



Filling a blank on the map: 60 years of fisheries in Equatorial Guinea

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Abstract Despite a scarcity of pertinent information, it has been possible to reconstruct time series of marine fisheries catches for Equatorial Guinea from 1950 to 2010 using per capita fish consumption and population numbers for small-scale fisheries, catch rates and number of vessels for industrial fisheries and discard rates to estimate the discarded bycatch. Small-scale fisheries, industrial large-scale fisheries, domestic and legal and illegal foreign fisheries and their discards are all included. Total catches were estimated at 2.7 million tonnes over the time period considered, of which 653 000 t were caught domestically compared to 187 000 t reported by FAO. This shows that fisheries have more importance for Equatorial Guinea's food security than the official data suggest. In contrast to what is suggested by official figures, fisheries were shown to be strongly impacted by civil and political unrest; notably, they declined overall because of civil and political conflicts, socio-demographic dynamics, and a growing role of the newly discovered oil resources, which directly and indirectly threaten the food security of the people of Equatorial Guinea.

KEY WORDS: catch reconstruction, FAO data, large-scale fisheries, small-scale fisheries, under-reporting.

Introduction

Truly global assessments of the status of fisheries are compromised by 'blanks on the map' – countries where official data either do not exist or are not provided to the UN Food and Agriculture Organization (FAO), which compiles such data. Even if such countries do provide estimates of fisheries catches, they are often based on perceived wisdom or 'best guesses', rather than direct survey or careful mining and reconstruction of available information. This study aimed to compile and analyse available information to fill in one such blank on the world fisheries map – Equatorial Guinea.

Equatorial Guinea (Fig. 1) consists of a mainland component, Río Muni, located between Cameroon and Gabon (where 80% of the population live), nearby islands (Corsico and the Elobay group) and more distant islands including Bioko (the former Fernando Pó, off the coast of Cameroon) and Annobón (off the coast of Gabon). Equatorial Guinea gained independence from Spain in 1968. During the Spanish colonial period, Equatorial Guinea had the highest per capita income in Africa (Kümpel *et al.* 2010). After independence, a reign of terror under President Francisco Macias Nguema began (Fegley 1981); Equatorial Guinea became, between the late 1960s and the late 1970s, the most

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repressive dictatorship Africa had ever known. The country was qualified as ‘worse than Nazi occupied Europe’ by Fegley (1981) and ‘a large torture camp’ by Liniger-Goumaz (1985). In the 1970s, 50 000 people (10% of the population) were murdered (Fegley 1981), and 125 000 people (a quarter of the population) became refugees in other countries (Liniger-Goumaz 1985), while immigrants were treated abominably. By 1976, 40 000 Nigerians brought to Equatorial Guinea to work on cocoa plantations (Fegley 1981) were sent back home. This situation drove the economy into a slump (Aworawo 2010), and Macias was overthrown in a military coup in 1979 by members of his own clan (Fegley 1981). Between 1979 and the mid-1980s, the rebuilding of Equatorial Guinea’s economy has focused on immediate benefits from extensive resource exploitation (Castroviejo *et al.* 1994). This is further illustrated by the nickname used to refer to the Minister of Forestry, that is ‘Minister Responsible for Chopping Down Trees’ (Wood 2004). With the discovery of substantial offshore oil reserves, Equatorial Guinea shifted from cocoa to the petroleum business in the mid-1990s (Liniger-Goumaz 1998). Today, earnings from oil and gas represent some 97% of the country’s exports, and thus, Equatorial Guinea has been dubbed the ‘Kuwait of West Africa’ (Wood 2004). Although the country is sometimes referred to as ‘rich’, a large part of the population remains extremely poor, a result of the former government having forced the population to revert to subsistence agriculture (Wood 2004). Today, most of the livelihoods in Equatorial Guinea continue to be based on subsistence activities, and the population struggles to meet basic needs; Equatorial Guinea thus ranks among the least developed countries in the world based on the purchasing power parity (PPP) per capita (Fernandez Moreno 1996).

With the collapse of the former post-independence government, international relations improved. In 1982, Nigeria and Equatorial Guinea signed an agreement focusing on trade, but also resource exploitation, including fishing and agriculture. Other agreements followed, notably with the EU, Spain, France and China.

Other than socio-anthropological reports, and political analyses that barely hint at the existence of a fishery sector, very scarce qualitative and quantitative data and published reports are publicly available on the fisheries of Equatorial Guinea. Indeed, up to 1976, the Spanish government classified all written documents as ‘*materia reservada*’ (Fegley 1981; Liniger-Goumaz 1985). As for Macias’ oppressive rule, it stopped any flow of information. Today, ‘all publications are subject to censorship’ (Wood 2004), which did not make this study any easier. Thus, the catch data found in

the FAO database for Equatorial Guinea consist largely of estimates designated by the letter ‘F’, that is dubious data that are often the result of *ad hoc* working groups generating numbers in response to some external demands (SOFRECO 2011). There is no efficient statistical system for data collection (Anon 2007a), except a few sporadic development surveys in the 1980s (Matthes 1980; FAO and WHO 1985, FAO 1986, UNCED 1992), most of which are fragmentary, when not contradicting each other. While statistical monitoring of artisanal fisheries remains rudimentary (FAO 2010) to non-existent (Kebe *et al.* 2007), industrial fisheries statistical monitoring relies on agents onboard industrial vessels (FAO 2010). Recent information on industrial fishing vessels suggests the presence of 60 small Spanish fishing vessels based in Bioko, and 35 tuna purse-seiners and longliners under agreement with the European Union and Japan (Anon 2013). However, there is no evidence of a recent frame survey that would have assessed the number of artisanal fishers or their canoes. Artisanal fisher numbers were surveyed at 8750 for 1996.¹ Artisanal fishing is conducted by canoes between 7 and 8 m long whose propulsion often relies on oars, sails and engines (Hellebrandt & Allison 2012). FAO statistics, featuring relatively low numbers, suggest that the fisheries are under-developed, but the overexploited/depleted status of the marine fisheries of Equatorial Guinea, due in part to largely unmonitored foreign fishing fleets, suggests the opposite (East *et al.* 2005). While the waters of Equatorial Guinea are productive, and could possibly sustain a catch of as much as 240 000 t yr⁻¹ (East 2003), the post-independence government under the Macias presidency banned fishing in key areas of the country (see below) and destroyed all fishing infrastructure in an attempt to stop the population from escaping by sea (East 2003).

Currently, the animal protein supply in Equatorial Guinea is ensured by bushmeat and fish, both of which being essential to the Equatoguinean diet (East *et al.* 2005). Freshwater and estuarine fish caught mostly by women and children in continental Equatorial Guinea plays a major role in supplying its population with animal protein (Perpiñá Grau 1945; Matthes 1980; Keylock 2002). This is particularly true for the poor communities who cannot afford other types of animal protein (Fa *et al.* 2009). This, along with relatively low prices (Keylock 2002; East 2003), makes

¹ www.fao.org/docrep/003/v4250s/V4250s04.htm [Accessed on August 06, 2015]

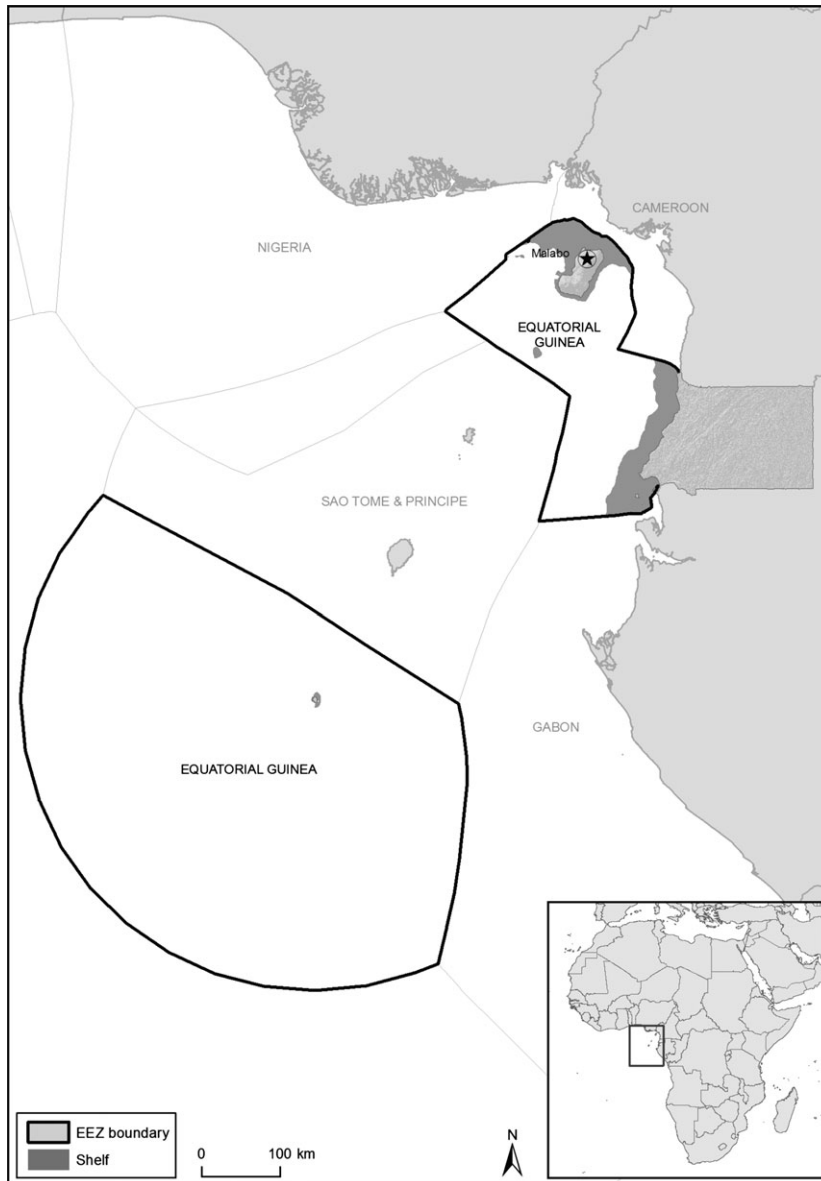


Figure 1. Map of Equatorial Guinea and its Exclusive Economic Zone (EEZ).

fish an important substitute for other types of animal protein such as bushmeat, to ensure food security (Wilkie *et al.* 2005). Therefore, to understand both Equatorial Guinea's dependence on fisheries and its contribution to global fish catches, it is necessary to reconstruct the history of fisheries and marine fisheries catches in Equatorial Guinea using the scant available literature, following the approach described below. In addition, it is very important to catch the trend as Equatorial Guinea develops its own fishing sectors, and grasp a realistic image of Equatorial Guinea's fisheries by sector for the development of proper management plans.

Methods

Human population

Of the few major ethnic groups in the country, the Fang are the dominant group (80% of the population). They inhabit the mainland (Rio Muni) and are primarily hunters and subsistence farmers (East *et al.* 2005; Fa *et al.* 2009). The *Playeros* ('beach people', Spanish word used for the *Ndowe* ethnic group) practice fishing and subsistence agriculture as their main activities. The *Bubi* live on the island of Bioko and represent 9% of the population. The *Bubi*, previously fishers and whale hunters,

have now converted to agriculture (Liniger-Goumaz 1985). The *Fernandinos* – descendants of freed slaves, originally from Sierra Leone, Ghana and Nigeria – and the *Annobón* are two other minority groups (Fegley 1981; Fernandez Moreno 1996).

When data on actual fishing effort are lacking, population data might be used as a proxy to realistically assess both trends of fishing and catches at the non-industrial level, as population movements (e.g. coastal migrations) are often directly related to fisheries exploitation (Pauly 1990). Population data were extracted from Populstat (www.populstat.info [2013]) for the period from 1950 to 1979, and from the WorldBank database (www.worldbank.org [2013]) for the subsequent years. Data were interpolated to fill in any gaps. Coastal population was estimated as the number of persons living within 10 km from the coast for 2012 (CIESIN 2012), that is 36%. The description of the population on the island of Bioko, along with socio-demographic and political events (see Belhabib *et al.* 2015), was combined to estimate the population on the islands at different points in time (Table S1). This, when subtracted from the total population, allowed for the estimation of the population in Rio Muni (i.e. continental Equatorial Guinea).

Given the relatively small size of the islands, all of their population was assumed to be coastal. The coastal population of Rio Muni was obtained by applying the previous coastal population proportion (36%) to the population on Rio Muni. The magnitude of two population segments could then be estimated: the insular segment (assumed all coastal) and the coastal population on the continent (Rio Muni). For 2010, the population was multiplied by the coastal population proportion (36%) and then interpolated to fill in the gaps (Table S1).

Small-scale fisheries

Small-scale fisheries include subsistence fisheries, also referred to as traditional fisheries, where the fishing activity is driven by personal consumption or trade for food and staples, in contrast to artisanal fisheries, which mostly supply Equatoguinean markets, associated with higher costs and return on investment. Social and political events played a major role in shaping small-scale fisheries effort in Equatorial Guinea (Morillas Gómez 2004), which were taken into consideration herein. Such events were a ban of fishing in the islands (Fegley 1981), the destruction of fishing gear (Matthes 1980) and the creation of maritime checkpoints (Campos-Serrano 2013). In addition, migrations, whether internal or external, contributed to increasing and/or decreasing fishing effort (Everett 1991).

Small-scale catches were estimated as the product of fish consumption rates during different time periods (in kg per capita) and the population of that specific time period to capture changes in small-scale fisheries catches through changing consumption.

The household consumption survey undertaken by Carrasco Saiz (1966) in the former Spanish Guinea in 1963 found that on average, 85% of animal protein consumed came from fish, at a total of 34 g of protein (meat and fish) per person per day in the islands, that is 29 g of fish protein. By contrast, a minimum of 10.8 g of protein per person per day was consumed in coastal areas of Rio Muni, that is 9.2 g of fish protein. This allows estimation of average fish protein consumption of 24 ± 4 g per person per day. Taking into account that 18 g of animal protein resulted from the consumption of 100 g of fish (Albrechtsen *et al.* 2005), the daily per capita consumption of fish would have been around 133 ± 22 g day⁻¹, that is 58.6 ± 8 kg capita⁻¹ yr⁻¹ for 1963. On the other hand, fresh fish consumption, that is originating exclusively from domestic small-scale fisheries, was estimated by Albrechtsen *et al.* (2005) by species per adult male equivalent (AME) as 0.96 capita (Fa *et al.* 2009). A random selection of 198 households within the *Fang*, *Bubi*, *Annobonese* and other ethnic groups, each containing 6.1 ± 2.2 AMEs, were chosen for the survey. The weighted average was estimated to which were added 0.8 t yr⁻¹ of molluscs provided separately by Albrechtsen *et al.* (2005), and then divided by the total number of AME (1208). Therefore, a consumption of 12.97 ± 3.09 kg AME⁻¹ yr⁻¹ (or 13.5 ± 3.2 kg capita⁻¹ yr⁻¹) from small-scale fisheries in Equatorial Guinea was estimated. The previous rates (58.6 ± 8 kg capita⁻¹ yr⁻¹ for 1963 and 13.46 ± 3.2 kg capita⁻¹ yr⁻¹ for 2003) were multiplied by the total population for the two respective years to estimate the total supply from small-scale fisheries, and then, the later was divided by the coastal population for 1963 and 2003 to derive per capita consumption rates as per capita catches by the coastal population. The per capita catch (for coastal population) was therefore derived as 104 ± 14.2 kg capita⁻¹ yr⁻¹ for 1963 and 36.1 ± 9.3 kg capita⁻¹ yr⁻¹ for 2003. Using the coastal rather than the total population allowed consideration of some of the historical and socio-demographical events described previously (also see Belhabib *et al.* 2015). In addition, distinguishing between the populations of the islands and those of the mainland allowed consideration of political restrictions on fishing in the islands on the one hand and the considerable migration towards the coast of the mainland on the other. These population data were adjusted to account for people who could not fish (inhabitants of the Islands and the *Ndowe* ethnic group in Rio Muni) by subtracting their number from the total coastal

population estimate. Per capita catch estimates were interpolated, assuming they were constant between 1950 and 1963, and 2003 and 2010, respectively, and then multiplied by the coastal population (Table S1) to obtain total catches from small-scale fisheries between 1950 and 2010.

Albrechtsen *et al.* (2005) and East *et al.* (2005) also investigated source of fish consumed through household food consumption surveys in Malabo (Bioko, $n = 1\ 208$ AMEs) and Bata (Rio Muni, $n = 882$ AMEs) and found that 3% and 4% (3.5% on average) of the fish was either caught directly by the household or received as a gift in 2003, the remaining being bought from local markets. Similarly, Keylock (2002) interviewed 41 households (300 AMEs over a total of 446 inhabitants) in Sendje (Rio Muni) between April and June 2002 and found that 25% of the total fish consumed was directly caught by a member of the household. This suggests that on average, 14.25% (average of 3.5% and 25%) of fish were caught directly by one member of the household, thus representing subsistence catch (Allebone-Webb 2009). Observations from in-country field research highlighted that fishers and households were keeping 'much more fish' for their personal consumption. Furthermore, in the 1950s and 1960s, prior to the post-independence government restriction on fishing in the islands, small-scale fisheries were primarily for subsistence and personal consumption (Carrasco Saiz 1966). Therefore, it is assumed the proportion of fish directly caught or received as a gift (i.e. subsistence) was 50% in the 1950s and 1960s; this is 'much higher' than the rate of 14.25% estimated for the 2000s. The 50% estimate was then increased slightly (to 55%) during the mid-1970s and 1980s, to account for the migration of people towards the coast of Rio Muni (Castroviejo *et al.* 1994), which compensated for the restrictions imposed on the insular parts of the country (Castroviejo *et al.* 1994).

The rates estimated from literature sources have limitations, notably because most, but not all, households sampled, were either in, or near urban centres. Furthermore, the choice of 50% is based on most small-scale fisheries being directed towards subsistence in the past. Since it is assumed that 'mostly' is at least half of small-scale fisheries, there is a range of other equally probable rates that are higher that could be used. However, it is reasonable to assume that such conservative averages capture the main features of changes in the contribution of subsistence fishing to small-scale fisheries. We interpolated between these rates, which were then multiplied by the total small-scale catch to estimate subsistence catches. The difference between total small-scale catches and subsistence catches yielded the artisanal catch.

The subsistence fishery of Rio Muni mainly consists of estuarine catches of catfishes (*Chrysichthys* spp.),

tilapia (*Oreochromis* spp.), snappers (*Lutjanus* spp.) and pampanos (*Trachinotus* spp.) (Belhabib *et al.* 2015), for which equal proportions were assumed, while the taxonomic breakdown for artisanal fisheries was derived from data on the frequency of fish categories reported as the three most important catches in the 2011 fishing season (Hellebrandt & Allison 2012). The frequency reported for each species is then multiplied by the average weight obtained using FishBase (www.fishbase.org), for which the percentage was then estimated in proportion to the total (Table 1).

Recreational fishing

Recreational fishing is primarily conducted by tourists (Anon 2007a). A hotel in the *Parc National de Mont Alén* received 200 tourists in 2007 (Anon 2007b) of which 80% fished for 3 days per week, and 60 for 1999 and 192 for 2010 using total tourist expenditure trends (Belhabib *et al.* 2015). Data available online² suggest the start of tourist activities date back to 1995, but it was assumed here the number of recreational fishers for 1995 was zero. Interpolations were performed. A CPUE of 14 ± 6.5 kg fisher⁻¹ trip⁻¹ was estimated by Belhabib *et al.* (2015) and multiplied by the number of fishers and the number of trips per fisher per year to estimate the total recreational marine catch in Equatorial Guinea. The documented catch showed on average 52% of barracudas (*Sphyraena* spp.), 18% of groupers (*Epinephelus* spp.), 9% of jacks (Carangidae) and 21% of other fishes.

Industrial fisheries

There is no clear evidence documenting the start year of industrial fishing, and colonial archives made available only recently (www.opensourceguinea.org [2013]) with detailed economic exploitation potential only referred to fisheries as a mean of subsistence for the local population, while emphasising forestry and agriculture, notably cocoa (Perpiñá Grau 1945). Thus, it is likely the only fleet present at the time was of Spanish origin and ownership for which trawlers of 40 GRT were documented in 1941 (Government of Spain 1941). Fishing vessels from other countries, notably trawlers, joined later. The effort was retraced using different sources for nine countries: The former Soviet Union (USSR) (Fegley 1981; Aworawo 2010), Spain (Government of Spain 1941),

² <http://www.indexmundi.com/facts/equatorial-guinea/international-tourism> [Accessed on August 06, 2013]

Table 1. Species composition of small-scale artisanal fisheries in Equatorial Guinea

Local name	Scientific name	%
Disco	Carangidae	3.98
Bacalao/bocacerdo	Serranidae	17.22
Merluza	<i>Sphyraena</i> spp.	16.58
Colorado	<i>Lutjanus</i> spp.	14.76
Marine fishes not identified	–	11.99
Capitan	<i>Pentanemus quinquarius</i>	8.54
Raya	Dasyatidae	7.69
Besugo	<i>Pomadasys jubelini</i> and <i>Pagrus africanus</i>	5.31
Dorado	<i>Coryphaena hippurus</i>	4.73
Corvina	<i>Pseudotolithus</i> spp.	2.85
Atun	<i>Caranx senegallus</i>	2.52
Guitara	Rhinobatidae	1.09
Lenguado	<i>Cynoglossus</i> spp.	0.85
Pez alicate	Tetraodontidae	0.83
Bonito	Scombridae	0.64
Arregue	<i>Ethmalosa fimbriata</i>	0.32
Langostas	<i>Panulirus regius</i>	0.09
Sardina	<i>Ilisha africana</i>	0.01

France (FAO 1986, Churchill 1987; Ministerio de Defensa 2006), Nigeria, Cameroon (Carroz & Savini 1983; Mangatalle 1996), São Tomé and Príncipe (Carroz & Savini 1983), and the European Economic Community (EEC) (later European Union) (Table S2). Effort, that is number of vessels, was reconstructed by country or entity by Belhabib *et al.* (2015) and then multiplied by the CPUE.

CPUE for Nigerian trawlers and purse-seiners of 1000 GRT (Mangatalle 1996) was conservatively estimated at 600 ± 120 t boat⁻¹ yr⁻¹ for 1985 (Belhabib *et al.* 2015). It was assumed that the CPUE was 10% higher in 1950 (660 t boat⁻¹ yr⁻¹) and 20% lower in 2010 (480 t boat⁻¹ yr⁻¹) relatively to the CPUE for 1985, given clear signs of overexploitation (Morillas Gómez 2004). A series of interpolations was performed to complete the time series. Thereafter, it was assumed that the CPUE for domestic vessels and those from Cameroon and São Tomé and Príncipe was half the CPUE of the vessels from Nigeria because of their lower efficiency and size (Mangatalle 1996). Similarly, because vessels from Europe were more efficient, it was assumed that the CPUE for European and Chinese vessels to be 20% higher than that of the Nigerian vessels. Between 1982 and 1986, CPUE for Spain was divided by two, to account for Spanish vessels (although under agreement with Equatorial Guinea) did not all operating exclusively in the Exclusive Economic Zone (EEZ) of Equatorial Guinea (Matthes 1980). As for the Soviet Union, five shrimpers landed 3840 t yr⁻¹ of ‘trash fish’ in 1978,

while most of the catch remained unreported (Matthes 1980). The word ‘most’ used by the author was interpreted to mean more than 50% (i.e. more than half); the mean between ‘most’ (50%) and all (100%) is 75%. To be conservative, under-reported catches were assumed to range between 60% and 75%, that is $70 \pm 5\%$. Moreover, only trash-fish catches were landed, that is reported (Matthes 1980), meaning that around 70% of targeted catches (Weber & Durand 1986) are transhipped elsewhere and therefore not reported. Therefore, reported catch were assumed to represent $30 \pm 5\%$ of the total Soviet catches for 1978, that is a total of $12\,800 \pm 640$ t·yr⁻¹ divided by the number of vessels (5), and obtained a CPUE of 2560 ± 366 t vessel⁻¹ yr⁻¹. The same rates as for other countries were applied to reflect on overexploitation and a CPUE of 2761 ± 394 t vessel⁻¹ yr⁻¹ was estimated for 1950 and 2008 ± 287 t vessel⁻¹ yr⁻¹ for 2010, which were interpolated linearly to fill in the gaps. Industrial catches were obtained by multiplying the effort per country by the respective CPUE.

This approach takes into consideration vessel gear type and their profiles (e.g. country of origin). It assumes that vessels operating within the same areas with the same gear type and profile would perform similarly; thus using the catch for each unit of capacity (GRT) that characterises vessels is deemed an appropriate measure assuming that fishing vessels would always tend to maximise their catch (Goffinet 1992; Johnstone 1996). This strategy is often used by governments to extrapolate fisheries data when they receive only partial data on catches, for example Liberia (D.B. Personal Observation), The Gambia (Belhabib *et al.* 2013), Côte d’Ivoire (Fonteneau & Troadec 1969). Belhabib *et al.* (2014) used this method to reconstruct illegal catches in Senegal and found that, overall, despite gear differences, the daily catch per unit of capacity was similar across gears (excluding tuna boats and their catches). Note that tuna catches were not reconstructed herein.

Illegal fishing

Illegal fishing encompasses all activities by vessels that are not authorised to fish in Equatorial Guinea’s EEZ. Equatorial Guinea has a low level of fisheries control, monitoring and surveillance. This suggests high rates of illegal fishing. In addition, Equatorial Guinea has also become a narco-state, acting as a staging post for drug operation where cargos are received from the high seas (Wood 2004); thus, the presence of illegal fishing vessels should be strongly suspected. However, in the particular case of Equatorial Guinea, a number of officials and military are often involved in drug dealing

(Wood 2004), which would provide a reason to monitor the Equatorial Guinea's EEZ, if only to keep a watch on their operations, implying that illegal fishing, although high, would be relatively lower than in the neighbouring countries. In 1952, Spain created the *Guardia Maritima Colonial de los Territorios de España en Guinea Ecuatorial* with the mission of monitoring coasts and fisheries (Ministerio de Defensa 2006). Thereafter, in the early 1970s, Soviet agreements with Equatorial Guinea included a strong military presence, notably in the form of three highly sophisticated intelligence vessels (Baynham 1980). Their presence, along with high security levels imposed by Macias, suggests that illegal fishing could have started only in the early 1980s. In the last decade, patrolling at sea by *barreras* increased due to incursions and recent attacks from the Niger Delta (Camps-Serrano 2013). However, these patrols are of a relatively low efficiency and illegal fishing has probably increased (see also Morillas Gómez 2004). While the main objective of these is the surveillance of offshore oil exploitation platforms (Bricola 2008), the patrol vessels initially donated by the USA to monitor the fishing ban along the coast are more involved in controlling and monitoring the potential infiltrations and return of refugees from Cameroon and Gabon rather than illegal fishing (Liniger-Goumaz 1996).

Illegal, unreported and unregulated (IUU) fisheries catches in Equatorial Guinea were estimated at 61% of declared catches (MRAG 2005), of which 14% was illegal fishing as defined in the present contribution, estimated using MRAG (2005) data (five cases against a total of 36 IUU activity reports in Africa). Illegal fishing was assumed to have begun in 1980 (zero in 1979), and interpolated linearly to 14% in 2005, and then kept constant between 2005 and 2010. The landing data supplied to the FAO were smoothed and these were used as a baseline, and then, the previous rates of illegal fishing were applied to the baseline data to estimate total illegal catches. Industrial illegal catches were believed to be exclusively Soviet between 1980 and 1985, to reflect the lack of monitoring during those years, and decreased linearly until they were zero at the collapse of the former Soviet Union in 1990, and then gradually replaced by illegal catches by Chinese vessels, which are now prevalent in the area (Belhabib *et al.* 2015).

Discards

Little information is found on discards in the waters of Equatorial Guinea. Kelleher (2005) provided an extremely low discard rate of 0.5%, which was applied to the domestic catches estimated here. Bricola (2008) indicated that discarded bycatch was often very high in the

Gulf of Guinea and in Equatorial Guinea and that a small portion of the unwanted bycatch that would otherwise be discarded is bought by artisanal fishers from industrial vessels while at sea. Therefore, it was conservatively assumed the equivalent of 30% of the catch by industrial Spanish, Soviet and Chinese trawlers were discarded. A discard rate of 0.5% was applied to the remaining Italian, French and Portuguese tuna vessels, and the vessels from Cameroon, Nigeria, and São Tomé and Príncipe.

Taxonomically, there was no available information specifically on the industrial fisheries of Equatorial Guinea, nor their discards. Therefore, it was assumed the species breakdown of neighbouring Cameroon would apply to industrial fisheries of Equatorial Guinea, given the similarities in the industrial fleets operating in both countries (Table 2).

Assessing uncertainty

The procedure to assess uncertainty of catches is described in Zeller *et al.* (2015) and uses criteria inspired by the Intergovernmental Panel on Climate Change (IPCC Mastrandrea *et al.* 2010.), which attributes to each fishing sector a 'score' that evaluates their quality within a given time as (4) 'very high', (3) 'high', (2) 'low' and (1) 'very low' (Table 1 in Zeller *et al.*

Table 2. Species composition of large-scale fisheries catches in Equatorial Guinea (Laure 1969)

English name	Scientific name	%
Bigeye grunt	<i>Brachydeuterus auritus</i>	39
Senegal seabream	<i>Diplodus bellottii</i>	26
Sea catfishes	<i>Carlarius</i> spp.	7
Bobo croaker	<i>Pseudotolithus elongatus</i>	6
Giant African threadfin	<i>Polydactylus quadrifilis</i>	4
Soles	<i>Solea</i> spp.	3
Longneck croaker	<i>Pseudotolithus typus</i>	3
Canary drum	<i>Umbrina canariensis</i>	3
Rays	Rajiformes	2
African sicklefish	<i>Drepane africana</i>	2
Marine fishes not identified	–	2
Seabreams	Sparidae	1
Sharks	–	1
Marine fishes not identified	–	1
Cassava croaker	<i>Pseudotolithus senegalensis</i>	<0.5
European barracuda	<i>Sphyrna sphyraena</i>	<0.5
Conger	<i>Conger</i> spp.	<0.5
Garfish	<i>Belone belone</i>	<0.5
Shrimps	Peneidae	<0.5
Crabs	Brachyura	<0.5
Lobsters	Palinuridae	<0.5
Cuttlefish	Sepiidae	<0.5

2015). Each score is assigned a confidence interval based on a uniform distribution, whose ranges were calibrated based on Monte Carlo simulations by Ainsworth and Pitcher (2005) and Tesfamichael and Pitcher (2007).

Results

Small-scale catches

Total small-scale catches (artisanal plus subsistence) increased from around $10\,520 \pm 3157 \text{ t}\cdot\text{yr}^{-1}$ in 1950 to $15\,100 \pm 4555 \text{ t}\cdot\text{yr}^{-1}$ in 1970 (Fig. 2). Catches declined considerably thereafter to remain at low levels of $6700 \pm 2557 \text{ t}\cdot\text{yr}^{-1}$ on average during the 1969–1979 fishing ban that restricted fishing activities on the islands and to a lesser extent in Rio Muni. Small-scale catches increased slightly, to around $9100 \pm 905 \text{ t}\cdot\text{yr}^{-1}$ in 2010 (Fig. 2). The contribution of subsistence fisheries to total small-scale fisheries has declined over time (Fig. 2). This decline is compensated by an increase in the contribution of artisanal fisheries (Fig. 2). The small-scale catch estimate takes into account both the increased migration from inland areas to the coast in Rio Muni, and the ban on fishing imposed on the inhabitants of the islands and the *Ndowe* ethnic group in Rio Muni.

Women go fishing typically less than once per month (Keylock 2002), mainly in brackish waters and along rivers (Perpiñá Grau 1945), while men spend an estimated 152 days per year fishing (Anon 2007a). Furthermore, for each woman fishing, there are, on average, three fishermen (Keylock 2002). Therefore, in addition to most of the subsistence catch being taken by women, at least 2.3% of the artisanal catch is taken by women, that is a total of 243 000 t between 1950 and 2010, or 37% of the domestic catch.

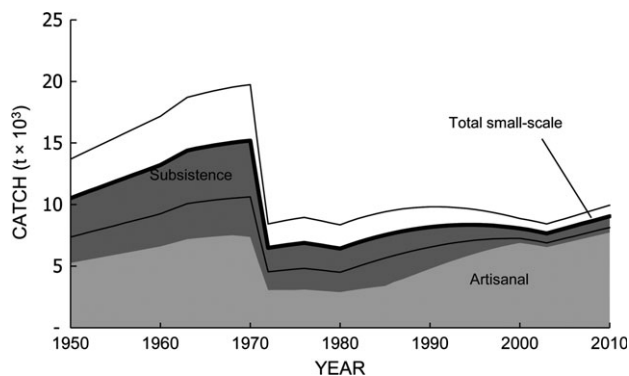


Figure 2. Reconstructed small-scale artisanal and subsistence catches from Equatorial Guinea Exclusive Economic Zone (EEZ), 1950–2010. Total small-scale catches are shown by the black line, and lower and upper bounds of the confidence interval for total small-scale catches are shown by a thin line.

Recreational catches

Recreational catches increased rapidly from $1.0 \pm 0.1 \text{ t}\cdot\text{yr}^{-1}$ in 1996 to $8.0 \pm 1.6 \text{ t}\cdot\text{yr}^{-1}$ in 2010 (Fig. 3). Recreational catches consist mostly of barracudas (*Sphyraena* spp.), groupers (*Epinephelus* spp.) and various species of jacks (Carangidae) along with other unidentified fish species.

Industrial catches by legal fleets

Industrial domestic catches by Equatorial Guinea began in 1986, and, although highly variable over time due to changing fishing effort, were marked by two peaks, the first one of $4100 \pm 813 \text{ t}\cdot\text{yr}^{-1}$ in 1989, and the second, of $3700 \pm 741 \text{ t}\cdot\text{yr}^{-1}$ in 2007, after which catches declined to $2900 \pm 576 \text{ t}\cdot\text{yr}^{-1}$ in 2010 (Fig. 4).

Industrial foreign catches represented the bulk of catches in the EEZ of Equatorial Guinea. Foreign catches, which were relatively constant during the 1950s and 1960s at around $9700 \pm 2831 \text{ t}\cdot\text{yr}^{-1}$, increased to

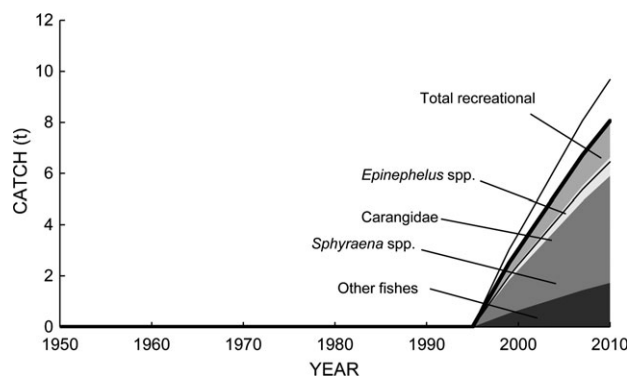


Figure 3. Reconstructed recreational catches from Equatorial Guinea Exclusive Economic Zone (EEZ), 1950–2010. Lower and upper bounds of confidence interval are shown with thin lines.

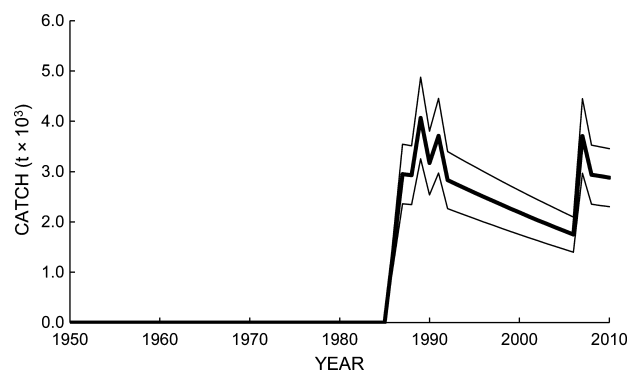


Figure 4. Reconstructed industrial domestic catches from Equatorial Guinea Exclusive Economic Zone (EEZ), 1950–2010. Confidence interval lower and upper bounds are shown with thin lines.

$28\,000 \pm 5\,914 \text{ t yr}^{-1}$ in 1978 when Equatorial Guinea and the Soviet Union signed a fishing agreement, then decreased drastically to $<1500 \pm 300 \text{ t yr}^{-1}$ in 1979, following the end of Macias' rule (Fig. 5). Industrial catches increased considerably with the first agreement with Spain, then with the EU, to $83\,000 \pm 16\,512 \text{ t yr}^{-1}$ in 1990, after which the fluctuations were due to changes in the number of vessels allowed to fish in Equatorial Guinea (Fig. 5).

Industrial tuna catches were not reconstructed herein because of their highly migratory nature and the wide range of movements of the foreign tuna fleets.

Industrial catches by illegal fleets

Illegal catches between 1950 and 2010 increased from zero in 1979 to around $1000 \pm 207 \text{ t yr}^{-1}$ in 2010 (Fig. 6). Illegal catches were taken by Soviet vessels in the past, which were gradually replaced by Chinese illegal catches of $1000 \pm 207 \text{ t yr}^{-1}$ in 2010 (Fig. 6).

Discards

Domestic industrial discards followed the same pattern as industrial domestic catches which are mostly driven by effort changes, that is changes in the number of vessels. Foreign discards were mostly generated by the legal fleet (99%). Foreign discards were relatively constant between 1950 and the mid-1960s at around $3100 \pm 942 \text{ t yr}^{-1}$ (Fig. 7). Discards increased with the presence of Soviet vessels to $8500 \pm 2534 \text{ t yr}^{-1}$ in 1978, after which the agreements with the Soviet Union were cancelled, which drove the industrial catch to its lowest levels (Fig. 7). Discards increased again to a peak of $16\,100 \pm 4827 \text{ t yr}^{-1}$ in 1981, when Spain and Equatorial Guinea signed the first fishing

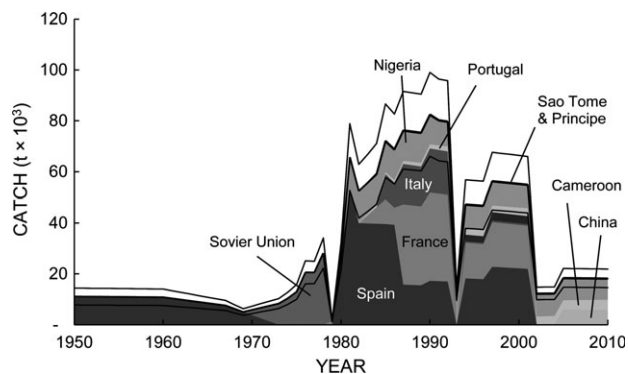


Figure 5. Reconstructed industrial foreign catches by country of origin from Equatorial Guinea Exclusive Economic Zone (EEZ) showing the contribution of each country to the total foreign legal removals, 1950–2010. Confidence intervals of total foreign legal catches are shown with thin lines.

agreement for around 100 trawlers (Fig. 7), and varied thereafter, following fluctuations of fishing effort and catches, before reaching $2100 \pm 630 \text{ t yr}^{-1}$ in 2010 (Fig. 7).

Total reconstructed catches

Total removals from the waters of Equatorial Guinea were relatively steady during the 1950s and the 1960s at around $26\,000 \pm 7600 \text{ t yr}^{-1}$ on average, increased to a first

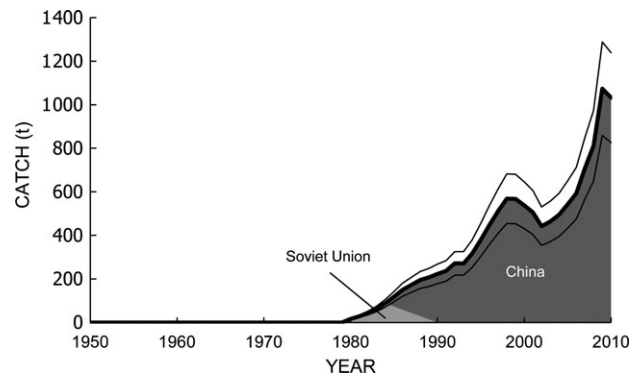


Figure 6. Reconstructed industrial illegal catches by flag from Equatorial Guinea Exclusive Economic Zone (EEZ), 1950–2010.

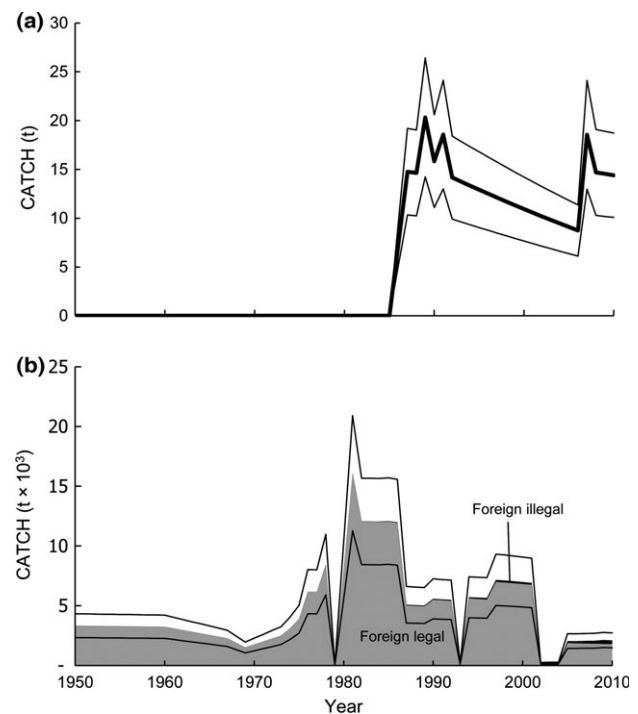


Figure 7. Reconstructed industrial discards by (a) the domestic fleet and (b) the legal and illegal fleets from Equatorial Guinea Exclusive Economic Zone (EEZ) with confidence intervals, 1950–2010.

peak of $43\,000 \pm 10\,400 \text{ t yr}^{-1}$ in 1978, before the departure of the Soviet trawlers decreased to their historical minimum of $8\,000 \pm 2\,300 \text{ t yr}^{-1}$ in 1979 driven by political changes and increased to a historical maximum of $99\,700 \pm 20\,500 \text{ t yr}^{-1}$ in 1990 when fishing effort (notably foreign fishing effort) was at its highest levels. Catches decreased thereafter, although with some fluctuations, to around $33\,200 \pm 6\,000 \text{ t yr}^{-1}$ on average during the late 2000s (Fig. 8a). Domestic catches were 3.5 times higher than the data reported by FAO on behalf of Equatorial Guinea for the 1950 to 2010 time period (Fig. 8a). Domestic catches included mostly jacks, groupers and snappers (Fig. 8b), while foreign catches targeted mainly croakers, sea breams and grunts (Fig. 8c).

Although there is a level of uncertainty related to catch estimates, these remain at acceptable levels, ranging between 10% for the small-scale sector to 20% for the industrial sector and 30% for the discards it generates, in the 2000s. Also, the lower bound of the confidence interval calculated for domestic catches (30% in the 1950s and 12% in 2010) is higher than the landings data provided by the Food and Agriculture Organization on behalf of Equatorial Guinea. When the data estimated here are compared to data provided to FAO, major discrepancies in both the data and their trend are revealed (Fig. 8d). As illustrated by a narrower confidence interval over time, the increasing amount of information that

became available over time reduced the uncertainty of the reconstructed catch (Fig. 9).

Discussion

Total catches from Equatorial Guinea's EEZ were estimated at 2.7 million t between 1950 and 2010, of which 653 000 t were caught domestically and slightly over 2 million t were caught by foreign fleets. Comparison between the reconstructed data and the data that are submitted to the FAO on behalf of Equatorial Guinea can only be done after summing up the domestic marine

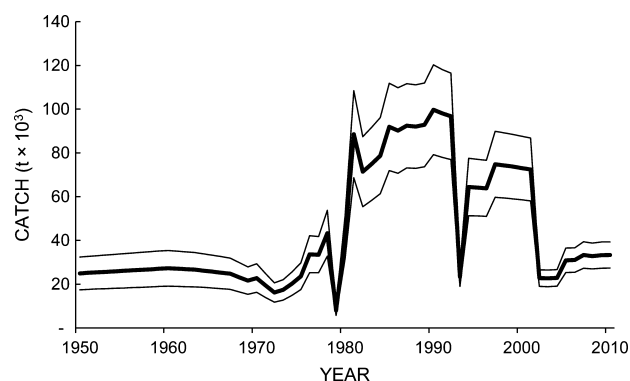


Figure 9. Total reconstructed catches from Equatorial Guinea with confidence intervals, 1950–2010.

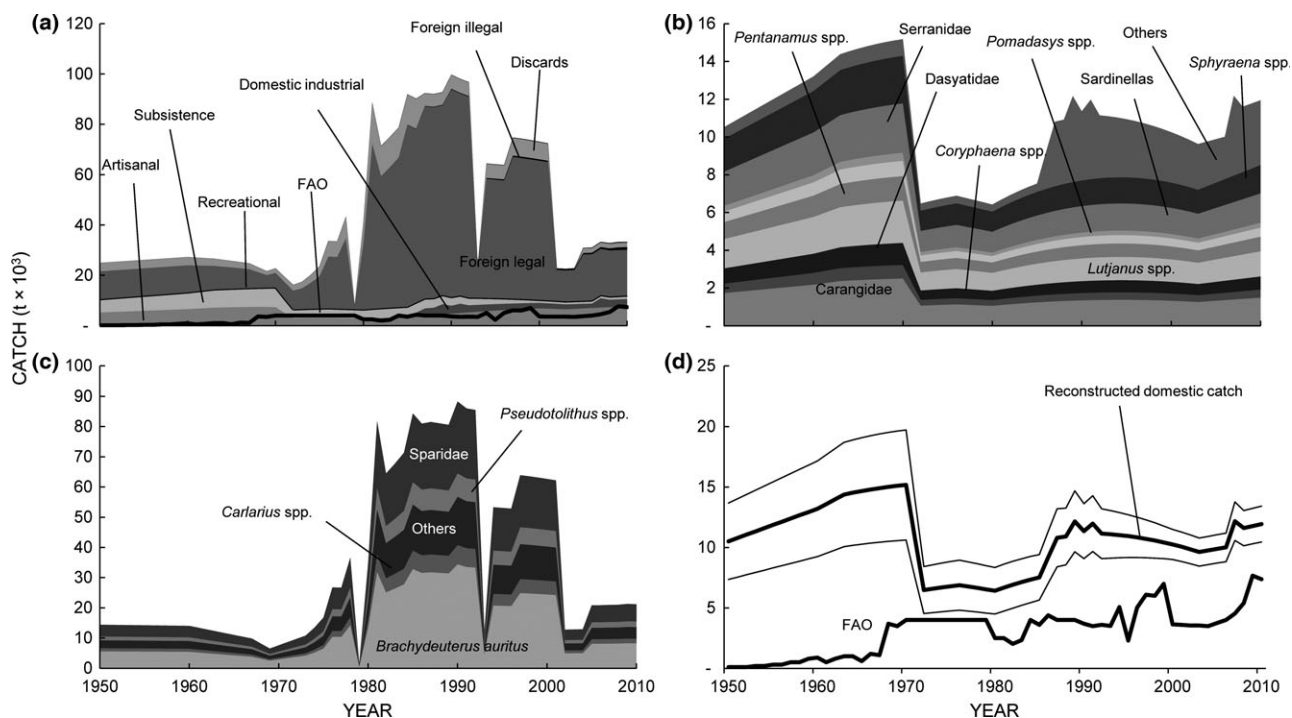


Figure 8. Total reconstructed catches from Equatorial Guinea by sector (a), by taxonomic group for the domestic sector (b), by taxonomic group for the foreign sector (c) and the uncertainty related to total reconstructed catches (d), 1950–2010.

sectors considered here, as official data refer, at least in theory, to catches by both the domestic large-scale and small-scale fisheries. The domestic catch of 653 000 t estimated here was 3.5 times than the 187 000 t reported by FAO on behalf of Equatorial Guinea. This discrepancy between the data reported to the FAO (or estimated by FAO; Garibaldi 2012) and the reconstructed catch data for Equatorial Guinea is one major outcome of this paper. Although the uncertainty involved in the latter is presented here, as opposed to that of the former, the issue at hand is that of bias, that is absence of accuracy. Indeed, reported data are often based on estimates themselves, for example from fishers estimating catches they enter into reporting forms, or landing site inspectors and survey staff, yet in no cases are estimates of uncertainty presented in the reported data. This issue of bias can only be resolved – at least in part – by presenting evidence documenting the likely existence of sectors that are completely or partly misreported, which leads to the bias. An approach is presented here for overcoming this bias while attempting to be conservative.

Equatorial Guinea is classified as ‘food insecure’ based on an argument that most of the animal protein consumed is thought to be imported (East 2003), which is likely because official figures do not include subsistence fisheries and bushmeat. However, it is shown herein that imported fish (114 000 t according to the FAO database) constitutes <50% of available fish supply.³ The importance of domestic fish supply is further illustrated by the observations that population of Equatorial Guinea, particularly people living in the areas classified as ‘food insecure’ consume animal protein – mostly fish and bushmeat – on a daily basis. Thus, the overexploitation of bushmeat species (East *et al.* 2005) adds an interesting and dangerous twist to the situation where fish is increasingly used as a substitute. While FAO and WHO (1985) recommend an average daily allowance of 52 g of protein per day, fish alone in Equatorial Guinea supplies 39 g of protein daily on average (Albrechtsen *et al.* 2005; Fa *et al.* 2009), which represent 75% of the protein allowance recommended in contrast to official figures of 58% (FAO 1997). This further illustrates the importance of fisheries to food security in Equatorial Guinea, as also highlighted by Keylock (2002).

Equatorial Guinea is not only a country where human rights are quashed (Wood 2004), but its population is poor and relies on subsistence activity and the informal economy for their food and livelihoods. Indeed, in contrast to official statements regarding the provenance of seafood, which state that 90% of the fish consumed comes from imports (East 2003), the results obtained here showed the domestic marine fisheries contribute about 50% of fish consumption, which reduces the contribution of imports correspondingly. The latter may be further driven down if freshwater fish catches were accounted for in the present study³.

Although fishing in Equatorial Guinea is perceived as ‘another male-dominated livelihood’ (Kümpel *et al.* 2010), women fishing with nets in groups contribute to feeding village populations (Nse Angüe 2010); this occurs commonly among the *Fang* (Mbama Nchama 1990). The latter author described fishing as a means of bringing food home and one of the major occupations of women of Equatorial Guinea in the past (Romero Moliner 1952). Of the total domestic catch of 653 000 t over the 1950–2010 time period, women caught 243 000 t, or 37% of the domestic catch. Neither the catch, nor the effort of these women has ever been reported, other than being barely mentioned *en passant*, illustrating how overlooking women’s fishing can bias fisheries statistics (Harper *et al.* 2013).

Fisheries in Equatorial Guinea were strongly impacted by the major socio-political events the country went through, particularly bans restricting fishing (mostly on the islands). This is reflected in neither the official figures nor the FAO statistics, which show steady catches during the 1968–1979 time period. On the one hand, killings, migrations, destruction of boats and other constraints to fishing caused domestic fisheries to decline drastically in the 1970s, while industrial fisheries increased due to fisheries agreements bartered for military assistance. On the other hand, after the departure of the Nigerians working on cocoa plantations during the same years, massive numbers of people migrated towards the coast in search of other livelihoods, notably fishing (Castroviejo *et al.* 1994), which eventually contributed to increasing domestic catches.

From the government perspective, newly developed oil exploitation contributed to disregarding fisheries as a source of foreign investment, as illustrated by the decreasing foreign catches resulting from decreasing fishing effort. Moreover, one may suspect that military abuse (Campos-Serrano 2013) and the lack of security within Equatorial Guinea’s waters may lead to the emergence of piracy (Belhabib *et al.* 2015), another risk factor for foreign would-be investors. What these developments imply for the long-suffering population of Equatorial Guinea can only be surmised.

³ This does not account for freshwater fish, which is likely to also be consumed, notably in Rio Muni. This has been accounted for, based on the apparent consumption formula, that is, consumption = (landings + imports – exports)/population. Including small-scale fisheries previously largely omitted from official statistics contributes to lowering the relative contribution of imports to total consumption.

As small-scale fisheries in Equatorial Guinea appear to have a scope for growth, oil companies could grasp this opportunity to direct some of their Corporate Social Responsibility Programmes (CSR) towards assisting fishers to increase domestic fish supply sustainably. For example, CSR programmes could be devoted to help increase appreciation of the crucial role that small-scale fisheries play in Equatorial Guinea, and increase monitoring and surveillance to reduce the impact of illegal fishing in Equatorial Guinea's waters. In addition, this development has to reflect upon strong management strategies such as the prohibition of destructive fishing gear, establishing legal minimum size for fish species and delimiting artisanal and industrial fishing zones. The latter can be done by establishing potential zones of conflict based on the species that are targeted by both sectors illustrated in the present analysis. Also, while there is a striking lack of literature and documentation on Equatorial Guinea's fisheries, the present study, which helped identify the crucial role of small-scale fisheries in ensuring food security, is but one example of the efforts by international non-governmental organisations (e.g. the Wildlife Conservation Society) towards documenting and understanding the current states of Equatorial Guinea's fisheries (see also Hellebrandt & Allison 2012). Supporting and working with the country's fishers requires a delicate navigation between the need to work with Equatorial Guinea's government while also challenging its policy of neglect and/or repression towards its population, and particularly its fishing communities.

Acknowledgments

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Population ('pop.') data used for the catch reconstruction.

Table S2. Industrial fishing vessels operating in Equatorial Guinea.