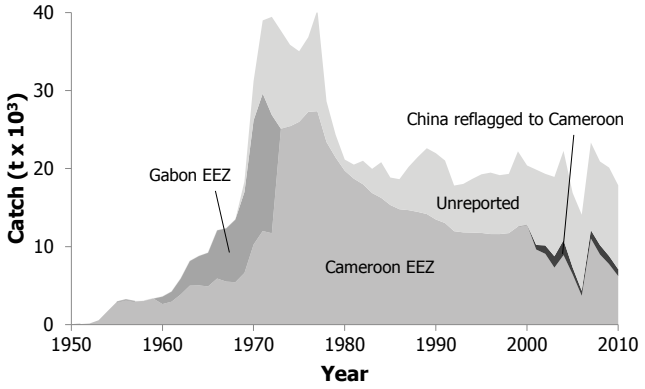

Figure 5. Cameroon reconstructed industrial landings from Cameroon and Gabon EEZs by the domestic and reflagged fleets, 1950-2010. Catches from the Gabonese EEZ were taken by the real domestic fleet of Cameroon and landed in Cameroon.

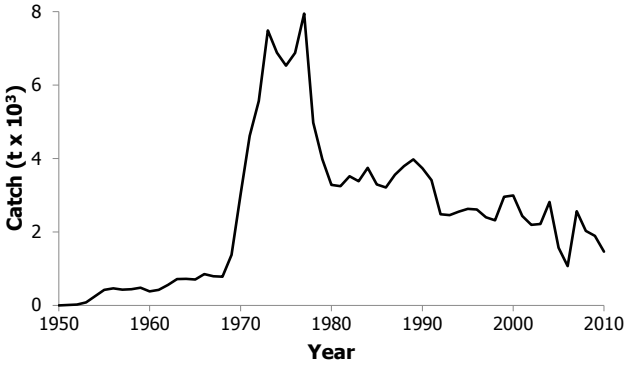

Figure 6. Reconstructed discards from Cameroon, 1950-2010.

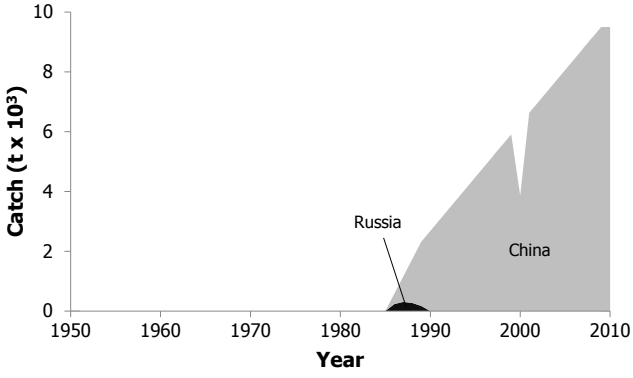

Figure 7. Reconstructed (unregulated and) illegal catches from the waters off Cameroon, 1950-2010.

Discussion

Total catches from the EEZ of Cameroon were marked by two main cycles; catches increased to a first peak in the 1970s following main agricultural reforms and development projects focusing on the primary sector industry, before decreasing rapidly following a period of instability; the second cycle was marked by the highest peak of catches which reached over 109,000 t·year^{-1} in the early 2000s, which were highly divergent with the data supplied to the FAO in amount and trend. Overall, reconstructed total catches were about 50% higher than the data supplied to the FAO. Although this discrepancy is not negligible, it is much smaller than the West African average.

The taxonomic separation between the industrial and small-scale fisheries suggested by the catch composition data presented above probably does not occur in reality, as the over-exploitation of the small EEZ of Cameroon forces small-scale fishers to shift to estuarine species (such as estuarine shrimps) to maintain their catches. Thus, the decline in under-reporting, rather than being a sign of improvement, probably reflects decreasing catches. This is masked by a false increasing trend in the official data, likely due to improved monitoring.

This study demonstrates that there is much room for improvement in Cameroon's statistical system. For example, the registration system for artisanal fisheries is virtually inexistent. Thus, accounting for catches is merely occasional, and occurs mainly when fisheries scientist require data for their research. Also, landing operations and reporting by industrial fleets are hardly controlled. Ironically, a part of the (unreported) industrial catches are landed in the only military port of the country. Moreover, management of Cameroon fisheries is a recent initiative, as the first fishery policy document for Cameroon was formulated in 2011 (ENVIREP-CAM 2011).

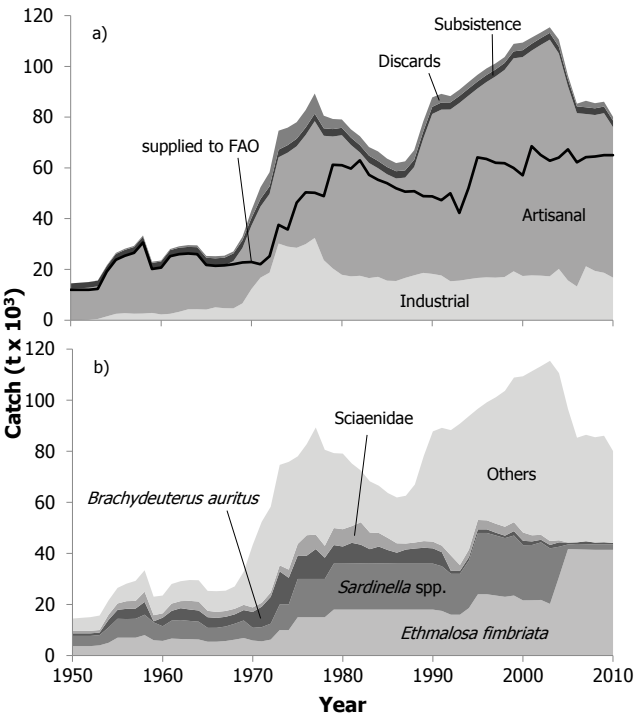

Figure 8. Reconstructed total catches by a) sector as compared to FAO with solid line indicating data supplied to FAO, and b) taxonomic group from Cameroon's EEZ, 1950-2010. 'Others' consist of 64 additional taxonomic categories.

Acknowledgements

This is a contribution from the *Sea Around Us*, a collaboration supported by The Pew Charitable Trusts and the Paul G. Allen Family Foundation.

References

Anon. (2009) Evaluation de l'impact de la hausse des prix des denrées alimentaires sur la securité alimentaire des ménages dans les villes de Bamenda, Douala, Maroua et Yaoundé au Cameroun. United Nations World Food Programme, Yaoundé. 70 p.

Anon. (2010) Cameroun. ACPFish II. Available at: http://acpfish2-eu.org/index.php?page=cameroon-fr [Accessed: 12/08/2014].

Anon. (2013) Pêche : Le Cameroun perd plus de 10 milliards par an. La Tribune du Citoyen, Yaoundé. Available at: http://tribune.tmp38.haisoft.net/index.php?option=com_content&view=article&id=447:peche—le-cameroun-perd-plus-de-10-milliards-par-an&catid=6:economie&Itemid=6 [Accessed: 12/08/2014].

Bamou E (1997) Impact des incitations économiques sur la pêche au Cameroun: simulations à l'aide d'un MCEG Document de Travail 12, Réseau de Recherche sur les Politiques Industrielles en Afrique, Yaoundé. 70 p.

Belhabib D, Hellebrandt D, Edward E and Pauly D (2015) Equatorial Guinea: a catch reconstruction (1950-2010). Fisheries Centre Working Paper #2015-71, University of British Columbia, Vancouver, 24 p.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, and Climate Estimates, Version 3 (PLACE III). Center for International Earth Science Information Network (CIESIN)/Columbia University, Palisades, NY. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3. [Accessed: Nov 21, 2012].

Djama T (1988) Estimation of growth parameters and mortality of longnect croaker (*Pseudotolithus typus*) in Cameroon. pp. 153-170 In Venema S, Möller-Christensen J and Pauly D (eds.), Contributions to tropical fisheries biology: papers by the participants of FAO/DANIDA follow-up training courses. Fisheries Report No. 389. FAO, Rome.

Djama T, Gabche C and Njifonju O (1989a) Growth of *Sardinella maderensis* in the Lobe Estuary, Cameroon. Fishbyte – Newsletter of the Network of Tropical Fisheries Scientists 7(2): 8-10.

Djama T, Gabche C and Youmbi-Tienctheu J (1989b) Comparison of the growth of West African stocks of *Sardinella maderensis* with emphasis on Cameroon. Fishbyte – Newsletter of the Network of Tropical Fisheries Scientists 7(3): 13-14.

Djama T, Nkumbe L and Ikome F (1990) Catch assessment of *Sardinella maderensis* in the Ocean Division, Cameroon. Fishbyte–Newsletter of the Network of Tropical Fisheries Scientists 18(1): 6-7.

Djama T and NNa Abo'o P (1999) Aperçu de la pêche camerounaise. Cours ACP-EU sur la gestion des pêches et de la biodiversité, Dakar, Sénégal, du 12 au 23 Avril 1999. FishBase, Dakar. Available at: http://fishbase.us/Training/CountryReports/Dakar/Cameroon.htm [Accessed: 06/08/2014].

Djama T and Pitcher T (1989) Comparative stock assessment of two sciaenid species, *P. typus* and *P. senegalensis* off Cameroon. Fisheries Research 7(111-125).

ENVIREP-CAM (2011) Overview of Management and Exploitation of the Fisheries Resources of Cameroon, Central West Africa. Institut de Recherche Agricole pour le Développement, Yaoundé. 70 p.

Kamgaing S (2009) Rapport Panorama I sur les statistiques agricoles et alimentaire. FAO, Rome. 78 p.

Kelleher K (2005) Discards in world's marine fisheries, an update. FAO Fisheries Technical Paper 470, FAO, Rome. 131 p.

Lagoin Y and Salmon G (1970) Etude Technique et Economique comparée de la distribution du poisson de mer dans le pays de L'Afrique Centrale Atlantique1. Secretériat d'état aux affaires étrangères chargé de la coopération. 500 p.

Laure J (1972) Vingt ans de pêche industrielle au Cameroun. Extrait de La Pêche Maritime 136, ORSTOM. 4 p.

Ngok E, Ndjamen D and Dongmo Jiongo V (2005) Contribution économique et sociale de la pêche artisanale aux moyens d'existence durables et à la réduction de la pauvreté. Rome, Programme pour des Moyens d'Existence Durables dans la pêche (PMEDP), Yaounde. 41 p.

Nnana Noah A (2010) Législation et réglementation de l'inspection des produits de la pêche au Cameroun : étude et propositions d'amélioration. EISMV, Douala. 200 p.

OECD (2007) Cameroon. African Economic Outlook, OECD. 14 p.

Pauly D, Belhabib D, Blomeyer R, Cheung WWWL, Cisneros-Montemayor AM, Copeland D, Harper S, Lam VWY, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2013) China's distant-water fisheries in the 21st century. Fish and Fisheries: n/a-n/a.

Seck P (1987) Catalogue des engins de pêche artisanale maritime du Cameroun. COPACE/PACE Series 87/43, FAO, Rome. Available at: http://www.fao.org/docrep/003/s5831f/S5831F00.htm#TOC [Accessed: 06/08/2014].

Ssentongo G and Njock J (1987) Marine fishery resources of Cameroon: a review of exploited fish stocks. CECAF/ECAF Series 87/44, FAO, Rome. Available at: http://www.fao.org/docrep/003/s4639e/S4639E00.htm#TOC [Accessed: 07/08/2014].

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

Year	FAO landing	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	12,000	14,500	0	12,300	2,180	0
1951	12,000	14,800	60	12,500	2,200	10
1952	12,000	15,000	120	12,700	2,220	20
1953	12,300	15,700	480	12,900	2,240	81
1954	19,100	21,600	1,500	17,600	2,260	252
1955	23,800	26,500	2,500	21,300	2,280	420
1956	25,400	28,200	2,750	22,700	2,300	462
1957	26,500	29,300	2,553	23,900	2,320	429
1958	30,600	33,400	2,610	28,000	2,340	438
1959	20,200	23,000	2,860	17,300	2,360	480
1960	20,734	23,500	2,254	18,500	2,390	379
1961	25,195	28,000	2,514	22,700	2,410	422
1962	26,047	29,100	3,302	22,700	2,510	555
1963	26,240	29,600	4,276	22,000	2,620	718
1964	26,031	29,500	4,308	21,700	2,730	724
1965	21,772	25,300	4,187	17,600	2,830	703
1966	21,419	25,200	5,058	16,400	2,940	850
1967	21,562	25,400	4,720	16,800	3,050	793
1968	22,063	27,100	4,653	18,600	3,040	782
1969	22,728	32,800	6,621	21,800	3,030	1,376
1970	22,876	43,300	12,259	25,000	3,020	3,026
1971	22,076	52,400	16,751	28,000	3,010	4,618
1972	25,242	58,300	18,728	31,000	3,000	5,566
1973	37,600	74,700	30,184	34,000	2,990	7,489
1974	35,736	75,800	28,991	37,000	2,980	6,880
1975	46,280	78,000	28,512	40,000	2,970	6,529
1976	50,397	82,800	29,973	43,000	2,960	6,877
1977	50,167	89,300	32,407	46,000	2,950	7,944
1978	48,867	80,600	23,648	49,000	2,940	4,978
1979	61,214	79,300	20,358	52,000	2,930	3,982
1980	61,045	79,100	17,878	55,000	2,920	3,278
1981	59,761	75,200	17,264	51,800	2,910	3,247
1982	63,012	72,500	17,486	48,600	2,900	3,517
1983	57,277	68,200	16,584	45,400	2,890	3,382
1984	55,299	66,500	17,073	42,800	2,880	3,748
1985	53,969	63,700	15,563	41,900	2,870	3,292
1986	51,981	61,900	15,434	40,400	2,860	3,209
1987	50,637	62,600	16,659	39,500	2,850	3,557
1988	50,800	67,000	17,683	42,700	2,840	3,792
1989	48,830	78,300	18,633	52,800	2,830	3,978
1990	48,743	87,800	18,238	63,000	2,820	3,734
1991	47,319	89,200	17,626	65,300	2,810	3,408
1992	49,975	88,300	15,346	67,600	2,800	2,480
1993	42,258	90,800	15,577	70,000	2,790	2,458
1994	52,021	93,800	16,133	72,300	2,780	2,552
1995	64,132	96,700	16,640	74,600	2,770	2,630
1996	63,530	99,200	16,876	76,900	2,760	2,609
1997	62,001	101,200	16,760	79,300	2,750	2,398
1998	61,801	103,700	17,007	81,600	2,740	2,317
1999	60,001	108,900	19,252	83,900	2,730	2,957
2000	57,110	109,400	17,408	86,200	2,720	2,992
2001	68,531	111,400	17,649	88,600	2,710	2,433
2002	65,135	113,300	17,541	90,900	2,700	2,195
2003	62,802	115,400	17,288	93,200	2,690	2,214
2004	64,001	110,600	20,192	84,900	2,680	2,819
2005	67,346	96,500	15,681	76,600	2,660	1,568
2006	62,233	85,300	13,263	68,300	2,650	1,070
2007	64,233	86,400	21,234	60,000	2,640	2,564
2008	64,501	85,500	19,391	61,400	2,630	2,027
2009	65,001	86,100	18,672	62,900	2,620	1,895
2010	65,001	80,100	16,758	59,300	2,610	1,461

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxonomic groups for Cameroon, 1950-2010. "Others" contain 64 additional taxonomic categories.

Year	*Ethmalosa fimbriata*	*Sardinella* spp.	*Brachydeuterus auritus*	Sciaenidae	Others
1950	3,700	4,000	1,000	1,000	4,800
1951	3,700	4,000	1,000	1,000	5,070
1952	3,700	4,000	1,000	1,000	5,340
1953	4,000	4,000	1,000	1,000	5,660
1954	5,000	6,000	3,000	2,000	5,610
1955	7,000	7,400	3,500	2,500	6,100
1956	7,000	7,300	4,000	3,000	6,860
1957	7,000	7,400	4,000	3,000	7,850
1958	8,000	8,000	5,000	4,000	8,380
1959	6,000	7,000	400	2,400	7,250
1960	5,730	5,730	3,340	1,720	6,970
1961	6,660	7,040	3,800	2,850	7,680
1962	6,490	7,420	4,630	2,780	7,800
1963	6,430	7,140	4,460	3,390	8,160
1964	6,290	6,990	4,370	3,490	8,340
1965	5,420	5,420	4,170	2,500	7,790
1966	5,430	5,430	3,880	2,330	8,140
1967	5,690	5,690	3,800	2,280	7,940
1968	6,230	6,230	3,660	2,200	8,750
1969	6,870	6,870	4,070	2,060	12,960
1970	5,900	4,960	6,210	1,770	24,460
1971	5,560	5,560	8,010	1,520	31,720
1972	6,250	6,250	10,490	1,730	33,580
1973	10,000	10,000	12,950	2,370	39,340
1974	10,000	10,000	10,440	3,220	42,190
1975	15,000	15,000	9,170	4,540	34,310
1976	15,000	15,000	9,120	8,000	35,690
1977	15,000	15,000	11,690	5,660	41,940
1978	15,000	15,000	8,310	4,650	37,600
1979	18,000	18,000	7,260	6,670	29,330
1980	18,000	18,000	6,700	6,770	29,600
1981	18,000	18,030	8,120	6,540	24,520
1982	18,000	18,060	7,340	8,800	20,270
1983	18,000	18,030	5,620	6,520	20,030
1984	18,000	18,070	6,610	5,330	18,490
1985	18,000	18,050	5,260	4,740	17,600
1986	18,000	18,000	4,280	3,670	17,950
1987	18,000	18,000	5,510	2,360	18,710
1988	18,000	18,000	5,910	2,360	22,700
1989	18,000	18,000	6,200	2,620	33,450
1990	18,000	18,000	5,980	2,620	43,180
1991	17,480	17,490	5,500	2,560	46,130
1992	16,000	16,010	1,140	6,050	49,080
1993	16,000	16,010	1,130	2,300	55,350
1994	18,600	18,600	1,280	3,000	52,280
1995	24,000	24,000	1,410	3,680	43,570
1996	24,000	24,000	1,410	3,540	46,240
1997	23,500	23,500	1,090	3,500	49,580
1998	23,000	23,000	940	3,500	53,210
1999	23,500	23,500	1,720	3,500	56,630
2000	21,610	21,610	1,720	3,260	61,160
2001	21,640	21,640	1,400	2,400	64,270
2002	21,780	22,540	1,010	1,950	66,040
2003	20,230	21,760	1,310	1,560	70,550
2004	30,800	11,800	1,730	800	65,460
2005	41,700	1,810	690	40	52,290
2006	41,590	2,100	620	20	40,950
2007	41,490	2,100	1,130	20	41,690
2008	41,400	2,100	730	20	41,230
2009	41,400	2,100	850	20	41,690
2010	41,400	2,100	580	20	35,980

Gabon fisheries between 1950 and 2010: a catch reconstruction[1]

Dyhia Belhabib

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.belhabib@fisheries.ubc.ca

Abstract

Fisheries removals from Gabon were reconstructed to include small-scale artisanal, subsistence catches and foreign industrial catches. Total removals from the Gabonese EEZ were estimated at less than 5,000 t in 1950, constituted mostly of small-scale catches, increased gradually to a peak of 242,000 t in 2000 and then decreased to 161,000 t in 2010. Domestic fisheries catches of Gabon were estimated to be 2.5 times the data reported by the FAO on behalf of Gabon; however, under-reporting decreased in the last few years, suggesting improvements in fisheries catch statistics. Artisanal fisheries represented 73% of total domestic removals from the Gabonese EEZ, which highlights the importance of small-scale fisheries to the local economy and domestic food security.

Introduction

Gabon (Figure 1), a country on the equator, is located in Sub-Saharan West Africa and is bordered by the Congo from the east and south, Cameroon and Equatorial Guinea from the north and the Atlantic Ocean from the west.

Figure 1. Map of Gabon with Exclusive Economic Zone (EEZ).

Gabon obtained independence from France in 1960, and has been considered one of the most prosperous economies of West Africa, thanks to a number of factors including low population, forest resources and abundant oil resources. The economy of Gabon relies mostly on extractive activities, notably timber, manganese, uranium and oil. After the 1973-1974 spike in oil prices, the dependence of Gabon on the oil industry grew strongly, which made it one of the wealthiest countries in Africa. However, the sharp decline in oil prices in 1986 resulted in a decline in the GDP by 43% between 1985 and 1987, threatening the local economy, despite Gabon having the highest human development index of Africa. This led the Gabonese government to diversify the economy and invest in other extractive sectors such as fisheries (Ijiff 1991).

As reported by the government, fisheries in Gabon include two main sectors. One is the industrial sector operated mainly by foreign vessels and joint ventures, including reflagged vessels often referred to as "domestic", but essentially remaining mainly under foreign beneficial ownership (Ekouala 2013). The other is the artisanal sector, which is operated mainly by migrant fishers, a distinguishing feature of Gabonese fisheries (Haakonson 1992). Artisanal fisheries in Gabon are the main source of domestic fish landings, and are characterized by the "weakness of its production tool and the supremacy of migrant fishermen" (Bignouma 2011). The informal nature of this sectors makes it difficult to monitor in terms of fisheries statistics (Bignouma 2011).

Total biomass estimates show an increase over time (Kébé *et al.* 1996); in contrast, catches show a decline. With over-exploitation being considered an issue, this does question the quality of data that are available officially. Furthermore, up to the mid-1990s, only 35% of the industrial fleet landed their catches in Libreville (Gabon); thus, official industrial statistics only account for that part of industrial catch that is landed in Libreville, and the remaining vessels' effort and catch data are unknown (Kébé *et al.* 1996). Moreover, non-commercial subsistence fisheries are not included in official statistics, and neither are discards and illegal fisheries.

[1] Cite as: Belhabib, D. (2015) Gabon fisheries between 1950-2010: a catch reconstruction. pp. 85-94. *In*: Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

Catch data have to be improved in order to better grasp the impacts of investments in fisheries (Kébé 2011). Therefore, the purpose of this report is to provide an alternative and comprehensive estimate for catches from the Gabonese Exclusive Economic Zone (EEZ) from 1950 to 2010, using the 'reconstruction' method developed by Zeller *et al.* (2007).

Methods

Total and coastal population of Gabon

Total population data were extracted from www.populstat.info (2014) for the period from 1950 and 1959 and from the World Bank database (www.worldbank.org) for 1960 and 2010. Coastal rural and urban population living within a range of 5 km from the coast was extracted from CIESIN (2012) for 1990, 2000 and 2010, then expressed as a percentage of total population, i.e., 33% for 1990, 43% for 2000 and 30% for 2010. We assumed coastal population represented 33% of the total population in 1950 and thus estimated coastal population for the same year at around 153,000 persons (Figure 2).

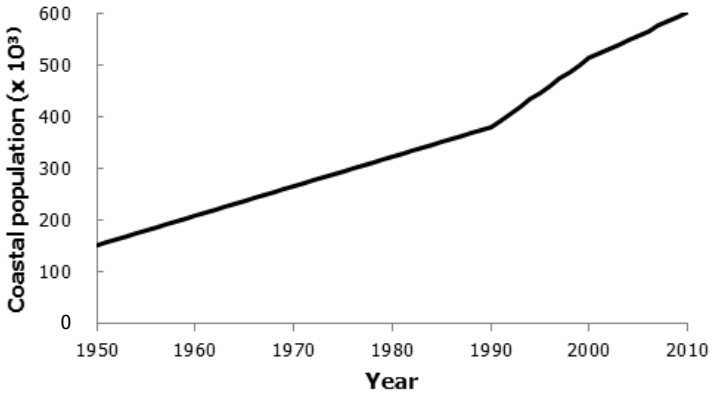

Figure 2. Coastal population of Gabon, 1950-2010.

Subsistence catches

A household survey conducted in the early 1960s estimated fish consumption from non-commercial activities (subsistence fishing) at 23.5 g·person^{-1}·day^{-1}, i.e. 8.6 kg·person^{-1} for 1963. This estimate was multiplied by the estimated coastal population, resulting in estimated subsistence catches of 1,944 t for 1963. Total subsistence catches were assumed to be 30% higher in 1950 compared to 1963. A more recent household survey estimated fish consumption per adult male equivalent (AME) at 200 g·AME^{-1}·day^{-1} from commercial small-scale and non-commercial sources (Wilkie *et al.* 2005), i.e., 150 g·person^{-1}·day^{-1} (1 AME is equivalent to 0.75 person) and 55 kg·person^{-1}·year^{-1}. The latter estimate was multiplied by the coastal population, then artisanal catches (estimated below) were subtracted, and the remainder treated as subsistence catches. Imports and exports extracted from the United Nations Food and Agriculture database for 2005 were also used to balance internal consumption. The same operation was performed for 2010, assuming the same consumption rate. We interpolated linearly to complete the estimates.

Artisanal catches

The number of artisanal canoes was provided by different sources for 1967, 1974, 1983, 1990, 1996, 2008, 2009, 2010 (Table 1). Given the evidence of a lower effort in the early 1950s (Lagoin and Salmon 1970), it was assumed that the number of canoes in 1950 was half of that of 1967; intermediate values were interpolated (Table 1). The catch per unit of effort (CPUE) was averaged at 294 kg·canoe^{-1}·day^{-1} from Kébé *et al.* (1996) for 1995 and at 55.1 kg·canoe^{-1}·day^{-1} from Badjina Egombengani (2011) between 2008 and 2010. Fishers noted a strong decrease in daily CPUE between the mid-1960s and the 1990s (Ijiff 1991); therefore, the CPUE in 1965 was set 20% higher than the CPUE in 1995. Similarly, given lower rates of motorization, and relatively smaller boats in the 1950s compared to later time periods, when migrant fishers introduced bigger boats, the CPUE in 1950 was set 50% lower than the CPUE in 1965, and intermediate values were interpolated (Table 1). The number of fishing days for 1,000 canoes were estimated at 99,744 days for 1995 and for 1,600 canoes at 157,510 days for 1999 (Ekouala 2013), i.e. 99 fishing days·canoe^{-1}·year^{-1} between 1995 and 1999. The number of fishing days per canoe for 2010 was obtained by dividing the 26,710 fishing days by the 176 canoes estimated as fishing in 2010 (Badjina Egombengani 2011). The latter was obtained by dividing the number of fishers (230 fishers) by the average number of fishers per canoe (1.3 fishers·canoe^{-1}) estimated from the total number of fishers and the total number of canoes surveyed by Badjina Egombengani (2011). The pattern of increasing number of fishing days suggests declining resources (Ijiff 1991); thus, this pattern was projected backward, i.e., the number of fishing days in 1950 was assumed to have been 40% lower than in 1995, i.e. 40 days·canoe^{-1}·year^{-1}. The days fished were then interpolated to fill in the gaps. Total artisanal catches were then obtained as the product of the number of canoes, the CPUE and the number of fishing days.

Table 1. Number of artisanal fishing canoes and corresponding CPUE in Gabon, 1950-2010. Values in italics are interpolated.

Year	Canoes	Source	CPUE	Source
1950	275	Assumption	176.0	Assumption
1965	518	Interpolation	353.0	Assumption
1967	550	Lagoin and Salmon (1970)	349.0	Interpolation
1974	600	Everett (1976)	335.0	Interpolation
1983	1,800	Haakonson (1992)	318.0	Interpolation
1990	1,110	Ijiff (1991)	304.0	Interpolation
1995	1,435	Interpolation	294.0	Kébé et al. (1996)
1996	1,500	Kébé *et al.* (1996)	276.0	Interpolation
2008	2,824	Kébé (2011)	55.1	Badjina Egombengani (2011)
2009	3,000	Kébé (2011)	55.1	Badjina Egombengani (2011)
2010	3,000	Assumed constant	55.1	Badjina Egombengani (2011)

Industrial catches

Domestic catches

The domestic industrial fishing fleet in Gabon includes vessels of foreign origin and majority foreign beneficial ownership, mainly from China. We first reconstructed total 'domestic' industrial catches, then allocated the catch to 'real domestic' and joint venture fleets. The first industrial trawler operated in Gabon in 1948, and it persisted into the 1950s (Haakonson 1992). Catches were low due to the experimental nature of the fishery, with about 60 t for 1956 and 101 t for 1957 (Haakonson 1992). It was assumed that catches were constant between 1950 and 1956. The number of boats was reported at 5 trawlers for 1967 (Lagoin and Salmon 1970) and 10 trawlers for 1974 (Everett 1976). The number of 'domestic' vessels was compiled by Ekouala (2013) for the period between 1979 and 2007, during which (in 1985) China entered the fishery through a joint venture with Gabon. The number of boats for the later years was provided by the Department of Fisheries and Aquaculture for 2008, 2009, 2010, showing both domestic and foreign vessels by name, flag, gear type, number of months fishing, and licence fees paid by each vessel (Anon. 2009, 2010, 2011). Kébé *et al.* (1996) reported a shrimp trawl CPUE of 300 kg·boat^{-1}·day^{-1}, while Ekouala (2013) estimated that catches were, in reality, 5 to 10 times higher than reported landings per boat, i.e. 7.5 times higher, as trawlers usually report only target species. Thus, the shrimp trawler total CPUE was estimated at 2,250 kg·boat^{-1}·day^{-1} (or 720 t·boat^{-1}·year^{-1}), assuming 320 fishing days per year for 1996 (based on the duration of fishing licences). Similarly, Kébé *et al.* (1996) reported 1,600 kg·boat^{-1}·day^{-1} for demersal trawlers. As shrimp trawlers are known to generate higher by-catch amounts, we assumed under-reporting was 50% lower for demersal trawlers. Therefore, the demersal trawler CPUE is estimated to be 3.25 times higher than the reported CPUE, i.e., 1,872 t·boat^{-1} for 1996. This yielded an average CPUE estimate of 1,296 t for 1996. It was assumed that the CPUE would have been 50% higher in 1950 and 10% lower in 2010; an interpolation was then performed to fill in the gaps, which the resulting trend corresponding to the drastic decline in CPUE documented since the 1960s (Ekouala 2013). The 'domestic' industrial catches from 1967 to 2010 were obtained by multiplying the number of 'domestic' industrial vessels by the estimated CPUE, then interpolating to the 1950, 1956 and 1957 catch estimates to complete the time series. To filter out 'real' domestic from joint venture catches, it was assumed that the officially reported industrial catch was that of vessels landing catches at ports of Gabon (Haakonson 1992; Kébé 2011; Ekouala 2013; Barretta and Houston 2014). Although, a few of these vessels might have been of Chinese origin as well, it is more likely that under-reporting is due to Chinese vessels landing their catch elsewhere, rather than being due to vessels based and landing in Gabon ports.

Foreign legal catches

The number of foreign fishing vessels, i.e., vessels that are flagged to and have majority beneficial ownership in countries other than Gabon, was gathered from different sources for 1965, 1974, 1979 and between 1991 and 2010 (Kébé *et al.* 1996; Anon. 2009, 2010, 2011; Ekouala 2013). Interpolations were performed back to 1965, which was deemed the start date of foreign fishing in Gabon waters. The foreign fishing effort was multiplied by the previously estimated CPUE (see above). Under-reporting by foreign vessels is likely higher as vessels are generally based in foreign ports, and their catch and effort data are not recorded by Gabon (Kébé *et al.* 1996). There are over twenty foreign countries operating under different types of access agreements in Gabon, flying a range of flags (real nationality in brackets): Angola, Belize (China), Belize (France), Belize (Spain), Cape Verde (China), Cameroon (China for bottom trawlers), China, Congo (China), France, Korea, Ghana, Guatemala, Guinea (China), Indonesia, Japan, Madagascar, Namibia, Netherlands Antilles (unknown), Nigeria (China), Philippines, Sao Tome and Principe, Togo (Spain), Spain, Portugal, and Panama (Korea) (Anon. 2009, 2010, 2011; Mallory 2013). The number of vessels per fishing entity was reported for the period between 2007 and 2010 (Anon. 2009, 2010, 2011). It was assumed that vessels flagged to African countries (except those of Chinese origin) and those that are European, but flagged to other countries such as Belize and Korea, started fishing when the foreign fishery began, given their documented presence in neighbouring countries. Japan started fishing in the early 1980s (Belhabib 2015); EU countries under the EU-Gabon fishing agreement started fishing at the beginning of the first agreement in 1998; China started fishing in Gabon in 1985 (Kébé 2011); Chinese vessels flying the Congolese flag started operating in Gabon in the early 2000s when China started reflagging to Congo (Belhabib and Pauly this volume); vessels from the remaining countries, mainly flag-of-convenience countries were assumed to have begun fishing in Gabon in 2000. We converted the number of vessels per country to percentages between 2007 and 2010, then we carried these percentages backwards to 2000 for all countries which began fishing in 2000, and to 1998 for fleets operating under the EU-Gabon agreement. For the remaining time period, we allocated catches evenly between countries documented within a similar time span.

Foreign illegal catches

Illegal fishing is widespread, but only partly controlled in Gabon. When foreign vessels are incriminated, foreign pressure is usually applied on local officials, such as to assist the foreign crew (Ekouala 2013). In 2010, six trawlers were caught fishing illegally during 17 days of patrol (Ekouala 2013). This number was extrapolated to the entire year, which led to an estimate of 21 vessels fishing illegally, which, when multiplied by the above-estimated CPUE, gives an estimate of 25,000 t·year^{-1} of illegal catch. For 2005, illegal catches were equivalent to 19% of the total legal catch (MRAG 2005). Thus, this estimate was multiplied by the reconstructed total catch by legal foreign fleets, which yielded an illegal catch of 14,356 t·year^{-1}. We assumed illegal fishing, mainly by Chinese operators, began when Chinese fleets started operating in Gabon waters, i.e., in 1985, and interpolated.

Discards

The data submitted by fishing vessels to the Department of Fisheries showed an average discard rate of 2% (Anon. 2009), which was applied across all trawl fleets between 1950 and 2010. This is likely an underestimate. For tuna vessels, i.e., those operating under the flag of Guatemala, Belize, Ghana, EU countries, Japan, Netherlands, Antilles and Cape Verde, discard rates from Romagny *et al.* (2000), and Chavance *et al.* (2011) summarized in Belhabib and Pauly (2015) were applied to the tuna catches by these vessels.

Species disaggregation

To disaggregate subsistence and artisanal catches, the species composition for 2000s (Badjina Egombengani 2011) and 1967 (Lagoin and Salmon 1970) were interpolated for each species/taxon. The catch composition was assumed constant between 1950 and 1967. Trawl catch composition between 2005 and 2009 was available from the Department of Fisheries reports (Anon. 2009) and for 1967 by Lagoin and Salmon (1970). For the tuna catch disaggregation, catch descriptions by Failler *et al.* (2013) and Anon. (2004) were used, from which discarded tuna by-catch composition was extracted.

Results

Subsistence catches

Subsistence catches decreased slightly from 2,500 t in 1950 to around 2,000 t in 1963, then increased to a peak of over 8,200 t in 2005, before decreasing again, to less than 4,000 t in 2010 (Figure 3).

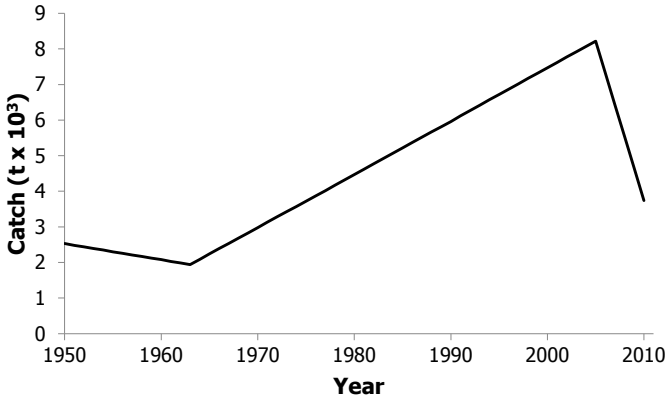

Figure 3. Reconstructed subsistence catches in Gabon, 1950-2010.

Artisanal catches

Artisanal fisheries catches witnessed changes over time as they increased slowly from 2,000 t in 1950 to 56,500 t in 1983 (due to the increase in fishing effort), then decreased to around 37,000 t in 1990 (Figure 4). Catches increased to a second peak of 60,000 t in 2004, before decreasing rapidly to around 28,400 t in 2010, mainly driven by over-exploitation.

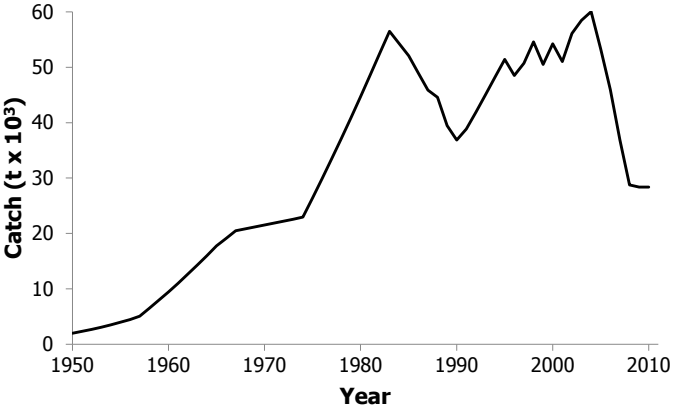

Figure 4. Reconstructed artisanal catches in Gabon, 1950-2010.

Industrial catches

Industrial 'domestic' catches (i.e., 'Gabon' in Figure 5) increased from 60 t in 1950 to about 8,600 t in 1967, and remained around that level until 1984, when China entered the fishery under Gabon's flag (Figure 5). Overall 'domestic' catches, Gabon and China reflagged to Gabon, increased rapidly to a first peak of 44,300 t in 1985, and a second peak of 53,000 t in 1994 (Figure 5), the latter due to the increase in the number of fishing vessels. Catches declined thereafter to approximately 18,000 t in 2010, of which 14,600 t were taken by Chinese vessels reflagged to Gabon (Figure 5).

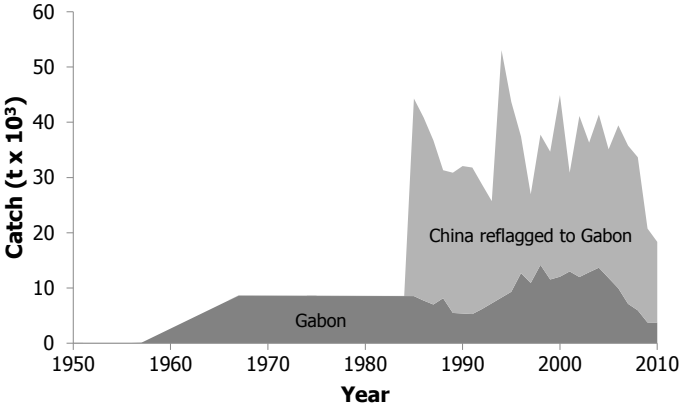

Figure 5. Reconstructed industrial 'domestic' catches including those by vessels of Chinese origin in Gabon, 1950-2010.

Foreign industrial catches (excluding China flagged as 'Gabon') increased from 9,000 t in 1965, when foreign fishing was deemed to have started, to around 74,000 t in 1979, after which they remained relatively constant until the early 1990s (Figure 6). Industrial foreign catches varied later-on due to changes in the number of legal foreign fishing vessels, and peaked at 104,000 t in 2000 and 101,000 t in 2008, before decreasing to 71,000 t in

2010. Foreign legal fisheries were dominated by trawl catches prior to the mid-2000s and by tuna catches thereafter (Figure 6). Illegal foreign catches increased from less than 1,000 t in 1986 to over 23,000 t in 2010 (Figure 6).

African countries catches represented the bulk of catches with around 47% of foreign catches from the Gabonese EEZ, while EU countries represented less than 20% and China slightly over 20%. However, the contributions of China and the EU to total foreign catches has increased over time.

Discards

Discards increased from around 550 t·year^{-1} in the late 1960s to around 5,000 t·year^{-1} between the early 1980s and the mid-1990s, before increasing to a first peak of 10,000 t in 2000, and then a second peak of 13,000 t in 2008 (Figure 7).

Total catches

Total domestic catches, including artisanal, industrial, and subsistence catches, as well as discards were estimated at around 4,600 t in 1950 compared to 2,400 t reported to the FAO, increased to a peak of 63,000 t in 1994 compared to 26,500 t reported to the FAO, and then decreased to less than 36,000 t in 2010 compared to 22,000 t reported to the FAO (Figure 8a). Overall, total catches were 2.5 times the data supplied to the FAO. However, under-reporting was at its maximum during the first years of industrial fisheries, and underreporting has declined considerably in the most recent time period (Figure 8a).

Taxonomically, domestic catches included around 70 groups. However, the bulk of the catch consisted of bonga shad (*Ethmalosa fimbriata*) and West African croakers (*Pseudotolithus* spp.) (Figure 8b).

Total foreign catches (legal, illegal and discards) were estimated at around 9,000 t in 1965, increased to a peak of 120,000 t in 1994 and a second peak of 176,000 t in 2008, before decreasing to 126,000 t in 2010 (Figure 10).

Discussion

Total domestic removals from the Gabonese EEZ were estimated at less than 5,000 t in 1950, constituted mostly of small-scale catches, increased gradually to a peak of 82,000 t in 2004 and then decreased to less than 36,000 t in 2010. Although the last figure triples when foreign catches are added, small-scale fisheries still constitutes on average 60% of the total legal catch. This highlights the importance of small-scale fisheries to the population of Gabon, which remains the second most practiced activity in rural areas of the country (Badjina Egombengani 2011). Although domestic catches were strongly under-reported, the relative decrease of the under-reported component indicates an improvement in catch statistics. This improvement is observed since the early 2000s herein and indicated by literature since 2003 (Badjina Egombengani 2011).

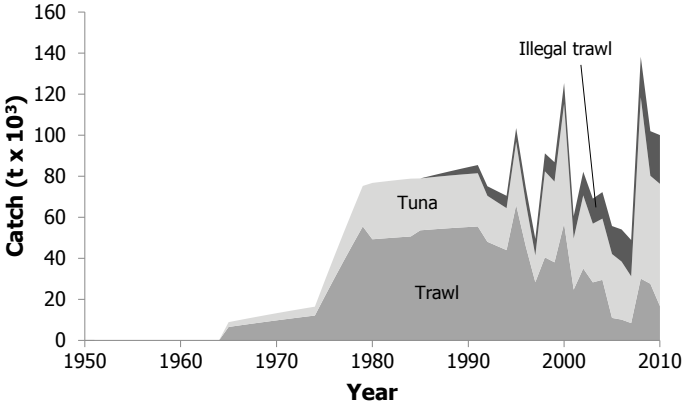

Figure 6. Reconstructed total foreign catches from Gabon, 1950-2010.

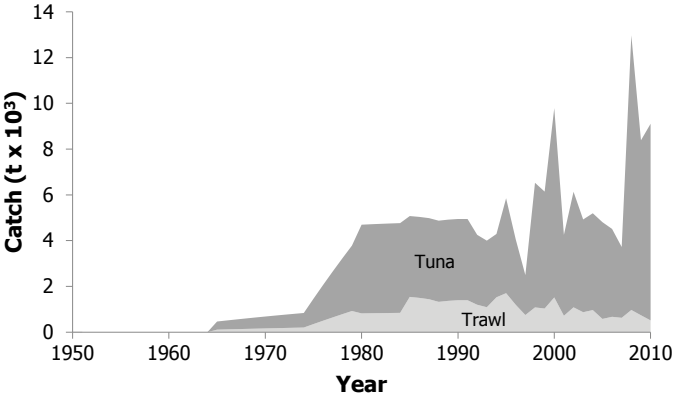

Figure 7. Reconstructed industrial discards from Gabon by gear, 1950-2010.

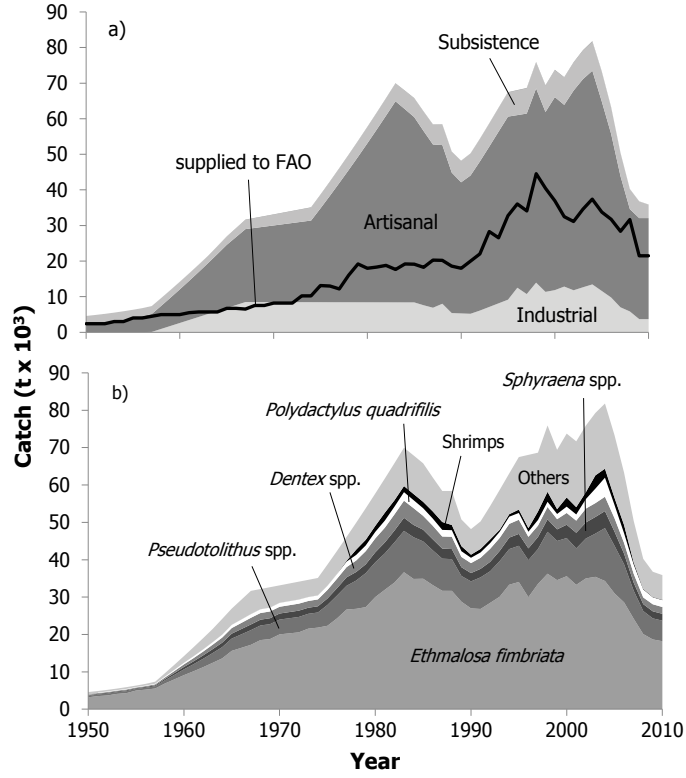

Figure 8. Reconstructed total domestic catches a) by sector from Gabon, 1950-2010, with solid line as data supplied to FAO. Discards plotted but cannot be seen on graph; b) by taxonomic composition from Gabon, 1950-2010. 'Others' consist of 55 additional taxonomic categories.

Illegal catches were estimated to have been the equivalent of 1% of legal catches in the past, and around 50% today, indicating an alarming increase in less than 25 years, which may partially explain the problem of over-exploitation in the waters of Gabon. Furthermore, of the around 80 taxa caught by the legal fisheries of Gabon, 40 taxa are also taken by illegal fisheries, indicating an overlap of 50% in taxa targeted or caught. Economically, illegal fisheries are estimated to have extracted over $207 million US in 2010 from the waters of Gabon that could have been extracted by legal fisheries, assuming a price of $8.3 US·kg^{-1} (RFI 2012). Thus, the net loss to the total Gabonese economy, if we could assume complete landings and processing within Gabo, using an economic multiplier of 2.95 (Dyck and Sumaila 2010), would be equivalent to $610 million US per year. The legal fisheries contribute $1.3 billion US to the Gabonese economy, i.e., around 9% of the Gabonese GDP in 2010, while small-scale fisheries alone contribute $800 million US of the total economy, i.e., 5% of the GDP, a clear indication of their importance to both the economy and food security.

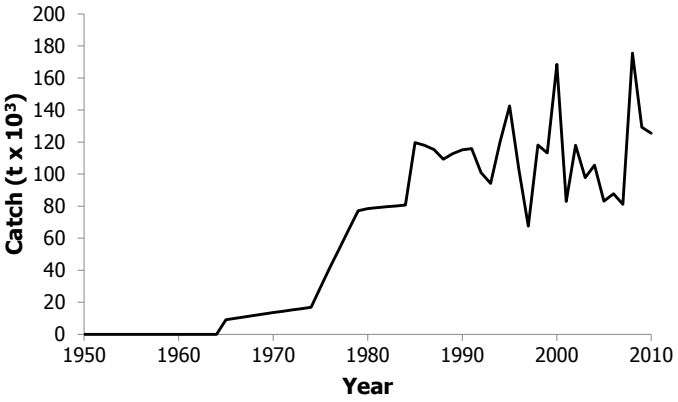

Figure 9. Reconstructed total foreign catches from Gabon, 1950-2010.

Small-scale fisheries in Gabon, the main source of animal protein, are threatened by increasing illegal fishing, combined with a low monitoring, control and surveillance capacity (Barretta and Houston 2014) and other threats, such as increasing migrations towards the coast. Although fisheries statistics have improved over time, there is still room for effort to refine the catch statistics, notably through a separate accounting of small-scale and industrial fisheries. Most important, however, is the enforcement of fisheries legislations, notably against foreign vessel incursions.

Acknowledgements

This is a contribution from the *Sea Around Us*, a collaboration supported by The Pew Charitable Trusts and the Paul G. Allen Family Foundation.

References

Anon. (2004) Framework contract for performing Evaluations, Impact Analyses and Monitoring Services in the context of Fisheries Partnership Agreements concluded between the Community and Non-Member coastal states. Sao Tome and Principe. Report to the European Commission by Oceanic Développement, Poseidon Aquatic Resource Management Ltd, and MegaPesca Lda., Concarneau, France. 126 p.

Anon. (2009) Annuaire statistique 2009. Direction Généale de la Statistique, Libreville. 245 p.

Anon. (2010) Publication du registre des licences de pêches. Situation au 1er semestre 2010. Ministère de l'agriculture, de l'élevage, de la pêche et du développement rural, Direction générale des pêches et de l'aquaculture, Libreville. 4 p.

Anon. (2011) Liste des recettes générées par les licences de pêche 1er semestre 2011. Ministère de l'agriculture, de l'élevage, de la pêche et du développement rural, Direction générale des pêches et de l'aquaculture, Libreville. 3 p.

Badjina Egombengani L (2011) Dynamique des changements dans l'activité de la pêche au Gabon de 1900 à nos jours, Université Segalen Bordeaux Université Victor Segalen Bordeaux 2 UFR « Science de l'Homme », Bordeaux. 425 p.

Barretta K and Houston JE (2014) Gabon: A Guide to Improving the Coastal and Inland Fishery Industries. Journal of Food Distribution Research 45(1): 8-20.

Belhabib D (2015) Fisheries of Sao Tome and Principe, a catch reconstruction 1950-2010. Fisheries Centre Working Paper #2015-67, University of British Columbia, Vancouver, 13 p.

Belhabib D and Pauly D (2015) Côte d'Ivoire: fisheries catch reconstruction, 1950-2010. Fisheries Centre Working Paper #2015-66, University of British Columbia, Vancouver, 33 p.

Belhabib D and Pauly D (2015) The implications of misreporting on catch trends: a catch reconstruction for the People's Republic of the Congo, 1950-2010. pp. 33-44. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [this volume]

Bignouma G (2011) Le concept de périphérie appliqué à l'activité halieutique : impact sur l'aménagement des pêcheries maritimes artisanales au Gabon. Geo-Eco-Trop 2011(35): 33-40.

Chavance P, Amon Kothias J, Dewals P, Pianet R, Amandè MJ, De Molina AD and Djoh A (2011) Statistics on tuna surface fishery's bycatch landed in Abidjan, Côte d'Ivoire, for the 1982-2009 Period. Collect. Vol. Sci. Pap. ICCAT 66, ICCAT. 2104-2112 p.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). Center for International Earth Science Information Network (CIESIN)/Columbia University, Palisades, NY. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3. [Accessed: Nov 21, 2012].

Dyck AJ and Sumaila UR (2010) Economic impact of ocean fish populations in the global fishery. Journal of Bioeconomics 12(3): 227-243.

Ekouala L (2013) Le développement durable et le secteur des pêches et de l'aquaculture au Gabon : une étude de la gestion durable des ressources halieutiques et de leur écosystème dans les provinces de l'Estuaire et de l'Ogooué Maritime, Université du Littoral Côte d'Opale, Ecole doctorale SESAM (E.D n°73), Laboratoire T.V.E.S (E.A n°4477), Lille. 408 p.

Everett G (1976) An overview of the state of fishery development and planning in the CECAF region. CECAF/ECAF Series 75/4, FAO, Rome. 67 p.

Failler P, Fonteneau A and Defaux V (2013) Evaluation rétrospective et prospective du protocole de l'accord de partenariat dans le secteur de la pêche entre l'Union Europeene et la Republique democratique de Sao Tome e Principe. COFREPECHE, MRAG, Poseidon Aquatic Resource Management Ltd, NFDS, Brussels. 123 p.

Haakonson J (1992) Industrial vs. artisanal fisheries in West Africa. The lessons to be learnt. pp. 33-53 In Tvedten I and Hersoug B (eds.), Fishing for development. Small-scale fisheries in Africa. The Scandinavian Institute of African Studies, Motala.

Ijiff A (1991) Migrations in Artisanal Marine Fisheries in Gabon. pp. 270-282 In Haakonson J and Diaw C (eds.), Fishermen's migrations in West Africa. Programme for Integrated Development of Artisanal Fisheries in West Africa-IDAF, Cotonou.

Kebe M (2011) Évaluation des investissements privés et publics réalisés dans la pêche et l'aquaculture au Gabon de 1980 à 2010, et analyse de leurs impacts dans le secteur. ACPFish II, Libreville. 46 p.

Kebe M, Njock J and Gallène J (1996) Revue sectorielle de la pêche artisanale maritime au Gabon. Rapport Technique 81, DIPA, Cotonou. 68 p.

Lagoin Y and Salmon G (1970) Etude Technique et Economique comparée de la distribution du poisson de mer dans les pays de L'Afrique Centrale Atlantique. Secrétariat d'état aux affaires étrangères chargé de la coopération. 500 p.

Mallory TG (2013) China's distant water fishing industry: Evolving policies and implications. Marine Policy 38(0): 99-108.

MRAG (2005) Review of impacts of Illegal, Unreported and Unregulated fishing on developing countries. Final report, MRAG, London. 176 p.

RFI (2012) Face à la hausse du prix du poisson, le gouvernement gabonais promeut la vente directe. Les Voix du Monde 2012(15-08): 1.

Romagny B, Menard F, Dewals P, Gaertner D and N'Goran Y (2000) Le "faux-poisson" d'Abidjan et la pêche sous DCP dérivants dans l'Atlantique tropical Est: circuit de commercialisation et rôle socio-economique pp. 634-652 In Cayré P, Le Gall J and Taquet M (eds.), Pêche thonière et dispositif de concentration de poissons. Colloque Caraibe-Martinique, Trois-Ilets, 15-19 Octobre 1999. Institut de recherche pour le developpement, Institut français de recherche pour l'exploitation de la mer, Ecole nationale supérieure agronomique de Rennes 38. Editions Quae.

Wilkie DS, Starkey M, Abernethy K, Effa EN, Telfer P and Godoy R (2005) Role of Prices and Wealth in Consumer Demand for Bushmeat in Gabon, Central Africa. Conservation Biology 19(1): 268-274.

Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years. Fishery Bulletin 105(2): 266-277.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	2,400	4,580	60	2,000	2,530	1
1951	2,400	4,860	60	2,320	2,480	1
1952	2,400	5,170	60	2,670	2,440	1
1953	3,000	5,520	60	3,070	2,390	1
1954	3,000	5,900	60	3,490	2,350	1
1955	4,000	6,320	60	3,960	2,300	1
1956	4,000	6,780	60	4,460	2,260	1
1957	4,500	7,360	101	5,040	2,210	2
1958	5,000	9,590	940	6,470	2,170	16
1959	5,000	11,870	1,780	7,940	2,120	30
1960	5,000	14,190	2,620	9,450	2,080	44
1961	5,500	16,560	3,459	11,010	2,030	59
1962	5,700	18,980	4,299	12,620	1,990	73
1963	5,700	21,450	5,138	14,280	1,940	87
1964	5,700	24,160	5,978	15,990	2,090	101
1965	6,700	26,920	6,817	17,750	2,240	115
1966	6,700	29,290	7,656	19,110	2,390	130
1967	6,500	31,660	8,496	20,490	2,530	144
1968	7,500	32,150	8,491	20,830	2,680	144
1969	7,500	32,640	8,485	21,180	2,830	144
1970	8,200	33,130	8,480	21,530	2,980	144
1971	8,200	33,630	8,475	21,880	3,130	143
1972	8,200	34,120	8,469	22,230	3,280	143
1973	10,200	34,620	8,464	22,580	3,430	143
1974	10,200	35,120	8,459	22,940	3,570	143
1975	13,100	38,690	8,453	26,370	3,720	143
1976	13,020	42,350	8,448	29,890	3,870	143
1977	12,210	46,090	8,443	33,480	4,020	143
1978	16,000	49,890	8,437	37,140	4,170	143
1979	19,200	53,760	8,432	40,860	4,320	143
1980	18,000	57,710	8,427	44,670	4,470	143
1981	18,346	61,730	8,421	48,550	4,620	143
1982	18,805	65,810	8,416	52,490	4,770	142
1983	17,649	69,960	8,411	56,490	4,920	142
1984	19,200	67,910	8,405	54,300	5,070	142
1985	19,153	65,800	8,400	52,050	5,220	142
1986	18,244	62,030	7,600	48,940	5,370	129
1987	20,286	58,390	6,900	45,860	5,520	117
1988	20,191	58,400	8,022	44,580	5,670	136
1989	18,601	50,770	5,400	39,460	5,810	91
1990	18,000	48,190	5,300	36,840	5,960	90
1991	20,000	50,240	5,200	38,840	6,120	88
1992	22,000	54,340	6,100	41,880	6,270	103
1993	28,290	58,680	7,120	45,030	6,420	120
1994	26,515	63,100	8,140	48,250	6,570	138
1995	32,777	67,460	9,159	51,430	6,720	155
1996	36,045	68,060	12,518	48,500	6,870	172
1997	34,073	68,640	10,738	50,710	7,020	177
1998	44,556	75,920	13,949	54,570	7,170	236
1999	40,453	69,400	11,353	50,530	7,320	193
2000	36,937	73,740	11,849	54,230	7,470	199
2001	32,482	71,670	12,844	51,050	7,620	160
2002	31,136	75,880	11,804	56,120	7,770	186
2003	34,576	79,270	12,648	58,490	7,920	211
2004	37,423	81,790	13,453	60,040	8,070	228
2005	33,727	73,310	11,619	53,270	8,220	197
2006	31,765	63,260	9,785	45,980	7,330	166
2007	28,374	50,420	7,016	36,850	6,430	119
2008	31,702	40,240	5,860	28,740	5,530	99
2009	21,457	36,780	3,696	28,380	4,640	63
2010	21,457	35,880	3,696	28,380	3,740	63

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxonomic category for Gabon, 1950-2010. 'Others' contain 55 additional taxonomic category.

Year	*Ethmalosa fimbriata*	*Pseudotolithus* spp.	*Sphyraena* spp.	*Dentex* spp.	*Polydactylus quadrifilis*	Shrimps	Others
1950	3,190	347	148	159	96	0	647
1951	3,500	440	187	201	122	0	410
1952	3,680	491	209	225	136	0	433
1953	4,100	467	199	214	129	0	413
1954	4,300	527	224	241	146	0	464
1955	4,990	437	186	200	121	0	384
1956	5,240	508	216	232	141	0	446
1957	5,540	597	253	273	165	0	535
1958	6,860	855	356	391	232	1	898
1959	7,970	1,197	494	547	322	1	1,336
1960	9,110	1,546	635	706	414	2	1,780
1961	10,140	1,889	763	861	497	3	2,411
1962	11,230	2,244	899	1,022	586	4	2,990
1963	12,400	2,611	1,045	1,189	681	5	3,512
1964	13,600	3,006	1,193	1,368	777	6	4,207
1965	15,610	3,285	1,319	1,496	859	5	4,341
1966	16,420	3,606	1,419	1,639	925	8	5,273
1967	17,230	3,929	1,520	1,783	990	10	6,206
1968	18,500	3,907	1,553	1,777	1,014	10	5,396
1969	18,770	3,989	1,586	1,813	1,038	12	5,438
1970	20,020	3,960	1,618	1,805	1,058	9	4,659
1971	20,290	4,040	1,651	1,840	1,081	10	4,713
1972	20,560	4,119	1,684	1,876	1,104	12	4,767
1973	21,560	3,969	1,622	1,807	1,064	13	4,582
1974	21,830	4,049	1,655	1,842	1,087	14	4,640
1975	22,330	5,571	1,723	2,289	1,125	10	5,648
1976	24,300	6,106	1,968	2,541	1,286	31	6,116
1977	26,680	6,346	2,261	2,731	1,479	223	6,371
1978	26,860	7,558	2,289	3,076	1,492	1,409	7,203
1979	27,310	9,098	2,351	3,528	1,527	1,506	8,437
1980	30,010	9,293	2,683	3,723	1,746	1,608	8,653
1981	31,960	9,735	2,926	3,948	1,905	2,108	9,145
1982	33,880	10,743	3,165	4,330	2,060	1,710	9,921
1983	36,650	11,065	3,509	4,565	2,286	1,630	10,259
1984	34,860	11,163	3,287	4,499	2,140	1,637	10,328
1985	34,920	9,990	3,128	3,715	2,041	1,701	10,313
1986	33,220	9,316	2,948	3,637	1,919	1,906	9,088
1987	31,680	8,602	2,698	3,233	1,765	2,114	8,300
1988	31,670	8,484	2,696	3,293	1,769	1,373	9,115
1989	28,780	6,879	2,336	2,758	1,530	1,348	7,139
1990	26,980	7,222	2,225	2,668	1,428	825	6,846
1991	26,820	8,454	2,273	2,965	1,431	939	7,355
1992	28,450	8,458	2,513	3,488	1,545	966	8,924
1993	30,100	9,540	2,709	3,485	1,646	540	10,661
1994	33,310	9,535	3,072	3,674	1,925	661	10,918
1995	34,030	9,692	3,181	3,787	1,819	898	14,053
1996	29,970	9,907	3,159	3,083	1,371	956	19,609
1997	33,520	9,331	3,222	3,039	1,524	2,250	15,757
1998	36,260	11,205	3,347	3,320	1,377	2,666	17,750
1999	34,540	10,487	3,102	2,725	1,394	1,278	15,878
2000	35,600	10,202	3,562	3,153	1,685	2,456	17,087
2001	33,270	9,748	4,189	3,245	1,663	1,947	17,607
2002	34,990	10,670	4,308	3,707	2,538	1,833	17,831
2003	35,420	11,564	4,452	3,707	3,880	3,544	16,699
2004	34,310	14,156	4,552	3,839	5,102	2,394	17,438
2005	31,000	12,722	3,791	3,595	3,534	1,920	16,754
2006	28,590	10,180	2,837	2,872	2,586	2,207	13,990
2007	24,220	7,509	2,145	2,372	2,505	550	11,118
2008	20,100	6,167	1,849	1,786	2,155	163	8,011
2009	18,670	5,636	1,888	1,883	1,875	102	6,728
2010	18,200	5,498	1,830	1,820	1,837	102	6,600

The implications of misreporting on catch trends: a catch reconstruction for the People's Republic of the Congo, 1950-2010[1]

Dyhia Belhabib and Daniel Pauly

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.belhabib@fisheries.ubc.ca; d.pauly@fisheries.ubc.ca

Abstract

The official fisheries statistics for the People's Republic of the Congo, also known as 'Congo (Brazzaville)' feature increasing landings, despite current, if anecdotal evidence of over-exploitation. This reconstruction brings to light that strong under-reporting in the past masked a massive exploitation and thus biased the trends of reported data. Reconstructed domestic catches within Congo (Brazzaville)'s EEZ increased from 7,110 t in 1950 to a peak of 99,300 t in 1977, declined to 30,500 t on average during the 1990s and then increased slowly to 45,000 t in 2010. Reconstructed total catches from the Congo within its EEZ were on average 2.8 times the data supplied to the FAO. As opposed to official statistics, which may have justified the licensing of an over-capitalized foreign industrial fleet, the reconstructed catch confirms fishers' accounts of declining catches and resources availability. This situation threatens the livelihoods of the coastal population of the Congo, which faces increasing resource scarcity and poverty.

Introduction

The People's Republic of the Congo, or 'Congo (Brazzaville)', thus named after its capital to avoid confusion with the 'Congo (ex-Zaïre)', is located in central West Africa (Figure 1). The relatively narrow coast opens to the Atlantic Ocean on the west, and ranges from Angola (Cabinda) in the South to Gabon in the North.

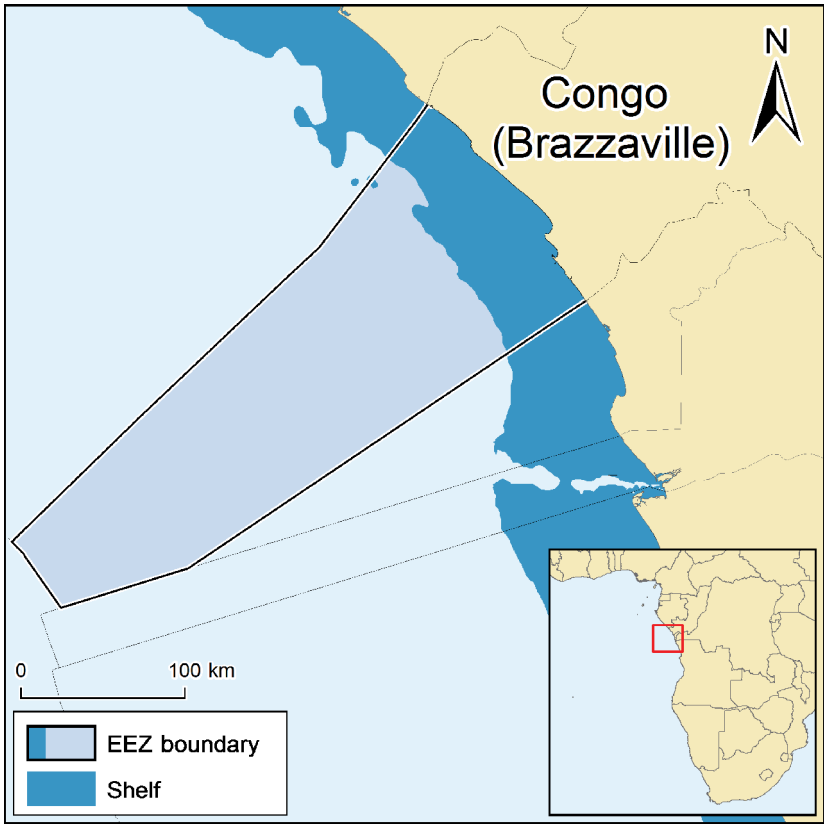

Figure 1. Map of Congo (Brazzaville) with Exclusive Economic Zone (EEZ).

The first steps toward independence from France began with a strong nationalist movement as early as 1926, due mainly to mistreatment of the Congolese by the French administration (Bernault 1996). The Congo became an autonomous republic in 1958, followed by a series of upheavals in 1959 and finally independence in 1960. Although the Congo may be considered peaceful when compared to its neighbours in the South, it remains a good example of how the democratization process can trigger a series of conflicts (Bazenguissa-Ganga 1999). Due to deteriorating economic conditions and a high unemployment rate (Bernault 1996), this led to a revolution in 1963 and a *coup d'état* in 1968. This period of instability eventually ended when an army colonel assumed the Presidency, and led the country into re-establishing its relations with France, and notably the French state oil company, Elf. This also involved a political conflict in 1993-2000 which ended in a civil war (www.ucdp.uu.se) that killed over 18,000 people between 1993 (3,000) and 1997 (15,000). The conflict further exacerbated with greater casualties in 1999, in addition to over 20,000 women raped (Yengo 2006) and between 100,000 to 300,000 people displaced (Bazenguissa-Ganga 1999). However, the security in the country has improved significantly since 2002, when groups of armed fighters were disbanded. Economically, the Congo relies mainly on minerals, agriculture and the oil sector which represents around 65% of the GDP. Despite a prevailing oil sector and an average GDP per capita of $3,800, which is relatively high compared to the rest of Africa, poverty and child malnutrition still prevail, particularly in rural areas (The World Bank 1997). With over a third of monthly expenses dedicated for bushmeat

[1] Cite as: Belhabib, D. and Pauly, D. (2015) The implications of misreporting on catch trends: a catch reconstruction for the People's Republic of the Congo, 1950-2010. pp. 95-106. *In*: Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

and fish, animal protein intake is a household priority (The World Bank 1997; Fa *et al.* 2003). Indeed, with some 4.2% of the Congo households fishing (Anon. 2006), fish contributes over 50% of the animal protein intake (Anon. 2011b) and around 2 to 3% of the national GDP (Horemans and Kebe 2006; COREP 2012). However, with declining fisheries resources (Nguinguiri and Katz 1996) due in part to overexploitation by foreign fleets, notably those from China, a complete lack of transparency and a high level of corruption (Transparency International 2010), which led to licenses being awarded to some 70 foreign vessels despite the sustainable level being much lower (Maloueki 1999, 2005), coastal populations find themselves trapped between increasing poverty and limited choices of livelihood (Brugère *et al.* 2008).

Official catch statistics reported by the Food and Agriculture Organization (FAO) on behalf of the Congo exhibit a continuous increasing trend, which in the light of the above issues, appears to be highly dubious. Although, there have been a great effort by the *Office de la recherche scientifique et technique d'outre-mer* (ORSTOM, now IRD) as early as 1981 to collect artisanal and industrial (small-pelagic) fishing data, "catch statistics for the 1970s are virtually non-existent" (Jul-Larsen 1994a). In addition to industrial trawl and artisanal fisheries being under-estimated given their scattered nature (as industrial fleets operate in other countries' Exclusive Economic Zones (EEZ) and artisanal are dispersed across the entire coast of the Congo), discards and foreign catches are also largely unknown. Herein, we reconstruct fisheries catch data between 1950 and 2010, by making coherent and compatible what little is known of the marine fisheries of the Congo, and thus generating what we hope are realistic fisheries catch trends.

Methods

Coastal population

The total population was obtained from the database of the World Bank (www.worldbank.org) for the period between 1960 and 2010 and from Populstat (www.populstat.org) from 1950 to 1959. Coastal rural and urban population estimates for 1990, 2000 and 2010 were extracted from CIESIN (2012), then expressed in percent of total population. We extrapolated backwards the rural and urban population percentage and completed the time series by a series of linear interpolations. We then multiplied the resulting percentages by the total population to obtain the coastal rural and urban population of Congo (Figure 2)

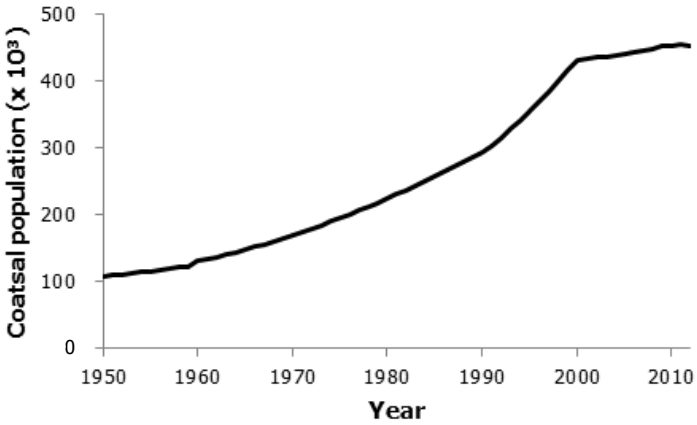

Figure 2. Coastal population of the Congo, 1950-2010, adapted from www.worldbank.org and www.populstat.org (see text).

Subsistence fisheries

In the past small-scale fisheries were directed mainly for personal consumption and canoe (*villi*)-type fisheries were described to be for subsistence (Le Gall 1975). Herein, we consider subsistence fishing, anything that is taken by non-artisanal fishers for household consumption, including children (Vennetier 1968)[2]; thus the part that is taken home by artisanal fishers is considered as a fraction of the artisanal fishery. Households in the Congo can consume fish as much as 5.8 times a week on average as revealed by a survey sampling 70 households in Pointe-Noire (Le Gall 1975). In the Pointe-Noire area, fish consumption ranged between at least 65 kg·capita^{-1}·year^{-1} (Lagoin and Salmon 1970) and 85 kg·capita^{-1}·year^{-1} (Cayre and Fontana 1977). These numbers are likely too high for the rest of the Congolese coast; however, they give a clear indication of the importance of fish consumption to Congolese households.

Dhont (1963) estimated a per capita consumption rate for the country as a whole of 500 g·capita^{-1}·week^{-1} for 1957 and 1 kg·capita^{-1}·week^{-1} for 1962, equivalent to 24 kg·capita^{-1}·year^{-1} and 48 kg·capita^{-1}·week^{-1} respectively. Lagoin and Salmon (1970) reported a higher consumption rate for 1967 of 55 kg·capita^{-1}·week^{-1}. For 2005, we converted the per capita calories intake from different kinds of fish and processed seafood products (Anon. 2006; Backiny-Yetna and Zodon 2009) to weight of the processed product, then to live weight using conversion factors from FAO (FAO 2000). We reached a consumption rate of 93.2 g·capita^{-1}·day^{-1}, i.e. 34 kg·capita^{-1}·year^{-1} for 2005. We assumed the consumption rate was constant between 1950 and 1957, between 2005 and 2010, and then interpolated linearly to fill in the gaps.

In inland fisheries, 35% of the fish caught by households is kept for personal consumption (Béné 2008). Assuming the same rate applies to coastal fisheries, 35% of the fish consumed by the coastal rural populations of the Congo would be caught by the household itself. Therefore, we multiplied the previous consumption rates by 35% and then by the rural coastal population, thus obtaining subsistence catches from the coastal waters of the Congo.

[2] The author suggests in his description of subsistence fisheries that "all children" in coastal Congo are fishing.

Artisanal fisheries

Artisanal catch data collection was conducted by ORSTOM scientists since the early 1980s at 4 landing sites of the Congo (Kebe and Njock 1995), mainly monitoring sardinella (*Sardinella* spp.) catches. We assume that previously, catches were not monitored. The two types of canoes operating along the coast of the Congo have different capacity and therefore are treated separately in the present reconstruction. The first type includes the motorized and unmotorized Congolese (*villi*) pirogues, also called '*bouatou*' (Dhont 1963), whose length is less than 6 m for the unmotorized ones and between 7 and 8 m for those with motors of 6.5 to 25 hp (Kebe and Njock 1995; Maloueki 1999). Villi fishers use gill-nets and hand lines (Tvedten 1990) and take onboard 1 to 2 fishers. The second type includes the Ghanaian pirogue-type used by the Popo ethnic group from Benin (Maloueki 1999). Their length reaches 14 to 18m and their engine power 25-40 hp (Tvedten 1990; Kebe and Njock 1995; Maloueki 1999) taking onboard 5 to 7 fishers (Mandilou 2010). These boats can carry from 4 t of fish every trip (Kebe and Njock 1995) to "tons of fish… every week"(Tvedten 1990).

Although the *villi* were not considered active fishers in the 1940s and the 1950s when the Popo seemed to have a monopoly (Vennetier 1968), a relatively large number of villi-type canoes was reported as early as 1962, which suggest that a strong villi fishery already in place the 1950s and the 1960s (Dhont 1963; Lagoin and Salmon 1970). This is supported by further evidence suggesting that this fishery was mainly for personal consumption prior to the 1970s (Le Gall 1975), which might be a reason why it is not considered in economic surveys of Congolese fisheries.

Table 1. Reconstructed artisanal fishing effort by ethnic group in the Congo

Year	Total canoes	Reference	Villi canoes	Reference	Popo canoes	Reference
1950	-	-	178	Assumed the effort in 1950 was half of that of 1962	3	Assumed constant
1955	-	-	252	Interpolation	3	Gobert (1985)
1958	-	-	297	Interpolation	16	Gobert (1985)
1960	-	-	326	Interpolation	24	Jul-Larsen (1994a, 1994b)
1962	356	Dhont (1963); Lagoin and Salmon (1970)	356	Dhont (1963); Lagoin and Salmon (1970)	38	Interpolation
1963	-	-	373	Interpolation	45	Jul-Larsen (1994a, 1994b)
1966	-	-	423	Interpolation	120	Jul-Larsen (1994a, 1994b)
1967	460	Lagoin and Salmon (1970)	440	Subtraction	20	Lagoin and Salmon (1970)
1970	-	-	414	Interpolation	24	Jul-Larsen (1994a, 1994b)
1975	500	Le Gall (1975)	370	Interpolation	102	Interpolation
1976	-	-	361	Interpolation	117	Jul-Larsen (1994a, 1994b)
1977	469	Fontana (1980)	352	Subtraction	117	Jul-Larsen (1994a, 1994b)
1978	-	-	362	Interpolation	59	Reduced by half[a]
1980	600	Chaboud and Charles-Dominique (1991)	382	Interpolation	84	Interpolation
1982	-		402	Interpolation	110	Jul-Larsen (1994a, 1994b)
1983	542	Nguinguiri (1991)	412	Subtraction	130	Jul-Larsen (1994a, 1994b)
1986	-	-	381	Interpolation	109	Jul-Larsen (1994a, 1994b)
1987	513	Barro *et al.* (1989)	371	Barro *et al.* (1989)	142	Barro *et al.* (1989)
1988	550	Kébé and Njock (1995)	401	Kébé and Njock (1995)	149	Jul-Larsen (1994a, 1994b)
1989	515	Kébé and Njock (1995)	355	Kébé and Njock (1995)	160	Kébé and Njock (1995)
1990	520	Kébé and Njock (1995); Bazon and Ngouembe (1995)	360	Kébé and Njock (1995); Bazon and Ngouembe (1995)	160	Kébé and Njock (1995)
1991	500	Kébé and Njock (1995)	380	Kébé and Njock (1995)	120	Jul-Larsen (1994a, 1994b)
1992	530	Kébé and Njock (1995)	395	Interpolation	120	Interpolation
1993	490	Kébé and Njock (1995)	410	Interpolation	120	Interpolation
1994	545	Kébé and Njock (1995); Jul-Larsen (1994a)	425	Kébé and Njock (1995); Jul-Larsen (1994a)	120	Kébé and Njock (1995); Jul-Larsen (1994a)
2000	518	Koumba (2012)	336	Koumba (2012)	182	Koumba (2012)
2001	532	Koumba (2012)	343	Koumba (2012)	189	Koumba (2012)
2002	720	Koumba (2012)	464	Koumba (2012)	256	Koumba (2012)
2003	506	Kibelolo (2003)[b]	594	Interpolation	180	Koumba (2012); Kibelolo (2003)
2004	506	Koumba (2012)[b]	724	Interpolation	180	Koumba (2012)
2005	588	Anon. (2011a)[c]	853	Interpolation	254	Koumba (2012)
2006	1199	Anon. (2011a)	983	Anon. (2011a)	216	Koumba (2012)
2007	1173	Anon. (2011a); InfoPeche (2008)	919	Anon. (2011a)	254	Koumba (2012)
2008	1171	Anon. (2011a)	811	Anon. (2011a)	360	Koumba (2012)
2009	1193	Anon. (2011a)	929	Anon. (2011a)	264	Koumba (2012)
2010	1193	Anon. (2011a)	929	Anon. (2011a)	264	Koumba (2012)

[a] 'Foreign' fishers were expelled (i.e., fishers of irregular status in the Congo) since 1960 until 1977, and fishers migrated again to Congo in 1979 (Gobert 1985); After the death of President Marien Nhouabi in May 1977, around 4/5 of the Popo community were repatriated and 166 outboard engines confiscated (the fishers had no residence permits, and their engines no import permits). The government also decided that the remaining Popo should "refrain from fishing" unless it was for subsistence (Jul-Larsen 1994a);

[b] This number was not taken into consideration as it was too low compared to the previous and later years;

[c] This number was adjusted upwards as a total of 1,347 pirogues was reported by Bignouma (2010) of which 254 are Popo.

The effort time series for both fisheries, expressed in number of canoes, was rebuilt using different literature sources (Dhont 1963; Lagoin and Salmon 1970; Le Gall 1975; Fontana 1980; Gobert 1985; Barro *et al.* 1989; Chaboud and Charles-Dominique 1991; Nguinguiri 1991; Jul-Larsen 1994a, 1994b; Kébé and Njock 1995; Kibelolo 2003; Anon. 2011a; Koumba 2012) and adjusted when necessary3 (Table 1). We interpolated linearly to fill in the gaps.

The catch per unit of effort was provided by Dhont (1963) at 750 kg·canoe^{-1}·month^{-1} for the *villi* canoes for around 11.5 days fishing per month (Gobert 1985, 1986), i.e., 65.2 kg·canoe^{-1}·day^{-1} for 1958. Similarly, the author provided a CPUE of 66.7 kg·canoe^{-1}·day^{-1} for the dry season and 44.4 kg·canoe^{-1}·day^{-1} for the wet season, i.e. 55.6 kg·canoe^{-1}·day^{-1} for 1962 on average. For 1993, we estimated the CPUE of the *villi* at 84.3 kg·unit^{-1}·day^{-1} by calculating the weighted average of the CPUE of motorized and unmotorized pirogues provided by Kébé and Njock (1995). We assumed the CPUE remained relatively constant between 1950 and 1958, and that it decreased linearly by 30% between 1993 and 2003 to reflect the over-exploitation, declining catches and declining fish sizes (Fontana 1980; Nguinguiri 1991; Nguinguiri and Katz 1996). We then interpolated linearly to fill in the time series of *villi*-type canoes CPUE.

Similarly, the CPUE of Popo-type canoes was estimated by dividing the total observed catch for the Popo-type canoes by the number of these canoes (Kebe and Njock 1995), i.e. 387 kg·canoe^{-1}·day^{-1} for 1993. Popo fishers observed that the time spent fishing increased because of declining catches; they catch in the 1990s the same amount of fish in one night than what they used to catch in 2 hours in the 1960s (Nguinguiri and Katz 1996). Moreover, although fishers used more rudimentary fishing gear in the 1960s, they used to catch more fish than today, even with increasing fishing net sizes (Nguinguiri and Katz 1996). This translates into the CPUE of 1960 being 6 times higher than the CPUE of 1990s, i.e. 2,322 kg·canoe^{-1}·day^{-1} for 1960, which is still below the capacity of a typical Popo-type canoe. We assumed the CPUE declined by 15% between 1993 and 2010 and then filled in the gaps by performing a series of linear interpolations.

We obtained *vili* and Popo catches by multiplying the number of canoes of each type by their respective CPUE.

Artisanal catches included mainly sardinellas (*Sardinella aurita, S. maderensis*) and bonga shad (*Ethmalosa fimbriata*) (Anon. 2011b), with the remaining evenly distributed between Southern meager (*Argyrosomus holopedium*), chub mackerel (*Scomber japonicus)* and Atlantic bumper (*Chloroscombrus chrysurus*) (Fontana 1980).

Industrial domestic fisheries

Industrial fishing in Congo began (in Pointe Noire) as early as the 1940s (Vennetier 1968), with the first industrial trawlers arriving in 1948 (Dhont 1963; Fontana 1980).

The number of shrimp trawlers, other demersal trawlers and small-pelagic purse-seiners were obtained from different literature sources which retrace the fishing effort between 1950 to 2010 (Dhont 1963; Crosnier and Tanter 1968; Vennetier 1968; Lagoin and Salmon 1970; Fontana 1980; Bazon and Ngouembe 1995; Kébé and Njock 1995; Cochrane and Tandstad 2000; Binet *et al.* 2001; InfoPêche 2008; Anon. 2011a, 2011b; Koumba 2012). Reported landings were often reported by the same sources as an aggregate of all industrial fishing segments and/or separated into demersal, shrimp and small-pelagic (*Sardinella* spp.) landings (Le Gall 1975; Cayre and Fontana 1977; Fontana 1980; COREP 2012).

Since ORSTOM staff started monitoring sardinella catches as soon as the fishery began (Fontana 1980), we assumed sardinella catches were reported properly and added 4% for the by-catch.

On the other hand, given the scattered nature of the demersal and shrimp trawl fisheries, operating between Gabon and Angola (Crosnier and Tanter 1968; Cochrane and Tandstad 2000), we reconstructed catches using a different method relying on the CPUE and the number of boats for every segment.

The CPUE for shrimp trawlers was estimated using the observed catch data by Fontana (1980) provided by kg·hour^{-1} for target species: deep-water rose shrimp (*Parapenaeus longirostris*), striped red shrimp (*Aristeus varidens*) and the deep-water shrimp (*Plesiopenaeus edwardsianus*), converted to catch per day using the conversion rate provided by the author, and estimated a CPUE of 5.85 t·boat^{-1}·day^{-1} of retained species and 4.27 t·boat^{-1}·day^{-1} of discarded species for 1975. Bazon and Ngouembe (1995) estimated a CPUE of 1 t·boat^{-1}·day^{-1} for 1986 and 0.4 t·boat^{-1}·day^{-1} for 1993. Given evidence of declining trawler CPUE (Bazon and Ngouembe 1995) , we assumed the CPUE in 1950 was 30% higher than in 1975, and that of 2010, 15% lower than the CPUE of 1993. Similarly, Bazon and Ngouembe (1995) estimated a CPUE of 4.5 t·boat^{-1}·day^{-1} for demersal trawlers for 1971, 3.7 t·boat^{-1}·day^{-1} for 1979, 2.4 t·boat^{-1}·day^{-1} for 1982 and 1 t·boat^{-1}·day^{-1} for 1990, we assumed that the CPUE in 1950 was 30% higher than the CPUE of 1971, and that of 2010, 15% lower than that of 1990. We interpolated linearly between the CPUE estimates and multiplied them by the respective number of boats.

In 1967, fishing in Angola declined because of its declaration of territorial waters (12 miles zone). On the other hand, in 1970, fishing by Congolese boats in Gabonese waters was prohibited; it was only in 1972 that an access agreement allowed Congolese trawlers to operate again in Gabon, if to a smaller extent. Maps included in the study of Fontana (1980) suggest a third of trawl catches landed in Congo were taken from Angola, a sixth from the democratic Republic of the Congo (ex-Zaïre), another sixth from Gabon up to 1974; then, their operation shifted North to Gabon and Congo, up to 1980 (Fontana 1980). The domestic industrial fleets targeting mainly shrimp (Crosnier and Tanter 1968; Cochrane and Tandstad 2000) reduced its fishing zone from Angola and Gabon in the 1980s to only Congo today (Nguinguiri and Katz 1996).

[3] Some references reported very low effort numbers in contrast to some others, in which case the highest number was taken into consideration as the effort was actually observed.

We assumed 70% of the shrimp catch was taken from Angola, the remaining distributed evenly between Gabon, the Congo (ex-Zaire) and the Congo between 1950 and 1967 when Angola claimed its territorial waters. In 1974, a third of shrimp trawl catches were taken from Angola and 17% from the Democratic Republic of the Congo (ex-Zaïre), 17% from Gabon and the remaining from the Congo. For 1980, when fishing in Angola ceased, we allocated 50% of the catch as taken from the Congo and 50% from Gabon, which were then kept at zero from 1989 on.

Reported catches often include only the targeted groups such as penaeid shrimps, crabs and other high value species for shrimp trawlers. Therefore, using the bycatch data provided by the authors (Fontana 1980), catches must be corrected.

The number of Chinese vessels is often included in the 'total' number of domestic vessels, thus causing a large increase in the latter. China started fishing in the Congo in 2000 (Kibelolo 2003). In 2006, 26 Chinese bottom trawlers were operating in the Congo (Anon. 2011a, 2011b; Koumba 2012). We obtained the number of Chinese vessels operating for the later years by subtracting the number of domestic demersal trawlers from the total provided in the literature (InfoPeche 2008; Anon. 2011a; Koumba 2012). We interpolated linearly to fill in the gaps and multiplied the effort by the CPUE calculated for demersal trawlers for 300 days, which we then adjusted by +20% for the difference in efficiency.

Between 1958 and 1961, other trawlers operated in Congo, but statistics were available (Poinsard 1969); thus, any estimate generated based on a CPUE and effort, as is the case here, is likely to be conservative.

We disaggregated shrimp trawl catches using the catch description of target species by Fontana (1980) and demersal trawl catches by combining the species disaggregation provided by different references (Poinsard 1969; Lagoin and Salmon 1970; Chardy and Le Guen 1971; Cayre and Fontana 1977; Fontana 1980). We assumed the species composition provided by Poinsard (1969) remained unchanged between 1950 and 1963, and similarly for that provided by Fontana (1980) from 1980 and 2010, and interpolated between them.

Illegal fisheries

"Unregulated and unsustainable industrial fisheries are the most significant threat. Increasing numbers of domestic and foreign fishing boats venture into coastal waters to fish illegally. Fish are caught at unsustainable levels" (WCS 2011). Chinese boats are often accused of illegal fishing in Congo; thus we assume illegal fishing by China began around the time China started operating in the area. Specifically, assumed that illegal Chinese catches started at zero in 2000, increased to 58% of the legal catch (MRAG 2005) in 2005 and further increased by 20% in 2010, given the evidence of an increasing pattern of illegal catches (MRAG 2005).

Discards

Although sharks were targeted for their fins for over 20 years (since the fishery began until the fishery was prohibited in the early 2000), discards were minimal because the carcasses were also used in local markets (Maloueki 2005).

Discards by the shrimp fleet were between 1,500-2,000 t·year^{-1} (Bazon and Ngouembe 1995), which is equivalent of 3.43 times the landed (estimated catch) for 1993. For 1975, using the data on non-target species catch provided by Fontana (1980), which was equivalent of 73% of landings. We assumed discards were constant between 1950 and 1975, and decreased by 50% between 1993 and 2010, to reflect upon over-exploitation which might have led vessels to increasingly keep by-catch. We then multiplied the resulting rates by the estimated shrimp trawl catch.

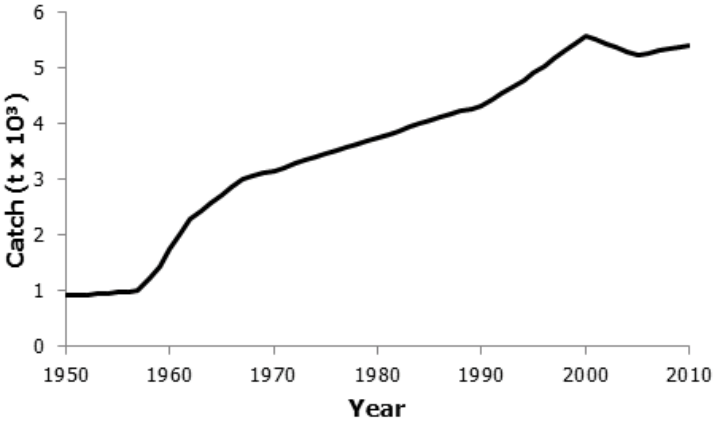

Figure 3. Reconstructed total subsistence catches from the Congo, 1950-2010.

Documents assessing discards by demersal fish trawlers in the waters of the Congo were not available. Therefore, to estimate domestic discards, we used the discard rate estimated by (Belhabib *et al.* 2014b) for the Congo (ex-Zaire) of 1.8% for domestic demersal trawl and 66% of landed catches for foreign discards.

Discards include soles (*Cynoglossus* spp.), porgies (*Pagellus* spp., *Pagrus* spp. and *Dentex* spp.), i.e., fishes that are not appreciated by Congolese consumers (Poinsard 1969). Shrimp discards were disaggregated using the data presented by Fontana (1980) for the contribution of non-targeted species to the shrimp trawl catch.

Results

Subsistence fisheries

Subsistence catches were estimated at 950 t·year^{-1} on average from 1950 to 1957 (Figure 3). Subsistence catches increasing since the early 1960s to a peak of 5,600 t in 2000, followed by a slight decrease to 5,400 t in 2010 (Figure 3).

Artisanal fisheries

Artisanal catches were estimated at around 6,600 t·year^{-1} on average in the 1950s, before they increased drastically to a peak of 52,300 t in 1966 driven by increasing Popo fisher catches and migrations into the Congo (Figure 4). Artisanal catches collapsed to less than 13,000 t in 1967 mainly due to the major decrease in Popo catches as fishers were expelled and their fishing gear confiscated (Figure 4). Catches increased thereafter to 37,300 t in 1976 and then increased again with the Popo fishers returning to the Congo (Figure 4). Catches declined slowly since the 1980s to less than 18,000 t in 2001 and then increased slightly with the increasing number of canoes to around 32,400 t in 2008 before they decline to 27,600 t in 2010 (Figure 4).

Industrial domestic fisheries

Industrial catches from the EEZ of the Congo increased from 2,300 t in 1950 to a peak of around 38,400 t in 1975 driven by increasing shrimp trawl catches and a high number of shrimp trawlers (Figure 5). Industrial catches from the coast of the Congo decreased thereafter, with a decreasing catch to less than 11,000 t in 2010, dominated by purse-seiners catches (Figure 5). In contrast, Congolese catches from outside the Congolese EEZ increased to a peak of around 37,400 t in 1968 before declining to very low levels by the late 1980s (Figure 6), after which the fleet operated mainly within Congolese waters.

Domestic discards

Discards by the Congolese fleets followed the same pattern than demersal and shrimp trawl catches, increasing from low levels in the 1950s to a peak of around 62,000 t in 1980, and then matching the decline of the demersal and shrimp trawl fisheries, and reaching less than 1,100 t in 2010 (Figure 7).

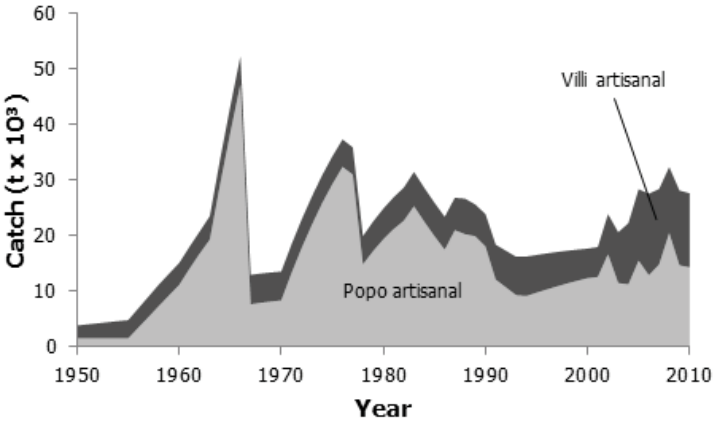

Figure 4. Reconstructed total artisanal Popo and villi catches from the Congo, 1950-2010.

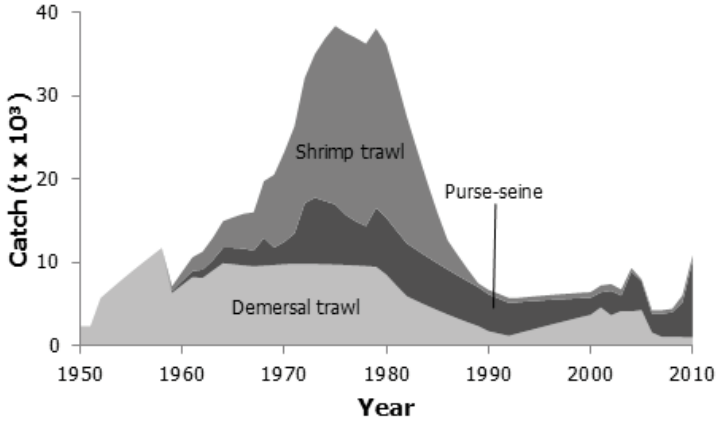

Figure 5. Reconstructed total industrial catches by gear type from the Congo.

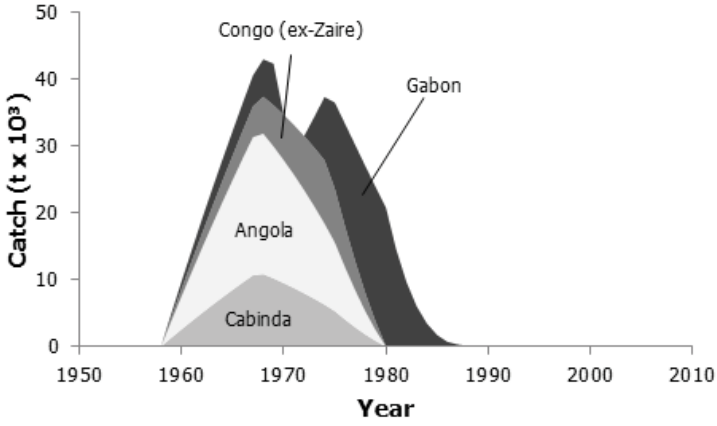

Figure 6. reconstructed total industrial catches by EEZ of the Congolese shrimp trawl fleet, 1950-2010.

Industrial foreign catches (China)

Industrial catches by the Chinese fleet unauthorized to operate in Congo increased from low levels when the fishery began in 2001 to around 14,800 t in 2010 (Figure 8). Similarly, legal catches by China, i.e., catches by vessels authorized to operate within the Congolese EEZ, and discards increased from low levels in 2001 to around 21,200 t and 13,900 t in 2010 respectively (Figure 8).

Reconstructed total catch

Reconstructed total domestic catches from the Congolese EEZ increased from around 7,100 t in 1950 compared to 5,000 t reported to the FAO to a peak of 99,300 t in 1977 compared to around 15,400 t reported to the FAO, driven by high shrimp and demersal trawl catches (Figure 9a). Catches declined thereafter to remain relatively constant at 30,500 t·year^{-1} on average during the 1990s and then increased slowly to 45,000 t in 2010 compared to around 34,700 t reported to the FAO (Figure 9a). Overall reconstructed domestic catches from the Congolese EEZ illustrate a declining pattern as opposed to increasing reported landings illustrated by the FAO data (Figure 9a).

Taxonomically, African spider shrimp (*Nematocarcinus africanus*; 13%) and other crustaceans (13%) along with *sardinella* spp. (25%) represented most of the catch in the past. More recently, sardinella spp. still compose a high proportion of the catch along with some other 70 demersal and small pelagic species (Figure 9b).

Discussion

Reconstructed total catches from the Congo within its EEZ were on average 2.8 times the data supplied to the FAO. Under-reporting was at its highest in the 1970s and 1980s, before the creation of the catch statistics division by ORSTOM. Clearly, this under-reporting contributed to biasing the trend illustrated by official data which showed continuous increase in catch, despite major signs of over-exploitation (WCS 2011).

Indeed, while migrant fisheries catches (mainly by ethnic Popo fishers) were limited by governmental restrictions and entry permits, the size of migrant pirogues has shown a steady increase from around 8 m in the mid-1950s, to 9.3 m in the mid-1970s and 11.35 m in the early 1980s, along with the generalization of the motorization in 1960 for migrant pirogues (Gobert 1985, 1986). This is a common strategy used by fishers to expand their fishing grounds and capacity, as it also occurs elsewhere in West Africa (Belhabib *et al.* 2014a). Similarly, the length of the fishing net increased from 135 m in the mid-1950s to 275 m in the 1972 to around 1,000 m today (Gobert 1985). This extension is an adaptation to decreasing catches (Kibelolo 2003; InfoPêche 2008; Anon. 2011b). Despite expanding effort, artisanal fisheries in Congo are facing reduced catches per fisher and shrinking fish sizes (Nguinguiri and Katz 1996). Moreover, finding new fishing grounds today is very difficult because of coastal development and oil production facilities (Watson and Morato 2013), which reduced the exploitable areas by 2/3 (Maloueki 2005). This certainly contributes to the unsustainable levels of small-scale fisheries resources that the Congo face today (WCS 2011). Not only does this raise concerns for Congolese fisheries management, but it also place additional pressures on other food alternatives as people seek to replace seafood in their diet, i.e., people find alternatives in bush-meat, they put "additional pressure on hippopotamus, crocodiles, turtles and dolphins" (WCS 2011).

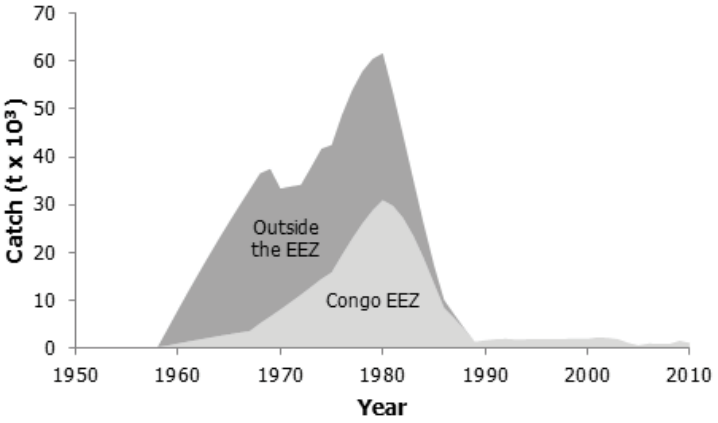

Figure 7. Reconstructed discards by the Congolese fleet, 1950-2010.

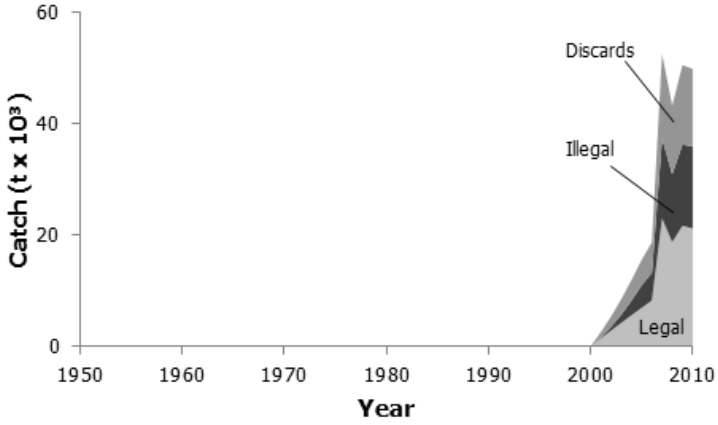

Figure 8. Reconstructed total industrial foreign catches by China in the EEZ of Congo, 1950-2010.

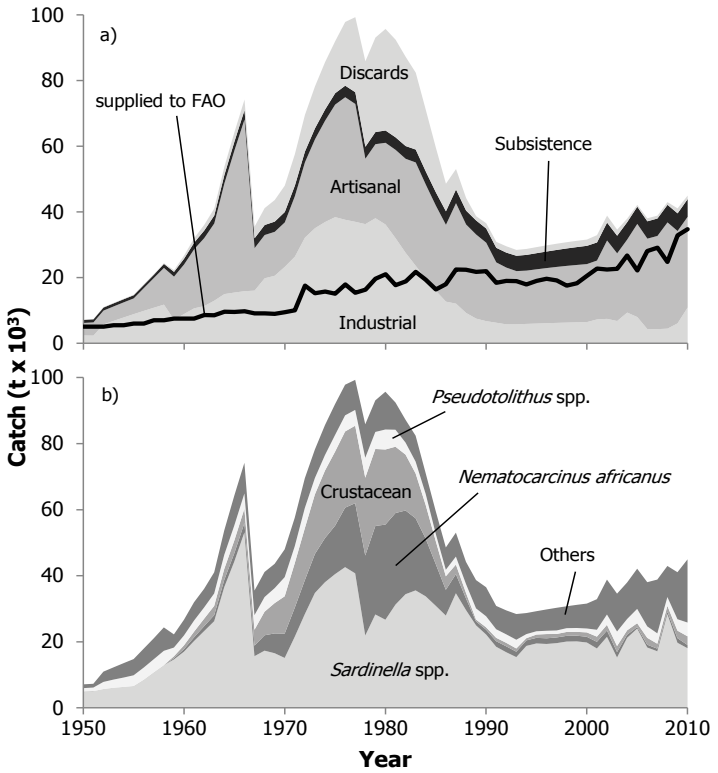

Figure 9. Reconstructed total catches for the Congo a) by sector and b) major taxa, 1950-2010.

Industrial fisheries, notably foreign Chinese fleets operating in the Congo, are often regarded as culprits when discussing issues of over-exploitation. This goes in hand with anecdotal evidence that the industrial effort is too high in the Congo. While the number of industrial domestic vessels and their capacity remains within the boundaries established for sustainable industrial fisheries, i.e., less than 30 vessels (Maloueki 2005), China deploys on average 70 fishing vessels (legally) in Congolese EEZ, which may render moot the management strategy for sustainable fisheries in the Congo. Indeed, industrial fisheries along with climate change are likely to be the strongest challenge for Congolese fishers in the next few years (Bassi and Lombardi 2013) and efforts to control are required.

The small-scale fisheries of the Congo operate within the context of strong traditional beliefs, which contribute to reshaping the fishing effort of the migrant artisanal fishers (Boungou 1986). Yet, despite strong traditional regulations aimed at maximizing fisheries output while maintaining the resource and continuous adaptive efforts, artisanal fishing households are among the poorest in the Congo (Brugère *et al.* 2008). Moreover, declining fisheries put further pressure on education and health of children in the Congo, in spite of fishmongers (mainly women) putting a particular focus on their children's education (Tati 2005) and health (Horemans and Kebe 2006).

It is perhaps encouraging that alternative livelihoods, as perceived by the most vulnerable fishing coastal households all exclude fishing (Brugère *et al.* 2008), as it may allow for moving excess fishers onto non-fishing activities. But the main task for Congolese fisheries management is to control foreign industrial fishing remains, without which all their other efforts will be in vain.

Acknowledgements

This is a contribution of the *Sea Around Us*, a scientific collaboration between the University of British Columbia and the Pew Charitable Trusts.

References

Anon. (2006) Enquête congolaise auprès des ménages pour l'evaluation de la pauvreté (ECOM 2005). Ministère du Plan, de l'Aménagement du Territoire et de l'Integration économique, Brazzaville, Congo. 141 p.

Anon. (2011a) Annuaire statistique du Congo 2009. Ministère de l'Economie, du Plan, de l'Aménagement du Territoire et de l'Intégration, Pointe-Noire, Congo. 414 p.

Anon. (2011b) Opportunités et obstacles au commerce durable intra et extra régional des produits de la pêche maritime et continentale en Afrique Centrale. European Union, Brussels. 103 p.

Backiny-Yetna P and Zodon Q (2009) Profil et perceptions de la pauvreté en République du Congo en 2005. Perspective Afrique 4(1-3): 1-21.

Barro M, Nguinguiri V and Mfina P (1989) Recensement du parc piroguier maritime congolais.73, ORSTOM, Pointe-Noire, Congo.

Bassi A and Lombardi N (2013) Définition d'un Cadre de Politique de l'Economie Verte pour un Développement Résilient au Changement Climatique: Le cas de la République du Congo. KnowlEdge Srl, Castellanza, Italy. 21 p.

Bazenguissa-Ganga R (1999) The spread of political violence in Congo-Brazzaville. African Affairs 98(390): 37-54.

Bazon A and Ngouembe A (1995) Revue du secteur des pêches et de l'aquaculture: Congo. FAO Circulaire sur les Pêches 887, FAO, Rome. 70 p.

Belhabib, D., Koutob, V., Sall, A., Lam, V.W.Y. and Pauly, D. 2014. Fisheries catch misreporting and its implications: The case of Senegal. Fisheries Research 151: 1-11.

Belhabib, D., Ramdeen, S. and Pauly, D. (2015) An attempt at reconstructing the marine fisheries catches in the Congo (Ex-Zaïre), 1950-2010. pp. 107-114. *In*: Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3), University of British Columbia, Vancouver [this volume].

Béné C (2008) Contribution of Fishing to Households' Economy-Evidence From Fisher-Farmer Communities in Congo. WorldFish Center–Regional Offices for Africa, Penang. 11 p.

Bernault F (1996) Démocraties ambiguës en Afrique centrale: Congo-Brazzaville, Gabon, 1940-1965. Karthala Editions.

Bignouma G (2010) Les pêches maritimes en Afrique centrale: Les préalables à une exploitation durable des ressources. Norois 216 (2010/3): 47-56.

Binet D, Gobert B and Maloueki L (2001) El Niño-like warm events in the Eastern Atlantic (6°N, 20°S) and fish availability from Congo to Angola (1964–1999). Aquatic Living Resources 14(02): 99-113.

Boungou G (1986) Le rôle des pratiques magico-religieuses des pêcheurs vili en baie de Loango. pp. 3-11 In Boungo G (ed.), Etudes sociologiques sur le Congo. ORSTOM, Paris.

Brugère C, Holvoet K and Allison EH (2008) Livelihood diversification in coastal and inland fishing communities: misconceptions, evidence and implications for fisheries management. Rome, Italy: Working Paper, Sustainable Fisheries Livelihoods Programme (SFLP) FAO/DFID.

Cayre P and Fontana A (1977) Pêche maritime et marché du poisson en République populaire du Congo. 50, ORSTOM, Pointe-Noire, Congo. 41 p.

Chaboud C and Charles-Dominique E (1991) Les pêches artisanales en Afrique de l'ouest : état des connaissances et évolution de la recherche. pp. 99-141 In Durand J, Lemoalle J and Weber J (eds.), La recherche face à la pêche artisanale, Symp. Int. ORSTOM-IFREMER, Montpellier France, 3-7 Juillet 1989. ORSTOM, Paris.

Chardy P and Le Guen J (1971) Essai d'analyse multivariable d'une série de chalutages au Congo. Cah. O.R.S.T.O.M., Ser. Océanogr. IX(1): 7-19.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). NASA Socioeconomic Data and Applications Center (SEDAC), Palisades, NY. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3 [Accessed: 29/10/2012].

Cochrane K and Tandstad M (2000) Report of the workshop on the small pelagic resources of Angola, Congo and Gabon. FAO Fisheries Report 618, FAO, Rome. 54 p.

COREP (2012) Economie et pêche au Congo. Commission Régionale des Pêches du Golfe de Guinee (COREP), Liberville, Gabon. 4 p.

Crosnier A and Tanter J-J (1968) La pêche des crevettiers espagnols au large du Congo et de l'Angola. Pêche Marit: 539-541.

Dhont Y (1963) La pêche a Pointe-Noire et ses possibilités de developpement. ORSTOM, Brazzaville, Congo. 168 p.

Fa JE, Currie D and Meeuwig J (2003) Bushmeat and food security in the Congo Basin: linkages between wildlife and people's future. Environmental Conservation 30(01): 71-78.

FAO (2000) conversion factors. Landed weight to live weight. FAO Fisheries Circular 847, FAO, Rome. 192 p.

Fontana A (1980) Milieu marin et ressources halieutiques de la République Populaire du Congo. ORSTOM, Paris. 332 p.

Gobert B (1985) Quelques aspects socio-economiques de la pêcherie artisanale beninoise de Pointe-noire (Congo). Rev. Trav. Inst. Pêches marit. 47(3 and 4): 251-260.

Gobert B (1986) La pêche artisanale maritime au Congo. Socio-economie de la production artisanale. 66, ORSTOM, Pointe-Noire, Congo.

Horemans B and Kebe M (2006) Enhancing the economic contribution of fisheries to West and Central African nations. IFFET 2006 Portsmouth Proceedings, Sustainable Fisheries Livelihoods Programme, FAO, Rome. 9 p.

InfoPeche (2008) Rapport de l'étude de faisabilité du Congo (2007). INFOPECHE, Abidjan. 16 p.

Jul-Larsen E (1994a) Migrant fishermen in Congo: Tradition and modernity. Chr. Michelsen Institute, Bergen. 70 p.

Jul-Larsen E (1994b) Migrant fishermen in Pointe-Noire (Congo): Continuity and continuous change. Programme for the Integrated Development of Artisanal Fisheries in West Africa, IDAF/WP/56, Cotonou.

Kébé M and Njock J-C (1995) Revue sectorielle de la pêche artisanale maritime du Congo.70, DIPA, Cotonou. 55 p.

Kibelolo S (2003) Congo-Brazzaville : Les pêcheurs chinois chassent les Béninois. Syfia International 2013(1612): 1-2.

Koumba P (2012) Investissements dans le secteur de la pêche et l'aquaculture en République du Congo et perspectives du secteur dans le cadre des réformes envisagées pour la restructuration de l'économie nationale à partir de 2011. ACP Fish II, European Union, Brussels. 30 p.

Lagoin Y and Salmon G (1970) Etude Technique et Economique comparée de la distribution du poisson de mer dans le pays de l'Afrique Centrale Atlantique. Secretériat d'état aux affaires étrangères chargé de la coopération. 500 p.

Le Gall P (1975) Etude economique de la pêche maritime et de la commercialisation du poisson en Republique populaire du Congo. 40, ORSTOM, Pointe-Noire, Congo. 70 p.

Maloueki L (1999) Données d'échantillonnages des captures de la pêche artisanales maritime au Congo. Longueur des principales espèces. Variation saisonnieres et interannuelles pour divers engins de capture de 1981 à 1995.81, IRD, Pointe-Noire, Congo. 63 p.

Maloueki L (2005) Modèle pour la soumission d'informations scientifiques pour l'identification des aires marines d'importance biologique ou écologique. IRD, Pointe-Noire, Congo. 24 p.

Mandilou D (2010) Services de base et dynamique sociale au Congo : regards croisés. L'Harmattan, Paris.

MRAG (2005) Review of impacts of Illegal, Unreported and Unregulated fishing on developing countries. Final report, MRAG, London. 176 p.

Nguinguiri V (1991) Fishermen migrations in the Congo. The so-called «popo» fishermen. pp. 283-296 In Haakonson J and Diaw C (eds.), Fishermen's migrations in West Africa 36. IDAF, Cotonou.

Nguinguiri V and Katz E (1996) Perception de l'impact de l'homme sur les ressources naturelles chez les vili du Congo. pp. 143-154 In Baudot P, Bley D, Brun B, Pagezy H and Vernazza-Licht N (eds.), Impact de l'homme su les milieux naturels, Perceptions et mesures. Editions de Bergier, Chateauneuf de Grasse.

Poinsard F (1969) La pêche au chalut à Pointe-Noire. pp. 381-390 In UNESCO (ed.), L'océanographie et les ressources halieutiques de l'Atlantique tropical. UNESCO, Paris.

Tati G (2005) Entrepreneurial African female migrants at the informal-formal interface of the urban economy: Are gender asymmetries modified by entrepreneurship?, University of Western Cape, Bellville, South Africa. 16 p.

The World Bank (1997) Congo, poverty assessment. The World Bank. 58 p.

Transparency International (2010) Indice de perception de la corruption 2010. Transparency International, Berlin. 12 p.

Tvedten I (1990) The difficult transition from subsistence to commercial fishing. The case of the Bijagos of Guinea-Bissau. MAST 3(1): 119-130.

Vennetier P (1968) Pointe-Noire et la facade maritime du Congo-Brazaville. ORSTOM, Pointe-Noire, Congo. 485 p.

Watson RA and Morato T (2013) Fishing down the deep: Accounting for within-species changes in depth of fishing. Fisheries Research 140: 63-65.

WCS (2011) Best of the wild: wildlife conservation society and the Congo basin coast. Wildlife Conservation Society, Bronx, New York. 18 p.

Yengo P (2006) La guerre civile du Congo-Brazzaville, 1993-2002:» chacun aura sa part». Karthala Editions.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	5,000	7,110	2,340	3,820	907	42
1951	5,000	7,290	2,310	4,020	916	42
1952	5,000	10,960	5,720	4,210	928	103
1953	5,500	12,250	6,790	4,400	940	122
1954	5,500	13,520	7,830	4,600	953	141
1955	6,000	14,760	8,850	4,790	967	159
1956	6,000	17,920	9,840	6,920	982	177
1957	7,000	21,050	10,800	9,050	998	194
1958	7,000	24,350	11,740	11,190	1,216	211
1959	7,500	22,240	7,130	13,140	1,444	521
1960	7,500	26,680	8,890	15,090	1,756	938
1961	7,500	31,980	10,620	17,990	2,024	1,346
1962	8,600	36,030	11,290	20,710	2,305	1,727
1963	8,500	41,030	12,950	23,530	2,432	2,118
1964	9,600	53,720	14,950	33,700	2,565	2,500
1965	9,500	64,270	15,420	43,290	2,705	2,856
1966	9,700	74,190	15,830	52,300	2,851	3,204
1967	9,100	35,500	16,010	12,940	3,003	3,543
1968	9,100	41,140	19,760	13,180	3,054	5,149
1969	8,900	43,590	20,540	13,380	3,106	6,570
1970	9,401	48,000	23,250	13,540	3,161	8,047
1971	10,013	57,570	26,350	18,420	3,219	9,575
1972	17,527	69,510	32,150	22,940	3,279	11,151
1973	15,204	78,230	35,030	27,090	3,340	12,772
1974	15,719	85,600	36,900	30,870	3,401	14,437
1975	15,104	91,950	38,390	34,280	3,460	15,816
1976	17,870	97,830	37,580	37,330	3,519	19,407
1977	15,365	99,300	36,960	35,900	3,577	22,860
1978	16,297	85,850	36,260	19,920	3,634	26,036
1979	19,630	93,090	38,060	22,550	3,692	28,783
1980	20,966	95,700	36,140	24,890	3,751	30,921
1981	17,665	92,440	31,960	26,920	3,812	29,743
1982	18,836	87,210	27,500	28,660	3,874	27,174
1983	21,708	82,400	23,550	31,490	3,936	23,416
1984	19,308	71,030	19,650	28,640	3,997	18,750
1985	16,340	59,520	15,950	25,940	4,056	13,575
1986	17,993	48,560	12,650	23,400	4,114	8,397
1987	22,469	53,040	12,040	30,600	4,169	6,227
1988	22,378	44,210	9,210	26,950	4,224	3,825
1989	21,708	38,680	7,480	25,610	4,277	1,304
1990	21,954	36,520	6,710	23,890	4,328	1,598
1991	18,371	30,860	6,230	18,370	4,442	1,815
1992	18,944	29,500	5,730	17,290	4,556	1,933
1993	18,899	28,400	5,750	16,200	4,671	1,777
1994	17,913	28,700	5,870	16,230	4,790	1,815
1995	18,965	29,260	5,970	16,530	4,912	1,847
1996	19,600	29,790	6,080	16,800	5,040	1,871
1997	19,095	30,290	6,180	17,050	5,173	1,890
1998	17,500	30,760	6,270	17,280	5,307	1,902
1999	18,241	31,180	6,350	17,480	5,438	1,907
2000	20,520	31,570	6,430	17,660	5,564	1,907
2001	22,729	32,900	7,230	17,940	5,506	2,228
2002	22,433	38,830	7,410	23,870	5,440	2,109
2003	22,683	34,570	6,750	20,610	5,370	1,841
2004	26,686	37,950	9,320	22,250	5,304	1,080
2005	22,116	42,120	7,960	28,370	5,243	553
2006	28,082	38,040	4,280	27,560	5,275	929
2007	29,096	38,840	4,270	28,390	5,313	868
2008	24,742	42,960	4,430	32,360	5,350	817
2009	32,833	41,060	6,040	28,120	5,380	1,516
2010	34,686	44,960	10,870	27,620	5,401	1,068

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxonomic group for the Republic of Congo, 1950-2010. "Others" contain 57 additional taxonomic categories.

Year	*Sardinella* spp.	*Nematocarcinus africanus*	Crustacean	*Pseudotolithus* spp.	Others
1950	4,910	0	1	1,060	1,140
1951	5,080	0	1	1,070	1,140
1952	5,700	0	4	2,150	3,110
1953	6,080	0	5	2,470	3,690
1954	6,330	0	6	2,840	4,350
1955	6,610	0	6	3,240	4,900
1956	8,520	0	7	3,660	5,730
1957	10,760	0	8	3,960	6,320
1958	12,930	0	9	4,330	7,080
1959	14,640	381	588	2,640	3,990
1960	17,010	755	1,161	2,990	4,760
1961	20,230	1,121	1,722	3,350	5,550
1962	23,240	1,480	2,270	3,420	5,630
1963	26,240	1,830	2,808	3,760	6,390
1964	36,560	2,173	3,334	4,270	7,380
1965	44,320	2,509	3,848	4,570	9,030
1966	53,120	2,836	4,350	4,610	9,270
1967	15,650	3,156	4,839	4,420	7,440
1968	17,310	4,658	7,137	4,440	7,590
1969	16,550	5,987	9,172	4,530	7,360
1970	15,120	7,368	11,287	5,800	8,420
1971	21,530	8,797	13,476	5,140	8,630
1972	28,380	10,272	15,733	6,140	8,990
1973	34,790	11,791	18,054	4,960	8,640
1974	38,040	13,349	20,443	4,700	9,070
1975	40,490	14,641	22,420	5,050	9,350
1976	42,600	18,003	23,072	4,880	9,270
1977	40,730	21,236	23,459	4,790	9,080
1978	21,900	24,210	23,552	6,050	10,130
1979	28,280	26,782	23,318	5,160	9,560
1980	26,680	28,800	22,735	6,060	11,430
1981	31,260	27,719	20,077	5,140	8,230
1982	34,410	25,337	16,933	3,630	6,900
1983	35,560	21,828	13,573	3,580	7,850
1984	33,760	17,470	10,183	3,360	6,250
1985	30,890	12,635	6,958	2,220	6,820
1986	27,940	7,797	4,098	1,980	6,740
1987	34,700	5,774	2,908	2,420	7,240
1988	29,610	3,534	1,676	2,690	6,690
1989	24,970	1,181	577	3,380	8,560
1990	22,200	1,466	718	3,340	8,790
1991	18,500	1,674	1,034	2,600	7,060
1992	16,830	1,789	1,064	2,570	7,250
1993	15,360	1,637	980	2,640	7,780
1994	18,760	1,668	672	1,230	6,370
1995	19,500	1,692	999	1,000	6,070
1996	19,340	1,710	1,288	1,000	6,460
1997	19,600	1,722	1,048	1,060	6,860
1998	20,070	1,728	1,176	1,150	6,630
1999	20,130	1,728	1,155	1,170	7,000
2000	19,790	1,722	1,333	1,180	7,540
2001	17,980	2,008	1,572	2,080	9,260
2002	21,490	1,912	1,733	3,130	10,560
2003	15,240	1,653	1,820	4,400	11,460
2004	21,200	941	1,327	3,430	11,050
2005	24,000	446	1,181	4,340	12,160
2006	18,270	843	2,089	3,460	13,380
2007	17,130	795	1,490	3,140	16,280
2008	28,370	747	1,769	2,670	9,400
2009	19,700	1,401	2,269	3,470	14,220
2010	18,050	982	2,630	4,170	19,130

An attempt at reconstructing the marine fisheries catches in the Congo (ex-Zaïre), 1950 to 2010[1]

Dyhia Belhabib, Sulan Ramdeen and Daniel Pauly

Sea Around Us, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.belhabib@fisheries.ubc.ca; s.ramdeen@fisheries.ubc.ca; d.pauly@fisheries.ubc.ca

Abstract

The catches of the marine fisheries of the Democratic Republic of the Congo 'DRC', formerly known as Zaïre (here: 'Congo (ex-Zaïre)', were estimated, in spite of low availability of quantitative data and pertinent literature. Reconstructed total catches were estimated to be at least twice as much as the data supplied to FAO on behalf of the Congo (ex-Zaïre), with around 764,000 tonnes between 1950 and 2010 compared to 338,000 tonnes reported to the FAO on behalf of the Congo (ex-Zaïre), of which about 70% were taken by the small-scale fisheries. The reconstructed catches illustrate the fact that while political turmoil caused the nascent industrial fisheries to fold, wars and other conflicts contributed to increasing the contribution of small-scale fisheries to total fisheries removals, thus demonstrating the resilience of small-scale fisheries and their crucial role in contributing to the food security of coastal communities.

Introduction

The Democratic Republic of The Congo (here alternatively referred to as 'DRC' and 'Congo (ex-Zaïre)' is located in West central Africa, bordered by nine countries: the Republic of the Congo, the Central African Republic, Southern Sudan, Uganda, Rwanda, Burundi, Tanzania, Zambia and Angola, with Lake Tanganyika, the second largest freshwater lake in the world, forming its eastern border. Although Congo (ex-Zaïre) is one of the largest countries of Africa, its coastline is extremely narrow, with a straight-line extent of 40 km from North to South.

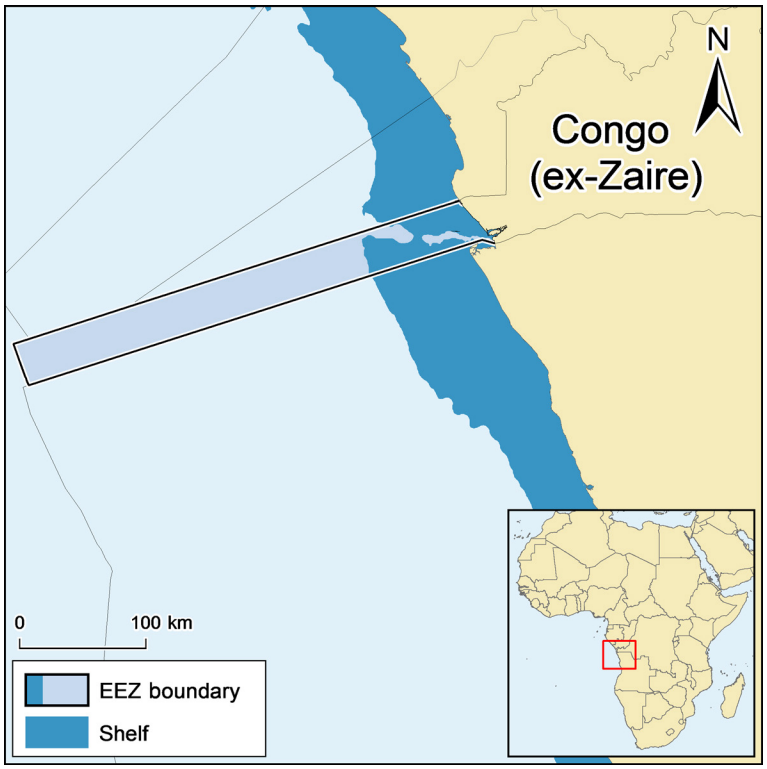

Figure 1. Map of Congo (ex-Zaïre) and its Exclusive Economic Zone (EEZ).

Historically, the Congo (ex-Zaïre) suffered from a succession of political disasters; repression, corruption, and violence are words that occur commonly when retracing the history of the country. Much of this sad story is yet another case of the 'curse' affecting countries rich in natural resources, in this case minerals such as diamonds and rare earths, as required in computer manufacturing. Since independence (in 1960), the country changed its name four times, suffered two major wars and a multitude of lesser, but still violent conflicts[2]. As a result, nearly 2 million people were displaced; over 5 million people alone died due to the prolonged conflict between 1998 and 2007, described as the deadliest conflict after World War II, and one that involved thousands of child soldiers (Weijs *et al.* 2012). The "debrouillez-vous" (approx. "you-are-on-your-own") policy declared by president Mobutu in response to his government's inability to pay public salaries, and who redirected public funds to pay off his cronies during his long tenure (1960 to 1997), led to a tremendous growth of the informal economy.

The decline of the formal economy and increase of poverty coincided with the "Zaïrianization" of the country in the 1970s, where many industries collapsed. In spite of a recent slight improvement, around 71% of the population still lives under the poverty threshold of 1 US$ per day, which is far behind the level of 1960 when the country gained independence from Belgium (Weijs *et al.* 2012). The country today ranks 168 over 169 in the human development index (UNDP 2010). Most of the economy, being informal, is undocumented, and this applies to fishing as well

[1] Cite as: Belhabib, D., Ramdeen, S. and Pauly, D. (2015) An attempt at reconstructing the marine fisheries catches in the Congo (Ex-Zaïre), 1950-2010. pp. 107-114. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

[2] http://www.ucdp.uu.se/gpdatabase/gpcountry.php?id=38&regionSelect=2-Southern_Africa [Accessed on 22/10/2013].

(Muzigwa Kashema 2006), although fishing ranks second in household activities, right after agriculture (Weijs *et al.* 2012). Weijs *et al.* (2012) write on this: "With regards to data availability and quality: this investigation finds a strong bias towards humanitarian issues and eastern DRC, a lack of studies that aim to bring underlying structures and dynamics into the picture, as well as a lack of focus on local needs. Additionally, there is little centralised data collection and exchange of findings, critical appraisal of available data, and a lack of methodologically sound, robust scholarly research. Local research capacity is lacking, there is a gap between research and policy… The reliability of official figures is questionable, but there are few alternatives."

The present reconstruction is proposed as a complement to official data, which fail to document the contribution of coastal fisheries, often overlooked, to food security in the DRC. This is viewed as particularly important as Congo (ex-Zaïre) remains "chronically" food insecure (OCHA 2011).

Methods

Often the few literature sources describing the fisheries Congo (ex-Zaïre) refer to the two main sectors, industrial and artisanal fisheries. However, subsistence fishing is mentioned by numerous sources, notably when describing the livelihood strategies of coastal communities and/or bushmeat surveys (Lagoin and Salmon 1970; de Merode *et al.* 2004; Weijs *et al.* 2012). Due to the narrowness of the DRC's coastline, and thus its small Exclusive Economic Zone (EEZ), foreign fishing fleets are relatively small. However, their presence cannot be overlooked, as the impact of foreign fishing in the EEZ of other West African countries – even small ones, such as The Gambia – is extremely important.

Farming and related activities constitute the main livelihood activities for 97% of the population in the Bas Congo, a province bordered by the Congo River and the Atlantic coast, of these farming and related activities 20% is fishing (Weijs *et al.* 2012).. Although there is a large overlap between artisanal and subsistence fisheries in the DRC, we rely on the nature of the craft to identify 'artisanal' fishing, whose main purpose is to catch fish for sale, as opposed to subsistence fishing, whose main purpose is household consumption. Thus here, fisheries involving canoes are considered artisanal, while all land-based fishing is considered subsistence fishing.

Artisanal catches

The marine artisanal fisheries of the Congo (ex-Zaïre) are not well monitored and reported upon in official statistics (Weijs *et al.* 2012), and thus, their catches are here estimated indirectly. The artisanal catch per unit of effort was estimated by dividing an observed localized catch of 150 tonnes (Lagoin and Salmon 1970) by the number of units involved, i.e., 20 canoes, i.e., 7.5 t·canoe^{-1} for 1967. We assumed this CPUE was constant between 1950 and 1967, and 10% lower in 2010 compared to the 1967 CPUE given the high fishing pressure by the many small-scale boats operating in the small EEZ of the DRC. We interpolated linearly CPUE estimates to complete the time series. Effort estimates were available for 1967 (588 canoes, Lagoin and Salmon 1970), 1994 (800 canoes, Horemans 1996) and an estimated 3,230 fishers along the Atlantic coast, which translates into 1,615 canoes (assuming two fishers per canoe) for 2008, of which only 5% are motorized (Mavinga Ngembo 2008). We assumed the effort was 10% lower in 1950 relative to 1967, given a lower number of canoes (Lagoin and Salmon 1970), and that the effort was constant from 2008 to 2010. We interpolated linearly effort estimates and then multiplied the annual CPUE by the annual effort estimates to obtain total artisanal catches. A taxonomic breakdown was obtained by allocating a third of catches to the first five categories described in the FAO profile[3] of the country, a third to the six following categories, and the final third to the remaining seven categories (Table 1).

Table 1. Assumed taxonomic composition of the artisanal and subsistence marine fisheries of the Congo (ex-Zaïre)

Scientific name	Common name	%
Pseudotolithus spp.	Croakers	6.6
Cynoglossus spp.	Tonguesoles	6.6
Dentex spp.	Seabreams	6.6
Pomadasys spp.	Grunts	6.6
Galeoides decadactylus	Lesser African threadfin	6.6
Pentanemus quinquarius	Royal threadfin	5.5
Epinephelus spp.	Groupers	5.5
Lutjanus spp.	Snappers	5.5
Brachydeuterus auritus	Bigeye grunt	5.5
Arius spp.	Sea catfishes	5.5
Sardinella spp.	Sardinellas	5.5
Ethmalosa fimbriata	Bonga shad	4.7
Trachurus treacae	Cunene horse mackerel	4.7
Sphyraena spp.	Barracudas	4.7
Carcharhinus spp.	Requiem sharks	4.7
Raja miraletus	Brown ray	4.7
Farfantepenaeus notialis	Southern pink shrimp	4.7
Parapenaeopsis atlantica	Guinea shrimp	4.7

Subsistence catches

Marine subsistence catches were surveyed in 1967 in a coastal community of the Congo (ex-Zaïre) and estimated at 100 t compared to an artisanal catch of 150 t within the same community (Lagoin and Salmon 1970), i.e., subsistence catches were equivalent of 66.7% of artisanal catches. We assumed this ratio was constant between 1950 and 1967 and multiplied it by the reconstructed artisanal catch during the same time period (2,934 t for 1967). We assumed that subsistence catches increased due to high insecurity in the eastern areas and migrations of people towards the coast, by 10% between 1967 and 1996 (first Congo war), i.e., 3,217 t for 1996 and by 20% between then and 2003 at the end of the second Congo war, i.e., 3,860 t for 2003.

[3] www.fao.org/fi/oldsite/FCP/fr/COG/profile.html [Accessed on 22/10/2013].

De Merode *et al.* (2004) surveyed sources of wild food within poor households of the Congo (ex-Zaïre) by asking the household member who prepared the food, and found that fish played a major role in household incomes, and less so as other food items. De Merode *et al.* (2004) estimated each household caught in total around 522 g·household^{-1}·day^{-1} and 191 kg·household^{-1}·year^{-1}. These numbers were obtained by dividing the daily value of the fish caught by each household (0.035 $·household^{-1}·day^{-1} worth of fish, part of which is kept for personal consumption and the other part sold to obtain other food staples) by the unit price given by the authors ($0.067 US/kg). Considering a household size of 5 people[4], the subsistence per capita catch is herein estimated at 38.1 kg·capita^{-1}·year^{-1} for poor households. To assess the poor urban and rural populations living in coastal areas in the 2000s, we first extracted coastal population estimates from CIESIN (2012) for 2010 (17,072 rural and 51,272 urban). We multiplied these estimates by 72% and 59%, the percentages of poor population to the total population in rural and urban areas respectively[5]. The resulting total poor population is then multiplied by the per capita catch of 38.1 kg·capita^{-1}·year^{-1} estimated above, which was assumed constant for the 2000s, and obtained a catch of 1,539 t for 2010. We then interpolated linearly to fill in the gaps for the intervening years (between 1967, 1996, 2003 and 2010). Given the overlap between artisanal and subsistence fisheries, we assumed the same species breakdown for artisanal and subsistence catches (Table 1).

Industrial catches

Industrial catches were assessed by Lagoin and Salmon (1970) between 1950 and 1968, and were estimated at 15,000 t for 1970 by Bongu (2006). Because of the narrowness of the DRC coastline, industrial vessels venture to the adjacent waters of the Republic of the Congo and Angola (Lagoin and Salmon 1970) prior to the Zaïrianization between 1976 and 1990, then to Angola, Namibia and Gabon (Muzigwa Kashema 2006; Anon. 2010). Thus, given the general over-exploitation pattern, notably due to the presence of foreign industrial fleets (Sumaila and Vasconcellos 2000; USAID 2006), various internal conflicts and an attempt to nationalize the industrial fisheries (Mavinga Ngembo 2008), industrial fisheries collapsed by the mid-1990s (Bongu 2006) and their catches were assumed to be zero since then. We interpolated linearly to complete the time series. Between 1950 and 1967, we allocated the catch equally to Angola (50%) and the Republic of the Congo and DRC (25% each), and between 1990 to 1996, to Angola, Namibia and Gabon. Reconstructed industrial catches were then compared to the catch data reported to FAO as caught by the Congo (ex-Zaïre) in the Southeast Atlantic. Reconstructed industrial catches were compared to the DRC's catch data reported by FAO in area 47 (Southeastern Atlantic), these being overall similar, however with slight differences, the highest catch per year was taken into consideration in the reconstruction, for example, if the catch data for a certain year in the FAO dataset for area 47 is higher than the reconstructed industrial catch for the same year, then the reconstructed industrial catch is replaced by the reported catch.

Around 6,000 t of fish were caught by foreign fleets operating in the DRC's EEZ in 2002 (Anon. 2008); assuming that these fleets started operating at the end of the Zaïrianization, we interpolated linearly between 0 in 1990 to 6,000 t in 2002. We then assumed a decline of 10% to reflect the over-exploitation that prevails in the area. Given the presence of a Chinese fishing group in Boma (Mavinga Ngembo 2008), we assumed that these foreign vessels were primarily of Chinese origin (see also Pauly *et al.* 2013).

To disaggregate industrial catches we relied on the species disaggregation by Lagoin and Salmon (1970) in which 10 taxa were allocated different percentages as a function of their contribution to catches (Table 2).

Table 2. Species breakdown for the industrial catches the Congo (ex-Zaïre)

Scientific name	Common name	%
Otolithes spp.	Croakers	12.5
Cynoglossus spp.	Tonguesoles	12.5
Arius spp.	Sea catfishes	10.0
Polynemus spp.	Paradise threadfins	10.0
Pomadasys spp.	Grunts	10.0
Lutjanus spp.	Snappers	10.0
Sparidae spp.	Seabreams	10.0
Sardinella spp.	Sardinellas	8.3
Ethamalosa spp.	Bonga shad	8.3
Miscellaneous marine fishes	N.A.	8.3

Foreign, illegal, unreported and unregulated (IUU) catches

MRAG (2005) estimated that for each landed tonne of fish, the equivalent of 1.23 tonnes were IUUs taken from the EEZ of the Congo (ex-Zaïre). Over 36 cases of IUU fishing, 5 (13.9%) were cases of illegal fishing, i.e. fishing without authorization (MRAG 2005). Therefore, we estimated illegal catches by multiplying the total reconstructed legal artisanal catch given that industrial fishing is conducted elsewhere, by 1.23 and then by 13.9% to account only for illegal foreign vessels. Catches under this segment are considered unregulated since the DRC did not declare an EEZ officially yet. Similarly, given the documented presence of China in the region (Pauly *et al.* 2013), notably in the neighbouring Congo, these catches are allocated to Chinese vessels.

Discards

Documents assessing discards in the waters of the Congo (ex-Zaïre) were not available. Therefore, to estimate domestic discards we assumed a similar profile with the domestic fleets of Gabon, where these fleets operated more recently, i.e., between 0.11% and 3.5% (averaged at 1.8%; Ekouala 2013). We applied the previous rate to the reconstructed industrial catch taken by the Congo (ex-Zaïre). For foreign (Chinese) industrial discards, we applied a discard rate of 40% of total catches, i.e., 66% of landed catches (Weber and Durand 1986), which we applied to the reconstructed foreign catch.

[4] http://www.cleancookstoves.org/countries/africa/democratic-republic-congo.html [Accessed on 23/10/2013].
[5] http://www.ruralpovertyportal.org/country/home/tags/dr_congo [Accessed on 23/10/2013].

Results

Small-scale fisheries

Artisanal fisheries were estimated at 353,000 tonnes between 1950 and 2010. Artisanal fisheries increased from around 4,000 t in 1950 to around 5,600 t in 1994 before the beginning of the first Congo war, and then increased rapidly to around 11,000 t·year^{-1} in the late 2000s (Figure 2).

Subsistence catches increased slowly from around 2,600 t in 1950 to 3,200 t in 1996 at the beginning of the first Congo war (Figure 2). Subsistence catches increased then to a peak of 3,900 t in 2003 during the second Congo war, to decrease thereafter to around 1,500 t·year^{-1}, i.e., following a trend that is the opposite of that observed for artisanal fisheries (Figure 2).

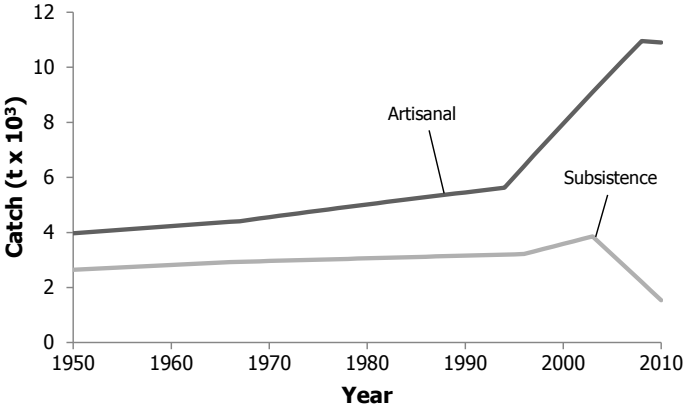

Figure 2. Reconstructed small-scale catches in the EEZ of the Congo (ex-Zaïre), 1950-2010.

Industrial catches

The total catches of the DRC's industrial vessels were estimated at 224,400 tonnes between 1950 and 2010; they increased from around 800 t in 1950 to a peak of 15,000 t in 1970, and then declined drastically at the start of 'Zaïrianization' to completely collapse in 1996 at the start of the first Congo war (Figure 3). These industrial reconstructed catches that are landed in the Congo (ex-Zaïre) were mostly taken from Angola with 97%, compared to 1.4% taken from the Republic of the Congo and less than 0.3% for Namibia and Gabon and only 1.4% were taken from the EEZ of the Congo (ex-Zaïre). The fraction of the catch taken from the waters of Gabon and Namibia increased in the recent years to be over two thirds (Figure 3), while catches taken from the Republic of the Congo peaked 450 t in 1977 right before they collapsed (0 t in 1990). Industrial catches taken from the EEZ of the Congo (ex-Zaïre) totalled 3,200 t·year^{-1}, with a peak of 459 t in 1977.

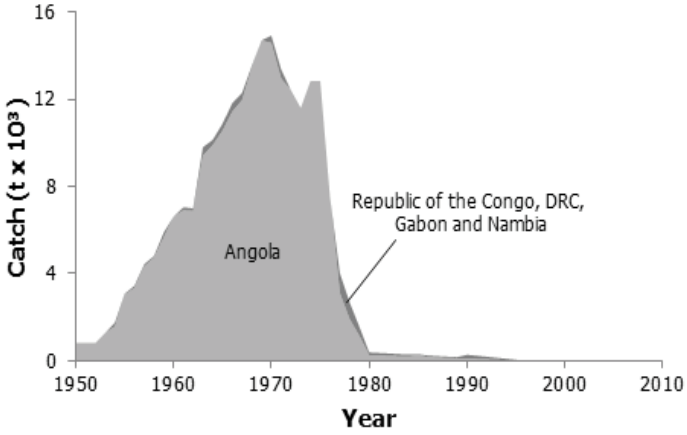

Figure 3. Reconstructed industrial catches by vessels from the Congo (ex-Zaïre), showing the EEZs from which these catches were taken, 1950-2010.

Chinese foreign catches (legal) from the EEZ of the Congo (ex-Zaïre) increased from 500 t in 1991 when they began, to a peak of 6,000 t in 2002, then declining to less than 5,500 t in 2010 (Figure 4). On the other hand, illegal catches increased from around 100 t in 1950 to 1,800 t·year^{-1} on average in the late 2000s (ie. 2008-2010) (Figure 4), which appears to be compensating for the declining legal catch.

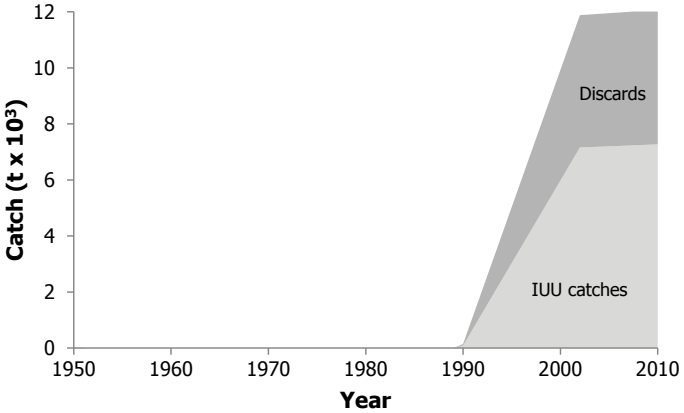

Figure 4. Reconstructed foreign industrial catches and discards by China within the EEZ of the Democratic Republic of the Congo, 1950-2010. Note: no foreign catches from 1950-1989.

Discards

Discards within the waters of the Congo (ex-Zaïre) were estimated at over 69,200 tonnes over the period between 1950 and 2010, of which around 99.9% were discarded by the Chinese fleets operating in the Congo (ex-Zaïre) and approximately 0.08% by the domestic industrial fleets. Foreign discards increased overall, following the same pattern than foreign industrial catches from around 60 t in 1990, when China began fishing in the Congo (ex-Zaïre) to around 4,800 t·year^{-1} on average in the late 2000s (Figure 4). Domestic discards from all EEZs were estimated at around 4,000 tonnes between 1950 and 2010, increasing from low levels in the 1950s to a peak of over 260 t in 1970 (Figure 5), and then decreased with the decrease of industrial fishing.

Total catches

Total (domestic) catches landed in the Congo (ex-Zaïre) were estimated at 764,000 tonnes between 1950 and 2010 compared to 338,000 tonnes of catch data supplied to the FAO on behalf of that country. Around 30% of the reconstructed total catch were industrial, and were all taken from outside the waters of DRC between the mid-1950s and the late 1970s, with around 231,000 tonnes during this time period (Figure 5), and corresponded to around 20,000 tonnes of discarded catch.

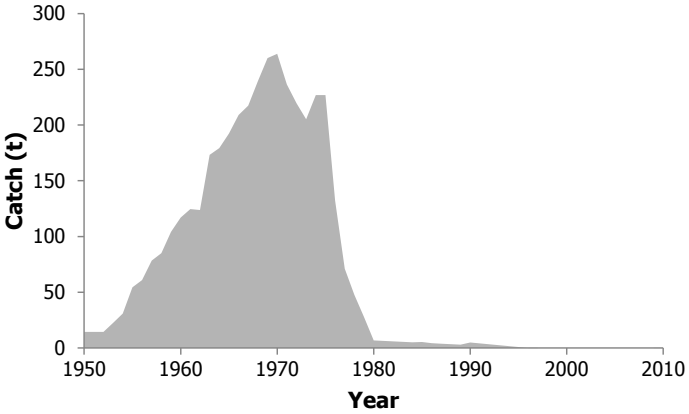

Figure 5. Reconstructed by the Congo (ex-Zaïre) from the EEZs of Namibia, Angola, Gabon and the Republic of the Congo, 1950-2010.

Domestic catches from the DRC's EEZ, including small-scale catches (artisanal and subsistence) were estimated at over 535,000 tonnes between 1950 and 2010 compared to around 134,000 tonnes of catch data supplied to the FAO (after filtering out catch data from outside the EEZ, i.e., industrial catches taken by the DRC). Domestic catches, small-scale in nature, increased overall between 6,600 t in 1950 to a peak of 13,200 t in 2008, and decreased slightly thereafter to 12,400 t in 2010. The bulk of increase is observed in the mid-1990s at the beginning of the first Congo war. Total removals from the EEZ of the Congo (ex-Zaïre) were estimated 712,700 tonnes between 1950 and 2010, including 76% domestically caught and 24% of foreign catches (by China), of which 20% were illegal (Figure 6).

Discussion

Total catches taken by the Congo (ex-Zaïre) were estimated at 766,000 tonnes between 1950 and 2010, twice as much as the catch data supplied to the FAO on behalf of the DRC. Only the small-scale portion of these, i.e., 70% were taken from the DRC's small EEZ. While total catches taken by DRC (including from outside the EEZ) declined dramatically when the 'Zaïrianization' of the economy was implemented, while small-scale catches increased during the war period. This can be explained by the fact that the conflict was moving westwards towards Kinshasa, the capital city, which may have pushed people to (*i*) increase their informal resource-seeking activities, including fishing (Weijs *et al.* 2012), and (*ii*) find in fisheries (along with agriculture) the only alternative to deal with poverty induced by the government's failure to create conditions that would have allowed the economy to develop.

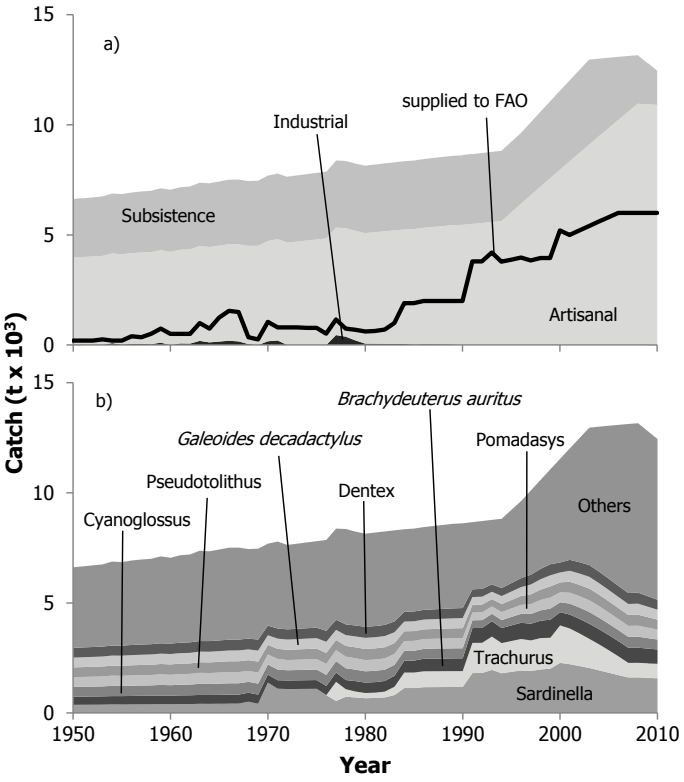

Figure 6. Reconstructed total catches for the Congo (ex-Zaïre) within its EEZ by a) sector (data supplied to FAO shown as solid line; discards plotted but not visible on graph), and b) taxonomic categories, with 'Others' containing 20 additional taxonomic categories, 1950-2010.

The governments of Angola and Namibia helped the DRC considerably, notably with troops, in taking back the Eastern part of the country from rebels, which provided a basis for mutually beneficial fisheries agreements which considerably helped coastal communities of the Congo (ex-Zaïre) through local fish landing and processing.

These agreements, however, could not prevent the collapse of the DRC's industrial fisheries, a direct result of their nationalization. Thus, after first the 'Zaïrianization' of the country and the nationalization of fisheries, and then the "you-are-on-your-own" policy, industrial fisheries declines drastically then stagnated at very low levels. With the political instability that had led the country to the first Congo war (1996), industrial fisheries collapsed completely and people thereafter were highly reticent to invest (Mavinga Ngembo 2008). It appears that only foreign fishing fleets, i.e., the Chinese fleet, operates within the small EEZ of the DRC (Pauly *et al.* (2013). On the other hand, before their complete collapse in 1996, the shift in fishing grounds by the industrial fleet, i.e., going further north (to Gabon) and south (to Namibia) shows that political conflicts and over-exploitation drives fleets to venture further in search for

fish, perhaps a last desperate move, before their complete collapse. Marine fisheries, as illustrated by official data seemed to have completely collapsed after the 'Zaïrianization' of the country, but this is only visible because the industrial fisheries were properly monitored. The industrial fisheries thus collapsed due to the absence of a state, rather than the war itself.

On the other hand, the Congo (ex-Zaïre) provides an interesting example of the resilience of small scale fisheries. With the war affecting mainly the central part of the country, it increased migrations towards the coast and toward Lake Tanganyika in the extreme east, whose catches increased during the war.

Moreover, while the contribution of marine fisheries to the total fishery product in DRC is considered insignificant, at only 2% (Muzigwa Kashema 2006), reconstructed catches landed represented almost a tenth of the total fishery yield (i.e., freshwater and marine catches), which shows that the unmonitored and overlooked marine fisheries the Congo (ex-Zaïre) are a significant source of food and income for local coastal communities.

Acknowledgements

This is a contribution of the *Sea Around Us*, a scientific collaboration between the University of British Columbia and the Pew Charitable Trusts.

References

Anon. (2008) Profils des pays: République Démocratique du Congo. StopIllegalFishing, London. 2 p.

Anon. (2010) Programme National de Sécurité Alimentaire (P.N.S.A). Ministère de l'Agriculture, Kinshasa. 86 p.

Bongu MM (2006) Tendance de la production halieutique et indicateurs biologiques, ecologiques et environementaux de la pêche marine en République Démocratique du Congo. CBD, Kinshasa. 68 p.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). NASA Socioeconomic Data and Applications Center (SEDAC), Palisades, NY. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3 [Accessed: 29/10/2012].

de Merode E, Homewood K and Cowlishaw G (2004) The value of bushmeat and other wild foods to rural households living in extreme poverty in Democratic Republic of Congo. Biological Conservation 118(5): 573-581.

Ekouala L (2013) Le développement durable et le secteur des pêches et de l'aquaculture au Gabon : une étude de la gestion durable des ressources halieutiques et de leur écosystème dans les provinces de l'Estuaire et de l'Ogooué Maritime. University of Université du Littoral Côte d'Opale, Libreville. 403 p.

Horemans B (1996) The state if artisanal fisheries in West Africa in 1995. Technical Report 84, Programme for Integrated Development of Artisanal Fisheries in West Africa, Cotonou. 52 p.

Lagoin Y and Salmon G (1970) Etude Technique et Economique comparée de la distribution du poisson de mer dans le pays de L'Afrique Centrale Atlantique. Secretériat d'état aux affaires étrangères chargé de la coopération. 500 p.

Mavinga Ngembo J (2008) Rapport d'enquête sur l'impact des importations des poissons sur la pêche artisanale au bas-fleuve Centre Régional d'Appui et de Formation pour le Développement, Kinshasa.

MRAG (2005) Review of impacts of Illegal, Unreported and Unregulated fishing on developing countries. Final report, MRAG, London. 176 p.

Muzigwa Kashema J (2006) How the DRC (ex-Zaïre) could become self-sufficient in fish production. Part I and II. Agricultural International Magazine, Leuven. 45 p.

OCHA (2011) Consolidated Appeals Process (CAP): Humanitarian Appeal Mid-Year Review 2011. United Nations Office for the Coordination of Humanitarian Affairs, Geneva. 73 p.

Pauly D, Belhabib D, Blomeyer R, Cheung WWWL, Cisneros-Montemayor AM, Copeland D, Harper S, Lam VWY, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2013) China's distant-water fisheries in the 21st century. Fish and Fisheries: n/a-n/a.

Sumaila UR and Vasconcellos M (2000) Simulation of ecological and economic impacts of distant water fleets on Namibian fisheries. Ecological Economics 32(3): 457-464.

UNDP (2010) Human development report 2010: The real wealth of nations: pathways to human development. United Nations Development Programme, New York. 238 p.

USAID (2006) Conservation of tropical forests and biological diversity. FAA 118-119 Analysis, USAID/Angola, Luanda. 37 p.

Weber J and Durand H (1986) Le secteur des pêches dans les pays d'Afrique. Réunion préparatoire pour l'Afrique en vue de la première consultation sur l'industrie de la pêche. 86, Organisation des Nations Unies pour le dévelopement industriel, Dakar, Sénégal. 135 p.

Weijs B, Hilhorst D and Ferf A (2012) Livelihoods, basic services and social protection in Democratic Republic of the Congo. Researching livelihoods and services affected by conflict, Wageningen University, Wageningen. 93 p.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	200	6,620	0	3,969	2,647	0
1951	200	6,660	0	3,995	2,665	0
1952	200	6,700	0	4,021	2,682	0
1953	250	6,750	0	4,047	2,699	0
1954	200	6,880	86	4,073	2,717	2
1955	200	6,850	20	4,099	2,734	0
1956	400	6,920	47	4,125	2,751	1
1957	350	6,970	51	4,151	2,768	1
1958	500	7,000	38	4,177	2,786	1
1959	750	7,110	106	4,202	2,803	2
1960	500	7,050	0	4,228	2,820	0
1961	500	7,160	70	4,254	2,838	1
1962	500	7,200	63	4,280	2,855	1
1963	1,000	7,370	188	4,306	2,872	3
1964	750	7,340	119	4,332	2,890	2
1965	1,250	7,420	156	4,358	2,907	3
1966	1,550	7,510	194	4,384	2,924	3
1967	1,500	7,510	163	4,410	2,934	3
1968	350	7,440	42	4,458	2,944	1
1969	250	7,460	0	4,507	2,953	0
1970	1,050	7,690	169	4,555	2,963	3
1971	800	7,790	206	4,602	2,973	4
1972	800	7,630	0	4,650	2,983	0
1973	800	7,690	0	4,697	2,992	0
1974	775	7,750	0	4,744	3,002	0
1975	775	7,800	0	4,790	3,012	0
1976	512	7,860	0	4,837	3,022	0
1977	1,155	8,370	451	4,883	3,031	8
1978	741	8,360	379	4,928	3,041	7
1979	693	8,240	208	4,974	3,051	4
1980	615	8,140	63	5,019	3,061	1
1981	640	8,190	59	5,064	3,070	1
1982	700	8,240	55	5,109	3,080	1
1983	1,000	8,290	51	5,153	3,090	1
1984	1,900	8,340	47	5,197	3,100	1
1985	1,900	8,370	23	5,241	3,109	0
1986	2,000	8,440	37	5,285	3,119	1
1987	2,000	8,490	35	5,328	3,129	1
1988	2,000	8,540	31	5,371	3,139	1
1989	2,000	8,590	27	5,414	3,148	0
1990	2,000	8,610	0	5,456	3,158	0
1991	3,800	8,670	0	5,498	3,168	0
1992	3,800	8,720	0	5,540	3,178	0
1993	4,200	8,770	0	5,582	3,187	0
1994	3,780	8,820	0	5,623	3,197	0
1995	3,876	9,220	0	6,017	3,207	0
1996	3,973	9,630	0	6,410	3,217	0
1997	3,844	10,110	0	6,800	3,308	0
1998	3,954	10,590	0	7,188	3,400	0
1999	3,945	11,070	0	7,574	3,492	0
2000	5,200	11,540	0	7,958	3,584	0
2001	5,000	12,020	0	8,340	3,676	0
2002	5,200	12,490	0	8,720	3,768	0
2003	5,400	12,960	0	9,098	3,860	0
2004	5,600	13,000	0	9,474	3,528	0
2005	5,800	13,040	0	9,848	3,197	0
2006	6,000	13,080	0	10,220	2,865	0
2007	6,000	13,120	0	10,590	2,533	0
2008	6,000	13,160	0	10,958	2,202	0
2009	6,000	12,800	0	10,929	1,870	0
2010	6,000	12,440	0	10,901	1,539	0

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxa for Congo (ex-Zaire), 1950-2010. 'Others' contain 20 additional taxonomic categories.

Year	*Sardinella* spp.	*Trachurus* spp.	*Brachydeuterus auritus*	*Cynoglossus* spp.	*Pomadasys* spp.	*Pseudotolithus* spp.	*Galeoides decadactylus*	*Dentex* spp.	Others
1950	371	0	371	443	443	443	443	443	3,660
1951	373	0	373	446	446	446	446	446	3,680
1952	375	0	375	449	449	449	449	449	3,710
1953	378	0	378	452	452	452	452	452	3,730
1954	387	0	380	466	464	455	455	455	3,810
1955	384	0	383	460	460	458	458	458	3,790
1956	389	0	385	467	465	461	461	461	3,840
1957	392	0	387	470	469	464	464	464	3,860
1958	393	0	390	471	470	466	466	466	3,880
1959	401	0	392	483	480	469	469	469	3,950
1960	395	0	395	472	472	472	472	472	3,900
1961	403	0	397	484	482	475	475	475	3,970
1962	405	0	400	486	484	478	478	478	3,990
1963	418	0	402	505	500	481	481	481	4,100
1964	414	0	404	499	496	484	484	484	4,080
1965	420	0	407	507	503	487	487	487	4,130
1966	426	0	409	514	509	490	490	490	4,180
1967	425	0	411	513	509	492	492	492	4,180
1968	512	0	409	495	493	489	489	489	4,070
1969	418	0	418	500	500	500	500	500	4,130
1970	1,379	0	365	458	454	437	437	437	3,720
1971	1,102	0	385	487	482	461	461	461	3,950
1972	1,088	0	388	464	464	464	464	464	3,830
1973	1,091	0	391	468	468	468	468	468	3,870
1974	1,095	0	395	472	472	472	472	472	3,900
1975	1,098	0	398	476	476	476	476	476	3,930
1976	813	0	418	500	500	500	500	500	4,130
1977	548	866	425	515	504	458	458	458	4,140
1978	738	342	417	536	527	488	488	488	4,330
1979	708	266	472	522	517	496	496	496	4,260
1980	672	236	473	512	511	504	504	504	4,230
1981	683	240	478	514	512	506	506	506	4,250
1982	708	263	483	513	512	506	506	506	4,250
1983	815	376	497	498	497	492	492	492	4,130
1984	1,133	703	540	447	446	441	441	441	3,750
1985	1,134	703	543	448	447	445	445	445	3,760
1986	1,173	720	570	447	446	442	442	442	3,760
1987	1,176	720	573	450	450	446	446	446	3,790
1988	1,178	720	576	454	453	450	450	450	3,810
1989	1,181	720	579	457	456	453	453	453	3,840
1990	1,182	720	582	457	457	457	457	457	3,850
1991	1,814	1,370	674	351	351	351	351	351	3,050
1992	1,817	1,370	677	355	355	355	355	355	3,080
1993	1,959	1,510	699	334	334	334	334	334	2,930
1994	1,804	1,370	684	363	363	363	363	363	3,150
1995	1,872	1,397	709	384	384	384	384	384	3,320
1996	1,929	1,432	737	405	405	405	405	405	3,500
1997	1,910	1,386	757	445	445	445	445	445	3,830
1998	1,976	1,426	790	471	471	471	471	471	4,040
1999	2,016	1,400	821	504	504	504	504	504	4,310
2000	2,278	1,700	598	452	452	452	452	452	4,710
2001	2,215	1,620	635	497	497	497	497	497	5,060
2002	2,131	1,480	661	515	515	515	515	515	5,640
2003	2,046	1,320	686	533	533	533	533	533	6,240
2004	1,937	1,180	687	523	523	523	523	523	6,580
2005	1,828	1,020	688	512	512	512	512	512	6,950
2006	1,719	850	689	501	501	501	501	501	7,320
2007	1,616	660	686	497	497	497	497	497	7,680
2008	1,618	660	688	500	500	500	500	500	7,700
2009	1,598	660	668	476	476	476	476	476	7,500
2010	1,577	660	647	452	452	452	452	452	7,300

Rich fisheries and poor data: a catch reconstruction for Angola, 1950-2010, an update of Belhabib and Divovich (2014)[1]

Dyhia Belhabib and Esther Divovich

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada
d.belhabib@fisheries.ubc.ca; e.divovich@fisheries.ubc.ca

Abstract

This is an update of an earlier catch reconstruction published by D. Belhabib and E. Divovich in 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).

[1] Cite as: Belhabib, D. and Divovich, E. (2015) Rich fisheries and poor data: a catch reconstruction for Angola, 1950-2010, an update of Belhabib and Divovich (2014). pp. 115-128. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

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).

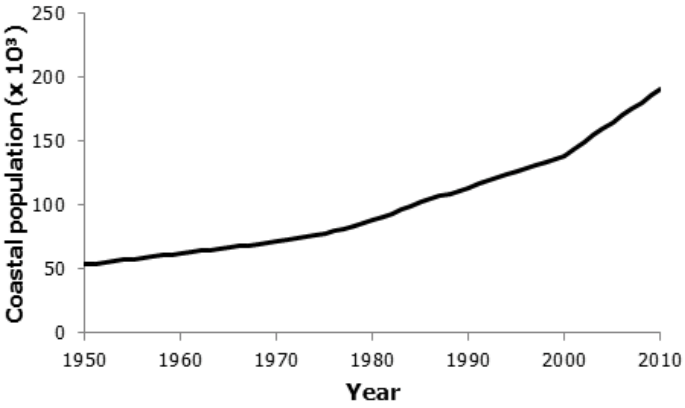

Figure 2. Estimated coastal population of Angola, 1950-2010.

Industrial catches

Industrial fisheries in Angola were dominated by foreign fleets whose catches are mostly unknown and while domestic fleets[2] 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).

[2] 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 illegal activities, leading to loss of lives. 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),[3] 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.* 2014). 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.* 2015a) and assumed that purse-seiners discarded clupeids as they do in Namibia (Belhabib *et al.* 2015b).

[3] 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).

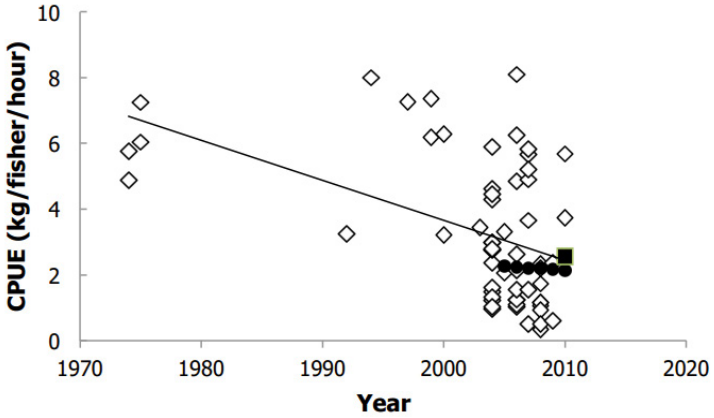

Figure 3. Observed and estimated CPUE of recreational fishers comparing various sources, ie. Anon. (2014); diamonds, Potts *et al.* (2009); dots and YouTube; black sqaures.

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.

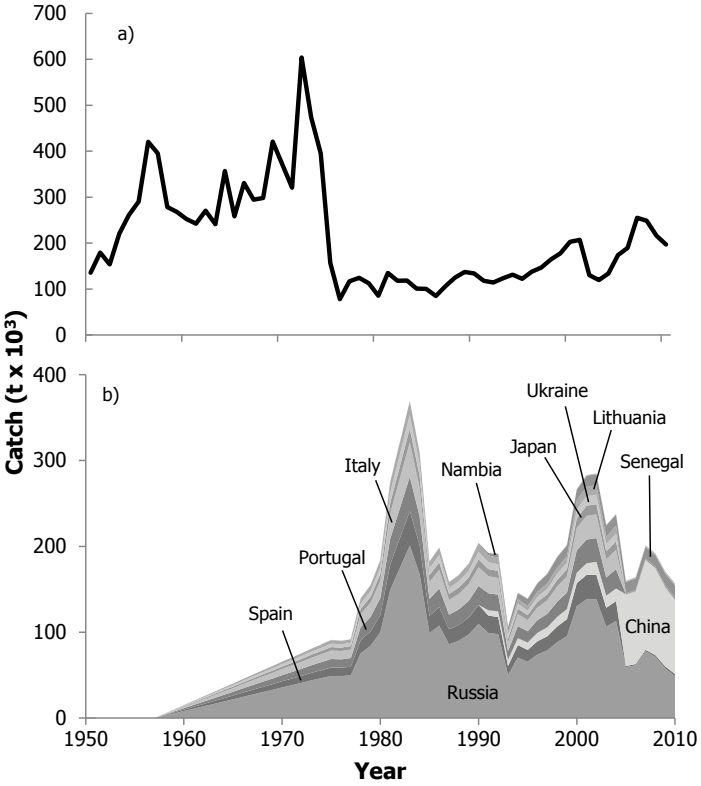

Figure 4. Reconstructed industrial fisheries catches from Angola EEZ by a) the domestic fleet and b) the foreign fleet by country, 1950-2010.

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).

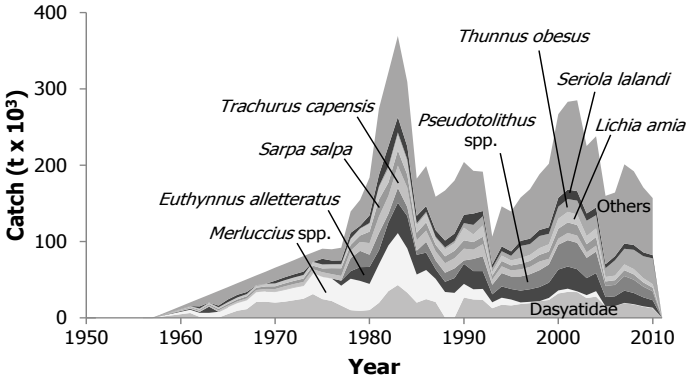

Figure 5. Reconstructed industrial fisheries catches (domestic and foreign) from Angola EEZ by major taxa, 1950-2010.

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 groups 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).

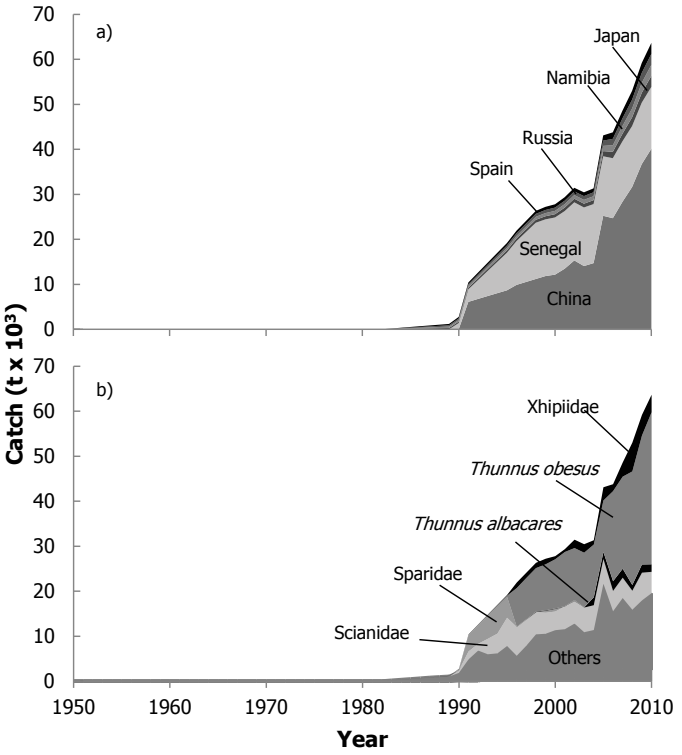

Figure 6. Reconstructed illegal catches from Angola by a) country and b) taxon, 1950-2010.

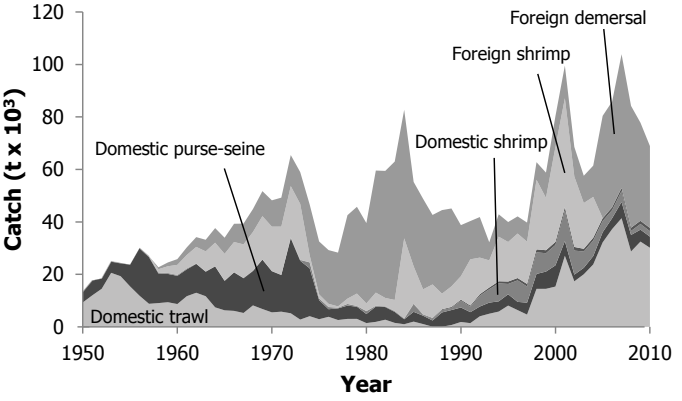

Figure 7. Reconstructed total discards by sector from Angola EEZ, 1950-2010.

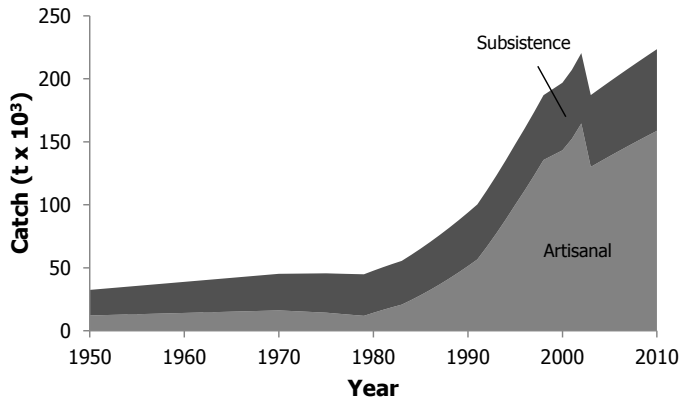

Figure 8. Reconstructed total small-scale artisanal and subsistence catches from Angola, 1950-2010.

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).

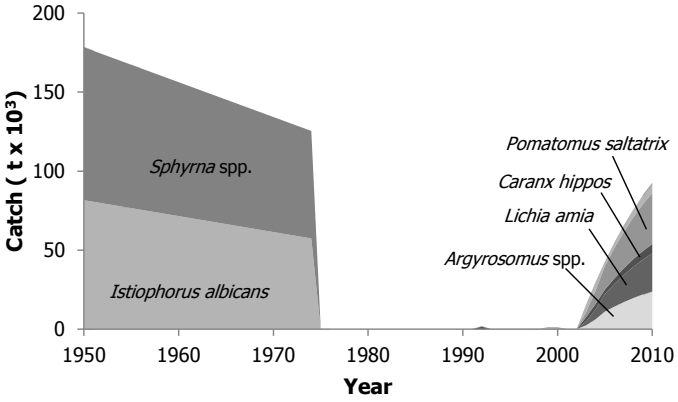

Figure 9. Reconstructed total recreational catches from Angola EEZ, 1950-2010.

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). 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, in the Eastern Central Atlantic area were almost completely unreported. Catches were nearly all small-scale, increased from around 7,300 t in

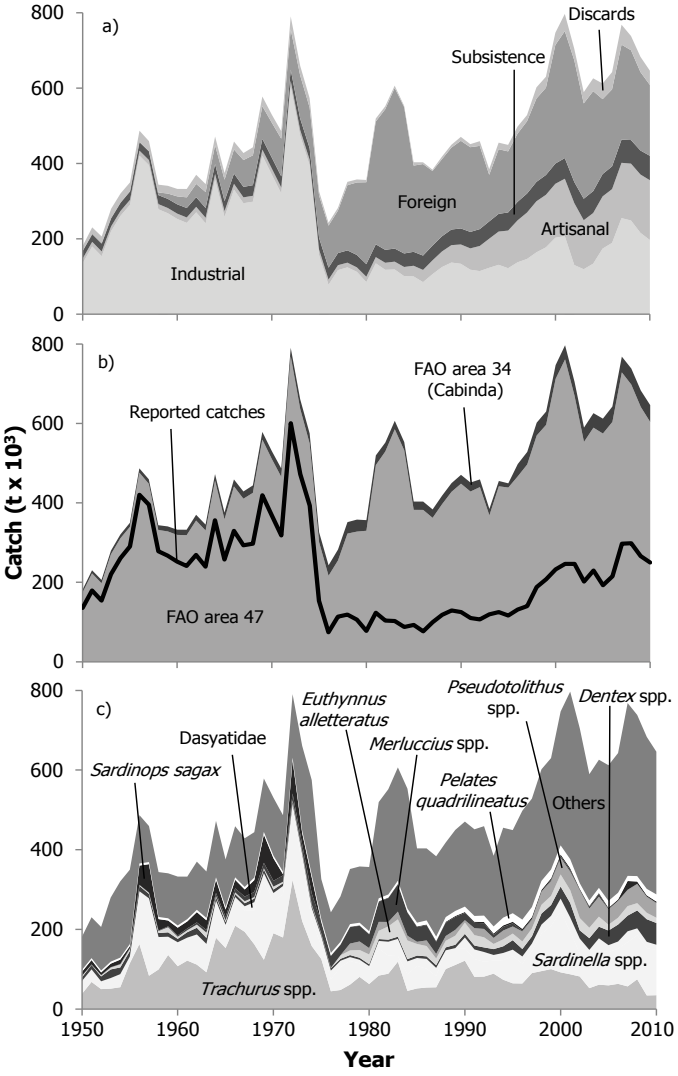

Figure 10. Reconstructed total catches from the Angolan EEZ by a) sector including domestic and foreign catches, b) area including domestic catches and c) taxon including domestic and foreign catches, 1950-2010.

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 of 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

We acknowledge the support of the *Sea Around Us*, a scientific collaboration between the University of British Columbia and The Pew Charitable Trusts. We thank D. Pauly for reviewing the text and for his helpful advice and suggestions.

References

Angonoticias (2013) Pesca ilegal afecta fauna marinha e prejudica operadores industriais. Noticias de Angola.

Agostinho D, Fielding P and Bergh M (2005) Overview and analysis of socio-economic and fisheries information to promote the management of artisanal fisheries in the BCLME region–Angola. Fisheries, Angola.

Angodenúncias (2014) Angola adquire novos navios para combater pesca ilegal. Angodenúncias.

ANGOP (2009) Marinha de Guerra apreende duas embarcações estrangeiras ilegais. Agência Angola Press (ANGOP).

ANGOP (2013) Marinha de Guerra detêm mais de 300 emigrantes ilegais em seis meses. Agência Angola Press (ANGOP).

Anon. (2003) Artisanal fisheries in Angola. IPA, Luanda. 2 p.

Anon. (2013) Seasonal monitoring in Angola. *Ad hoc* report. JRC Scientific and Policy Reports, European Commission, Brussels. 12 p.

Anon. (2014) Records do mundo de Angola na pesca deportiva. Federacao Angolana de pesca desportiva, Luanda. 3 p.

BBC (2013) Angola profile. BBC News.

Belhabib D and Divovich E (2014) Rich fisheries and poor data: a catch reconstruction for Angola, 1950-2010. Fisheries Centre Working Paper #2014-12, University of British Columbia, Vancouver, 19 p.

Belhabib, D., Koutob, V., Sall, A., Lam, V.W.Y. and Pauly, D. 2014. Fisheries catch misreporting and its implications: The case of Senegal. Fisheries Research 151:1-11

Belhabib, D., Ramdeen, S. and Pauly, D. (2015a) An attempt at reconstructing the marine fisheries catches in the Congo (Ex-Zaïre), 1950-2010. pp. 107-114. *In:* Belhabib, D. and Pauly, D. (eds). Fisheries catch reconstructions: West Africa, Part II. Fisheries Centre Research Reports vol.23(3). Fisheries Centre, University of British Columbia

Belhabib, D., Willemse, N.E. and Pauly, D. (2015b). A fishery tale: Namibian fisheries between 1950 and 2010. Fisheries Centre Working Paper #2015-65, University of British Columbia, Vancouver, 17 p.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). NASA Socioeconomic Data and Applications Center (SEDAC), Palisades, NY. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3 [Accessed: 29/10/2012].

Coelho ML and Stobberup KA (2001) Portuguese catches of Atlantic cod (*Gadus Morhua*) in Canada from the period 1896-1969: A comparison with NAFO data. Fisheries Impacts on North Atlantic Ecosystems: Catch, Effort, and National/Regional Data Sets Vol. 9 (3), Fisheries Centre, University of British Columbia, Vancouver, Canada. 236-239 p.

COFREPECHE (2013) Preparation of the Horse mackerel (*T. trecae*) Management Plan for Angola. Strengthening Fisheries Management in ACP Countries.

da Silva C (2012) Actividade dos pescadores é difícil e arriscada. Jornal de Angola, online, edition of March 22, 2012

de Matos PF (1984) Recordações do passado: ligeira contribuição para a história dos serviços de marinha de Angola. Clube Militar Naval.

de Sousa Ferreira E (1985) A lógica da consolidação da economia de mercado em Angola, 1930-74. Análise Social: 83-110.

DN (2012) Barcos chineses apreendidos por pesca ilegal em Benguela. Diário de Notícias.

Du Preez M-L (2009) Fishing for Sustainable Livelihoods in Angola: The Co-operative Approach. South African Institute of International Affairs, Johannesburg.

Embaixada da República de Angola em Portugal (2014) Pesca.

FAO (2007a) The Republic of Angola. Fishery Country Profile, FAO, Rome.

FAO (2007b) Results and conclusions of the project "ecosystem approaches for fisheries management in the Benguela Current Large Marine Ecosystem". FAO Fisheries Circular 1026, FAO, Rome. 166 p.

Gianni M and Simpson W (2005) The Changing Nature of High Seas Fishing: how flags of convenience provide cover for illegal, unreported and unregulated fishing. Australian Department of Agriculture, Fisheries and Forestry, International Transport Workers' Federation, and WWF International. 88 p.

Guerra HL (1979) Angola: estrutura económica e classes sociais: os últimos anos do colonialismo Português em Angola. Edições 70.

IPA (2002) Artisanal Fisheries in Angola Institute for the Development of Artisanal Fisheries, Luanda.

Kelleher K (2004) Discards in the world's marine fisheries: an update. FAO Fisheries Technical Paper 470, FAO, Rome. 134 p.

Krantz L (1984) A pesca artesanal em Angola: estudo sócio-enconómico do apoio à pesca artesanal em Angola. Stockholm University.

Lankester K (2002) The EU-Angola fisheries afreement and fisgeries in Angola. Scomber Fisheries Management and Wildlife, Amsterdam. 12 p.

Macauhub (2014) Pesca em Angola atinge as 370 mil toneladas em 2013.

McGrath R (1993) Land Mines in Angola (101). Human Rights Watch.

Medeiros I (1982) Contribuição para o estudo da colonização e da pesca no litoral de Angola ao sul de Benguela. Instituto de Investigaçoes Científicas Tropical / Junta de Investigaçoes Científicas do Ultramar, Lisboa. 68 p.

MRAG (2005) Review of impacts of Illegal, Unreported and Unregulated fishing on developing countries. Final report, MRAG, London. 176 p.

Norfolk S, Ribeiro V and Groenendijk K (2006) Assessment of agricultural information needs in African, Carribean and Pacific (ACP) states for CTA's products and services. Africa, country study: Angola. Technical Centre for Agricultural and Rural Cooperation (CTA) Brussels. 100 p.

O País (2012) Pesca artesanal é importância para as populações angolanas. O País online.

O País (2014) MGA avança para a modernização. O País–O Jornal da Nova Angola.

Ojukwu C, Beileh A, Johm K and Marttin F (2013) Fisheries sector support project. Angola. African Development Fund. 19 p.

Pauly D, Belhabib D, Blomeyer R, Cheung WWWL, Cisneros-Montemayor AM, Copeland D, Harper S, Lam VWY, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2013) China's distant-water fisheries in the 21st century. Fish and Fisheries: n/a-n/a.

Potts W, CHILDS AR, Sauer W and Duarte A (2009) Characteristics and economic contribution of a developing recreational fishery in southern Angola. Fisheries management and ecology 16(1): 14-20.

Potts W, Sauer W and Shaw P (2011) Transboundary climate induced distributional changes in an important artisanal and recreational west African fish species. Consequences and adaptation. Luanda. 15 p.

Preez M (2009) Fishing for sustainable livelihoods in Angola: The co-operative approach. Occasional Paper 45, South African Institute of International Affairs. 26 p.

Sall A, Belliveau M and Nayak N (2002) Conversations: a trialogue on organization, power and intervention in fisheries.

Salopek P (2004) Fade to blue. A tale of fish, pirates, greed and the end of a global frontier. The Chicago Tribune, Chicago. 18 p.

Sowman M and Cardoso P (2010) Small-scale fisheries and food security strategies in countries in the Benguela Current Large Marine Ecosystem (BCLME) region: Angola, Namibia and South Africa. Marine Policy 34(6): 1163-1170.

Stop Illegal Fishing (2006) Angola.

Urquhart AW (1963) Patterns of settlement and subsistence in southwestern Angola. National Academies.

Valério N and Fontoura MP (1994) A evolução económica de Angola durante o segundo período colonial—uma tentativa de síntese. Análise Social: 1193-1208.

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