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

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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

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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).

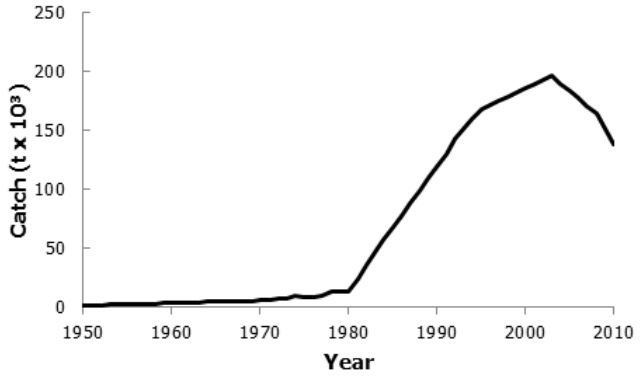

Figure 2. Reconstructed industrial catches from the EEZ of Nigeria, 1950-2010.

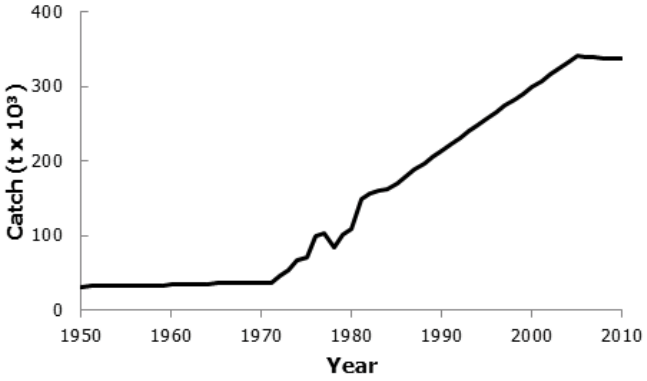

Figure 3. Total reconstructed artisanal catches from the EEZ of Nigeria, 1950-2010.

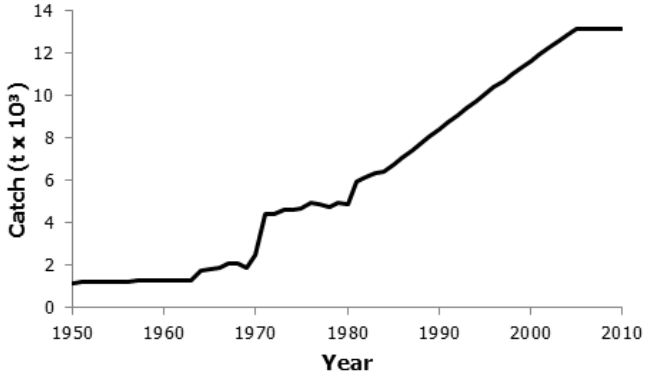

Figure 4. Total reconstructed subsistence catches from the EEZ of Nigeria, 1950-2010.

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).

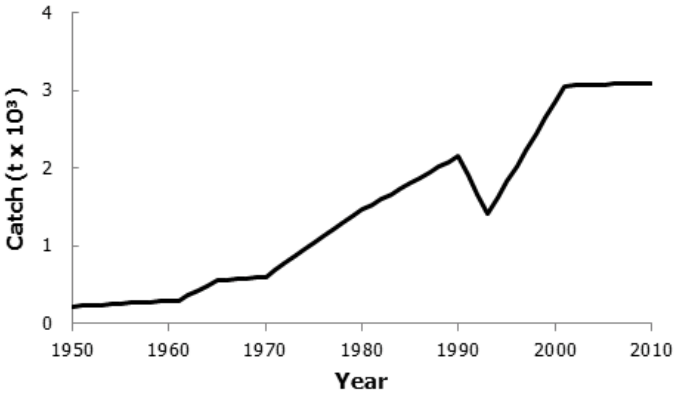

Figure 5. Total reconstructed shrimp trawl discards from the EEZ of Nigeria, 1950-2010.

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).

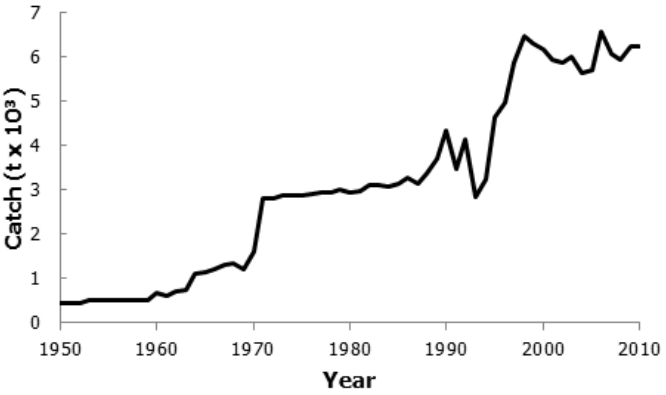

Figure 6. Total reconstructed illegal catches from the EEZ of Nigeria, 1950-2010.

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.

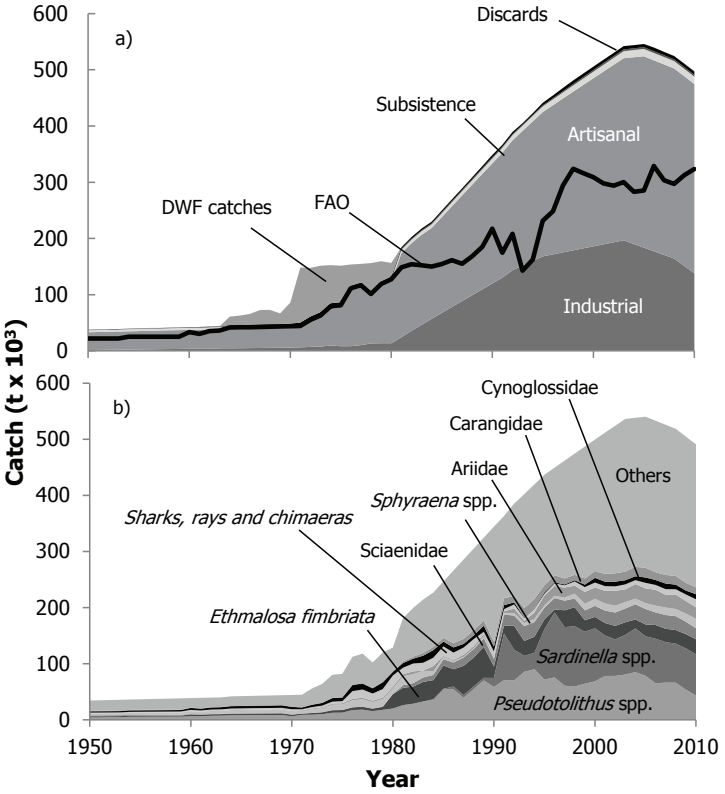

Figure 7. Total reconstructed domestic by Nigeria, by a) sector, with data as reported by FAO overlaid as line graph; and b) taxon, 1950-2010. Distant water fleet (DWF) catches refer to those catches reported to the FAO by Nigeria but that were taken from outside Nigeria within the area comprised between 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.*"

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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