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Marine Fisheries Catches in Ghana: Historic Reconstruction for 1950 to 2010 and Current Economic Impacts

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Ghana has a long fishing tradition, including industrial fishing. After many of the countries where Ghanaian fleets were actively fishing declared an Exclusive Economic Zone in the 1980s, the distant-water fleet of Ghana returned to its home waters, precipitating a collapse of some local stocks. While official catches reported to the FAO document this decline, the catches of other sectors (artisanal, subsistence, and recreational fishing) were not reported, their contribution to the livelihoods of Ghanaians was simply not documented, and their impact on fish stocks overlooked. Herein, total catches were estimated at 20.8 million tonnes between 1950 and 2010 compared to 11.8 million tonnes reported to the FAO. Subsistence catches, notably from coastal lagoons represented the bulk of unreported catches and seemed to have increased overall during this period, while the artisanal and large-scale sector catches decreased. Furthermore, the economic contribution of artisanal fisheries to Ghana is declining mainly due to use of non-sophisticated technology and activities of industrial fisheries making already poor communities poorer while industrial (particularly tuna) fisheries are increasing their profitability margin due to high technology being adopted and operating in less exploited parts of the continental shelf of Ghana. Accurate catch statistics and a better understanding of the contribution of the marine fisheries sector are needed for sustainable management of the fishing industry in Ghana and its contribution to the Ghanaian economy.

Keywords small-scale fisheries, marine fisheries, catch, economic, industrial, reconstructed, Ghana

INTRODUCTION

Ghana lies in West Africa, and is bounded by Burkina Faso in the north, Côte d'Ivoire on the west, Togo on the east, and the Gulf of Guinea on the south. The country became independent from Britain in 1957 and its current population is about 25 million (UN, 2011), with a land area of nearly 240,000 km^2.

Ghana has numerous rivers which flow from the northwestern part and the northern-central part of the country (see Figure 1). The Volta River empties its water into the Volta Lake, which covers 8500 km^2, behind the Akosombo hydroelectric dam, built in 1964, and which created one of the world's largest artificial lakes. Located in the Gulf of Guinea Large Marine Ecosystem, the coastline of Ghana is rather monotonous, except for relatively large lagoons that are located at its eastern and western extremities. The continental shelf (i.e., waters down to 200 m) is relatively narrow, and ranges from 24 to 80 km offshore. The presence of two major currents, i.e., the Guinea Current, which flows eastwards and the South Equatorial Current, which flows westwards, supports two seasonal upwellings, a high biological and fisheries productivity (FRU/ORSTOM, 1976; Longhurst and Pauly, 1987; Mensah and Koranteng, 1988).

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Figure 1. Map of Ghana showing some major towns, Lake Volta, and the Exclusive Economic Zone claimed by Ghana.

Fish and fishery products are now the country's most important non-traditional exports accounting for over 50% of earnings from non-traditional exports (Bennett, 2002). Moreover, fish contribute 60% of all animal protein consumed by Ghanaians (Sarpong et al., 2005).

Historically, Ghana had a vibrant fishing industry long before the introduction of motorized crafts in 1946 (Irvine, 1947) consisting of a very powerful fleet of canoes using "*ali*"-nets and shore-based fishing using beach-seines, hooks, and lines, and cast and setnets. In fact, the Fisheries Department in Ghana, formed in 1946 by the Colonial Administration, was not intended to start an industry, but only to mechanize and modernize the one already in place. However, the later collapse of the Ghanaian distant water fleet (Atta-Mills et al., 2004), the resulting repatriation of large industrialized vessels and the very presence of foreign fleets resulted in massive overfishing of Ghanaian fisheries resources, and in an impoverishment of the about 200 Ghanaian coastal communities that directly depend on fish for their livelihoods (EPA 1994; Mensah and Antwi, 2002). These communities' actual catch and hence incomes are imperfectly known, as official statistics emphasize more of industrial and commercial landings (Alder and Sumaila, 2004).

This article presents a "catch reconstruction" sensu Zeller et al. (2007), summarized from Nunoo et al. (2014), which provides information on fisheries not covered by official data, and then presents an economic analysis of the reconstructed catch. Herein, emphasis is given to two questions: (i) What is the contribution of marine fisheries to the economy of Ghana and food security? (ii) How did the collapse of the distant water fleet in Ghana impact the livelihoods of coastal communities? An attempt is made to answer these questions by (1) comparing reconstructed catches by sector to the officially reported catch as presented in the fish landings reported by the Food and Agriculture Organization of the U.N. (FAO) on behalf of Ghana; (2) estimating the landed value and profitability of its industrial and small-scale fisheries; (3) assessing the employment generated by fisheries; and (4) analyzing the economic impact of small-scale fisheries on the economy of Ghana.

APPROACH TO RECONSTRUCTION

National landing datasets were compared with the data supplied to the FAO. The first dataset is presented in three categories, i.e., artisanal, industrial, and tuna landings, whereas FAO landing data show species or higher taxonomic grouping. The comparison revealed that overall national data were higher than the data supplied to FAO (Figure 2). While the reason behind this is unknown, we use the FAO data as a baseline and considered the difference as unreported catch given that catch data for commercial sectors (artisanal, industrial and tuna) are comprehensively assessed by Ghana.

Small-Scale Fisheries

Small-scale fisheries include artisanal fisheries operated in the marine waters of Ghana, and subsistence fisheries, represented by the portion of the fish caught by the artisanal fleet that is taken home by fishers, and the subsistence lagoon component. Currently over 12,000 artisanal canoes and about 200,000 fishers (with about 2 million dependents) operate from 334 landing centers in almost 200 fishing villages located

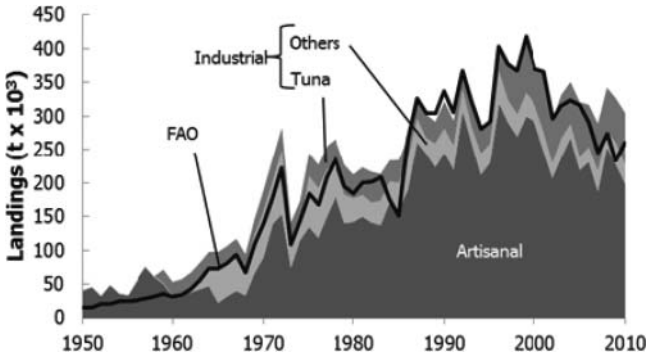

Figure 2. Comparison between national landings and FAO data, 1950–2010.

along the coast (Amador et al., 2006). Official data suggest that this fleet is responsible for over 70% of the total annual landings of both pelagic (sardinellas, mackerels, and anchovies) and demersal fish species (croakers, breams, snappers, etc.). Frame surveys covering artisanal fisheries in Ghana exist (see Nunoo et al., 2014), but they fail to cover the artisanal catch that is taken home for consumption and subsistence catches.

The percentage of catch aimed at personal consumption was estimated on the basis of the observation that a fisher and his family consumed one and half times the annual national average (25 kg of fish per caput), i.e., about 37.5 kg per year per capita (Awity, 2005). The number of fishers for 1950, 1955, 1960, 1969, and 2010 was obtained by multiplying the number of canoes for each year, respectively, by the average number of fishers per canoe, while average household size was reconstructed using government census data.

While there are large lagoons on the western and eastern end of the coast of Ghana, there are also numerous smaller lagoons whose number and surface area were estimated by Walter Pople, a marine scientist at the University of Ghana in the late 1960s and early 1970s (see also Figure 9 in Pauly 1976). Overall, the large lagoons of Ghana, plus the small ones cover a cumulative area of 1100 km^2. As elsewhere in the world, these lagoons are of outstanding economic importance for the over three million people who live close to them (Kapetsky, 1984; Pauly and Yañez-Arancibia, 2013). Nunoo et al. (2014) estimated the mean fisheries catches in Ghanaian lagoons at 13.2 $t \cdot km^{-2} \cdot year^{-1}$, which is reassuringly close to the mean yield of 107 coastal lagoons presented by Kapetsky (1984), i.e., 11.3 $t \cdot km^{-2} \cdot year^{-1}$. Multiplying the former figure by 1100 km^2, gives an annual catch of lagoon fishes of 14,520 $t \cdot year^{-1}$, which is assumed constant during the period considered here.

Recreational fishing in Ghana is a highly popular tourist activity, notably targeting tunas and billfishes[1] (Obeng, 2003), although, herein it is assumed this activity began with the creation of the first tourism board in 1974. Recreational catches were estimated by multiplying the estimated number of tourist fishers by the number of fishing trips estimated at 7 days per tourist and by a CPUE obtained from YouTube records. In the absence of recreational catch records, which is a common issue in fisheries catch statistics, data on the CPUE, the species caught and the number of fishing trips per person could be difficult to obtain. Ghana, although an uncommon touristic destination, remains a popular recreational fishing destination (Obeng, 2003). Thus, tourists tend to document their fishing trips through online fora, blogs, and most commonly YouTube videos. Using the videos posted on YouTube documenting 25 recreational fishers and the species they caught daily, an estimate was made of the average weight caught by each tourist daily at 32.6 $kg \cdot tourist^{-1} \cdot day^{-1}$ (details in Nunoo et al., 2014). When the number of tourists was unclear in the videos, the number of lines observed was used as a proxy. This method was used by Belhabib et al. (2014) to estimate recreational catches in Senegal and Angola (Belhabib and Divovich, 2014) and found that there was no significant difference between catch per fisher records supplied by recreational fishing clubs, obtained from a sound sampling analysis.

Large-Scale Fisheries

Large-scale fisheries in Ghana are divided into three distinct categories, the semi-industrial sector, the industrial, also called "distant-water fleet" (DWF; consisting predominantly of trawlers) and the foreign tuna fleets based in Ghana. Originally, the DWF were fishing outside Ghanaian waters, e.g. in Mauritania and Angola, but the emergence of Exclusive Economic Zone concept in the late 1970s, along with financial difficulties and political instability (Atta-Mills et al., 2004) forced the large DWF vessels to operate in Ghanaian waters, where the continental shelf is rather narrow (Figure 1), resulting in a sharp resource decline (Atta-Mills et al., 2004). The commercial tuna fleet, on the other hand, consisted primarily of Japanese, and later Japanese and Korean, vessels. The peak of foreign fleet domination of the industry occurred in 1973, with 40 foreign tuna vessels based at Tema (Kwei, 1988).

Since the beginning of commercial tuna fishing in the country in 1962 (Kwadjosse, 2009), sardinellas and anchovies were used as live bait and the industry depended entirely on the availability of these small pelagic fish. In the early 1970s, when sardinella fisheries collapsed in Ghanaian waters, anchovy became the only fish used as bait for tuna fishing. Baitfish catches were estimated, which at times represented a non-negligible competition for the artisanal canoe fishery, using the catch/effort of 12.3 $t \cdot boat^{-1} \cdot trip^{-1}$ in Mensah (1977). For the years prior to 1974, it was assumed that 50% of baitfish catches were 50% sardinella and 50% anchovy, given the abrupt decline in sardinella catches in 1973 (Troadec and Garcia, 1980; Binet et al., 1991). From 1974 to 1977, the percentage of sardinella was gradually decreased to 0% and that of anchovy increased to 100%.

Foreign Legal Fisheries

There are relatively few foreign fishing vessels operating legally in Ghanaian waters (Atta-Mills et al., 2004), and most of them appear to be tuna vessels.[2] While in the past tuna vessels were mostly foreign (NOAA 1981), and landed their catches elsewhere, and under-reported it, most of the tuna

[1]http://www.gipcghana.com/life-leisure/recreation.html [Accessed on 27/08/2013].

[2]http://www.fao.org/docrep/v9982e/v9982e1o.htm [Accessed on 26/08/2013].

caught in Ghanaian waters were landed in Ghana (Falaye, 2008). The unreported portion of these catches[3] was estimated, assuming that the unreported component was 10% of the declared national landings at the beginning of the fishery in 1959, and decreased linearly to 1% in 1986. A re-allocation of catches per flag of origin such as Japanese fleet caught 100% of industrial tuna catches between 1959 and 1981, half of the catches were then taken by Korea in 1988, and then each of Japan, Korea, and Ghana were responsible for around a third of these catches in 2010; an interpolation was then done between these rates (details in Nunoo et al., 2014).

All trawlers operating in Ghana were reported as "Ghanaian" regardless of their country of origin, even though the beneficial ownership of these vessels, particularly from China (Pauly et al., 2013), is clearly not Ghanaian. China has recently begun operating pair-trawlers in the waters of Ghana, despite a national ban of pair-trawling in 2007 (Bromfield, 2010). An average catch rate of 1252 $t \cdot vessel^{-1} \cdot year^{-1}$ and vessel numbers between 2002 and 2010 (from Pauly et al., 2013) was used to estimate their catch (details in Nunoo et al., 2014).

Illegal Fisheries

Unlike many other West African countries, the problem of IUU fishing in Ghana lies mostly in the licensed trawlers operating in the artisanal fishing zone, or using illegal fishing gear, illegal trans-shipments, etc. (Falaye, 2008). However incursions, notably by unlicensed trawlers from the EU, and China do occur (Pauly et al., 2013; Antwi, 2006). MRAG (2005) estimated illegal unreported and unregulated catches to be 4% of the total legal catch, but arrests documented in the literature within Ghanaian waters are exclusively due to fishing without licenses/authorization (Kwadjosse, 2009). It was therefore assumed that illegal catches were the equivalent of double this estimate, i.e., 8% at the introduction of the tuna commercial fishery to Ghana after the joint US-Ghana tuna survey of 1959, then decreased to 4% between 2005 and 2010. This rate was then multiplied by tuna landings, which provided an estimate of illegal catches from Ghana. It was assumed that 100% of these catches were of Spanish origin (via incursions from Togo) before 1983, and that 50% were Chinese and 50% Spanish since then.

Discards

Mensah (1977) estimated that about 2015 $t \cdot boat^{-1} \cdot year^{-1}$ of juvenile tuna were discarded at sea. If a bait boat discarded 2015 $t \cdot year^{-1}$, a purse seiner would have discarded at least twice that quantity in a trip since purse seiners were less selective of size; they had higher fishing capacity than bait boats per trip (Kofi Amador, pers. obs.). An interpolation was first made between the number of bait boats and purse-seiners and then multiplied the number of bait boats per year by a discard rate of 2015 $t \cdot boat^{-1} \cdot year^{-1}$ and the number of purse-seiners by a discard rate of 4030 $t \cdot boat^{-1} \cdot year^{-1}$ to estimate the quantity of discards of the tuna fleet operating from the Tema port in Ghana annually between 1959 and 2010.

Discard rates were estimated to be equivalent to landings in the past, i.e., 50% of total catches (Koranteng, 2003). More recently, since evidence suggests that artisanal fishers would buy part of these catches, a conservative assumption was made that only 40% was really discarded at sea. Since this practice is recent and unwanted by-catch in Ghana are increasingly being used as highlighted by Nunoo et al. (2009), discard rates were likely higher in the past. Therefore, an assumed decrease from 50% (average estimate) of total catches, in 1958, when trawling began in Ghana, to 30% of catches in 2010 was made.

Employment

The number of boat owners was taken as the number of boats, while the crew is estimated by multiplying the average number of the crew by the number of boats per segment of the fleet (Table 1). This also applied to the artisanal sector given that the census numbers provided in Nunoo et al. (2014) only accounted for fishers operating canoes. Herein, we used the weighted average equivalent number of fishers for the total artisanal fleet, including beach seines (estimated at 19.2 fishers per boat, using data by Lery et al. (1999). Similarly, we repeated this operation for industrial tuna boats, trawlers and other vessels (semi-industrial fleet and bait boats). Finally, the number of lagoon subsistence fishers was obtained by dividing the total lagoon catch by the average per capita consumption rate of 37.5 $kg \cdot capita^{-1} \cdot year^{-1}$ (Nunoo et al., 2014).

The number of people supported by Ghanaian fisheries (D_t) is obtained as the product of the number of fishers (F_t) and the number of dependents per fisher calculated as the average size per household (Ht) minus 1, to which is added the number of subsistence fishers (S_t), or the equation used to calculate the number of dependents is: $D_t = F_t(H_t - 1) + S_t$. This number of

Table 1. Profitability of Ghanaian fisheries in real \$ $US_{2012} \cdot boat^{-1} \cdot month^{-1}$

Variable	Artisanal	Industrial	Tuna
Revenue	360	2823	90,931
Fishing cost	302	665	43,777
Net income	58	2157	47,154
Average profitability (%)			
1977	84	—	—
1995	27	3	21
2010	16	76	52

[3]Considering the FAO data as the baseline, the total unreported tuna catch is the sum of the difference between the national tuna catch data and the FAO data to which is added this component.

dependents was rather low compared to the general idea that prevails in Ghana regarding small-scale fishers' households, which tend to be more polygamous, and thus have higher fertility rates (Marquette et al., 2002). Therefore, it is reasonable to assume that the number of dependents for artisanal and subsistence fisheries is between our estimate of four derived from the literature and country-wide census data and 7–8, as estimated by the latest census for small-scale fishers (Nunoo et al., 2014). We estimated a minimum and a maximum number of dependents for small-scale fisheries by multiplying the number of fishers by the lower and upper bounds of the household size, respectively.

Landed Value and Profitability

The annual landed value was obtained by multiplying the reconstructed catch landed in Ghana (Ct) by the ex-vessel price (Pt), which is the value of the fish at landing, i.e., $Vt = Ct \times Pt$. Ex-vessel price data in \$ $US_{2006} \cdot t^{-1}$ were extracted from the Sea Around Us database (Sumaila et al., 2007) for Ghana, as revised by Swartz et al. (2012). Ex-vessel prices were obtained by dividing the value at landing by the quantity of fish caught between 2004 and 2008 in New Ghanaian Cedis[4] then converted to \$ US. The price for 2009 was obtained by dividing the price of a box of fish by the unit price of \$7.35 $US_{2009} \cdot box^{-1}$ (Anderson et al., 2010). Each box has a volume of 18.9 L, i.e., 16.35 $kg \cdot box^{-1}$ assuming a fish density of 0.866 $g \cdot cm^3$, i.e., the price for 2009 was estimated at \$449.6 $US_{2009} \cdot t^{-1}$. The nominal ex-vessel prices were adjusted to obtain real ex-vessel prices using the Consumer Price Index (CPI) from the World Bank database.[5] Further, real ex-vessel prices was multiplied by (1) the artisanal reported landings to estimate the reported value for artisanal fisheries; (2) the reconstructed small-scale (subsistence and artisanal) catch to estimate the total reconstructed small-scale catch value; (3) the reported industrial tuna landings to estimate the reported value of tuna fisheries; (4) the reconstructed tuna catch to estimate the total reconstructed tuna catch value per country and that lost by Ghana; (5) other industrial reported landings to estimate the reported landed value for other industrial fleets; and (6) the reconstructed industrial catch value for other fleets.

The landed value per fisher was calculated as the weighted average of the revenue received by fishers, where boat owners and the crew receive different shares depending on the sector. Given that tuna boats reported paying a daily wage with no further details (Lery et al., 1999), it was assumed that the latter was around 5% of the total revenue, which is slightly higher than the crew wage assumed by Sylvia and Davis (2012) for the 2000s (\$0.30 US per hour).

[4]http://munin.uit.no/bitstream/handle/10037/3527/thesis.pdf?sequence=1 [Accessed on 04/11/2013].

[5]http://www.worldbank.org/ddp/home

Profitability is used to assess the ability of Ghanaian fisheries to generate revenue that was over and above the cost of fishing. It is measured as the ratio of the net income (NI) to the total revenue per month (R) for 2010, i.e., $P = NI/R$, where $NI = R - Cv + Cf$, where Cv denotes variable (i.e., operating costs) and Cf stands for fixed costs. Profitability was estimated across all gears, as costs were averaged to allow for harmonization and extrapolation of costs.

While studies documenting the cost of artisanal fishing were available for 1977, 1986, 1989, 1992, 1995, 2010, 2011, and 2012 (Seini 1996; Lery et al., 1999; Obeng and Anderson, 2010; Mensah, 2012; Aheto et al., 2012), the cost of industrial fishing was only documented for 1995 and 2003. To harmonize the costs provided by these different sources, we adjusted the costs; thus, for 1977, we used cost estimates provided by Seini (1996). For 1995, we averaged costs across all artisanal gear provided by Lery et al. (1999). For 2011, we divided variable costs by total catches provided by Mensah (2012) to estimate an average unit cost, which was then multiplied by the total reconstructed artisanal catch, and divided by the number of artisanal boats to estimate variable costs per canoe for 2011. The same operation was performed for 2012 when Aheto et al. (2012) provided costs per kg. Given that opportunity cost for the crew is assumed to be zero (no alternatives other than artisanal fishing), and that the fixed costs are considered sunk costs (the boat is already owned), crew and fixed costs was removed from the total costs. Two cost estimates were available for tuna fisheries and other industrial fisheries (all industrial fisheries excluding tuna) for 1995 (Lery et al., 1999) and for 2003 presented as costs per trip. These costs were multiplied by the corresponding number of trips for industrial fisheries provided by Lery et al. (1999) and estimated total variable costs, and then obtained 2010 variable costs by extrapolating the 1995–2003 trend forwards. Fixed costs for industrial fisheries were only available for 1995 (Lery et al., 1999); therefore, assuming the same trend as for artisanal fishing fixed costs, the costs of industrial fishing for 2010 for both tuna vessels and other industrial fishing vessels was extrapolated. The fixed cost was depreciation, assumed to be 10% of the initial investment, while variable costs consisted of fuel, ice, and labor costs, along with minor repairs. All costs were adjusted onto real costs using CPI.

Economic Impact of Fisheries on the Economy of Ghana

Using the landed value as a proxy for the economic output from fisheries greatly underestimates the full economic impact of fisheries in Ghana, as it ignores downstream activities (Christensen et al., 2013). To account for these, a fishing output multiplier approach was developed by Dyck and Sumaila (2010). This multiplier accounts for direct and indirect effects of the marine fishery on the economy, and allows for the estimation of the total output supported throughout the economy at a given fisheries landed value. The landed value weighted

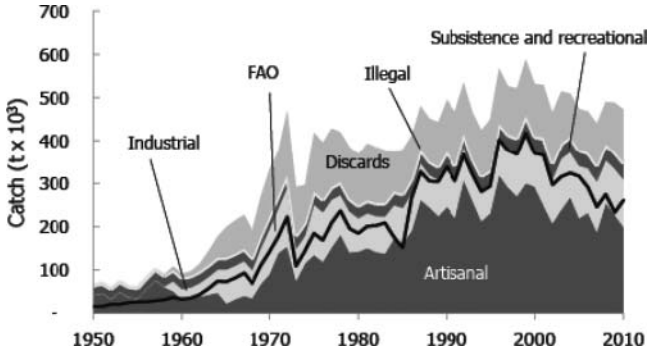

Figure 3. Reconstructed total catches by sector, 1950–2010.

multiplier (M) for Ghana was estimated at 3.14, i.e., each dollar of the landed value generated by fisheries in Ghana (V) can be expected to generate 3.14 dollars of downstream economic output (E), or $E = V \times M$.

CATCH UNDER REPORTING AND VALUE OF GHANAIAN FISHERIES

Total Reconstructed Catches

Total catches from the waters of Ghana were estimated at 20.8 million tonnes between 1950 and 2010, of which 44% were taken by the artisanal fleet (9.2 million t) and 22% by the industrial fleet (notably that reflagged to Ghana), which discarded around 25% of the total (reconstructed) catch (5.2 million tonnes between 1950 and 2010). Non-commercial subsistence and recreational catches contributed 8%, and around 1% was taken illegally by foreign vessels operating in the Ghanaian EEZ. Domestic and reflagged vessel catches were estimated to be almost twice as high as the data supplied to the FAO, with 20.6 million tonnes compared to 11.8 million tonnes between 1950 and 2010. Total catches increased from around 63,000 t·year^{-1} in 1950 compared to 15,000 t·year^{-1} reported to the FAO (for FAO area 34), to a first peak of 469,000 t·year^{-1} in 1972 compared to 222,000 t·year^{-1} reported to the FAO (Figure 3). Catches declined rapidly after the 1972 military coup, to 291,000 t·year^{-1} in 1973 compared to 108,000 t·year^{-1} reported to the FAO (Figure 3). Catches increased thereafter gradually to a peak of 588,000 t·year^{-1} in 1999, with, however, a fluctuating pattern, notably a slight decrease after the second military coup of 1979, and a rapid increase after the 1983 Economic Recovery Programme was initiated (Figure 3). Catches declined gradually thereafter, notably after the 2001 decision to remove fuel subsidies, to 472,000 t·year^{-1} in 2010 (Figure 3).

Tuna catches in Ghana, estimated at 2.4 million tonnes between 1950 and 2010, were mostly taken by Japan and Korea. Overall, tuna catches increased from low levels in 1959 when the tuna fishery was initiated by Japan, to a peak of around 88,000 t·year^{-1} in 2001, of which 40% were caught by Korean vessels, 40% by Ghanaian vessels, and 20% by Japanese vessels (Figure 4). China and Spain were responsible for illegal catches and caught as much as 164,000 tonnes between 1950 and 2010, with increasing illegal catches by Chinese pair trawlers (Figure 5).

Economic Analysis

The economic analysis revealed that ex-vessel prices varied greatly in the early time periods varying from \$300 US·t^{-1} in 1950 to less than \$150 US·t^{-1} in the mid-1950s and then increased to over \$460 US·t^{-1} in the early 1960s, likely due to highly variable inflation rates. Ex-vessel prices, although variable, remained relatively constant since then with a few spikes notably in 1975, 1999, and 2008. The landed value of reconstructed catches in Ghana was estimated at \$4.22 billion US between 1950 and 2010, which is 30% higher than the value of reported landings (\$3.25 billion US), of which 70%, i.e. around \$2.97 billion US were by small-scale fisheries. The total landed value was relatively constant in the past, at an

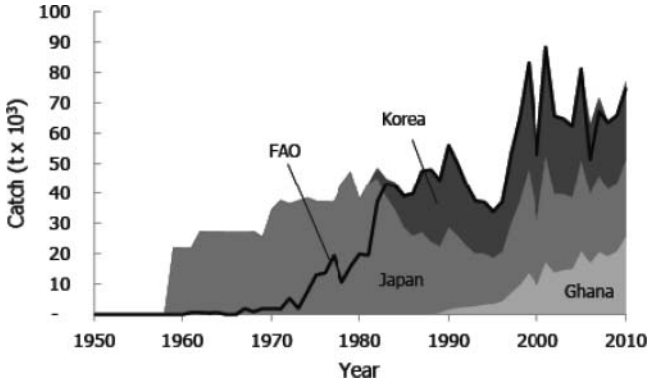

Figure 4. Reconstructed tuna catches compared to the catch data supplied to the FAO, 1950–2010 (note that vessels from Japan and Korea were originally reflagged to Ghana).

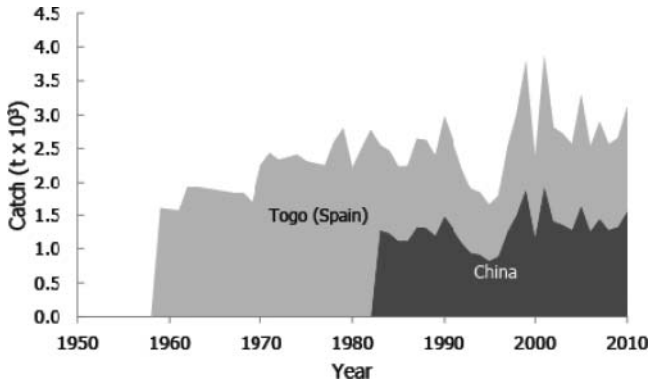

Figure 5. Reconstructed illegal catches from the waters of Ghana, 1950–2010.

average of \$14 million US·year^{-1} in the 1950s, compared to a value of reported landings of \$4.5 million US·year^{-1}. The gap between the landed value and the value of reported landings decreased constantly since the 1950s due to the enhancement of reporting and monitoring of fisheries in Ghana to \$97 million US·year^{-1} compared to \$73.6 US·year^{-1}, respectively, i.e., 30% under-reported (Figure 6). Although the contribution of small-scale fisheries to the total landed value was the highest (Figure 6), the landed value per fisher is by far the lowest (\$20 US·fisher^{-1}·month^{-1}) compared to industrial fisheries (\$84 US·fisher^{-1}·month^{-1}) and tuna fisheries (\$6231 US·fisher^{-1}·month^{-1}). The monthly landed value per small-scale fisher increased from around \$ 11 US·fisher^{-1}·month^{-1} in 1950 to a peak of \$63 US·fisher^{-1}·month^{-1} in 1999, and then decreased rapidly thereafter to be less than \$20 US·fisher^{-1}·month^{-1} in the late 2000s. On the other hand, the tuna fisheries generated an income of around \$12,000 US·fisher^{-1}·month^{-1}when they started and were all Japanese, this value increased to a peak of around \$18,000 US·fisher^{-1}·month^{-1} in the mid-1970s when the fishery was still dominated by Japanese vessels, then decreased gradually to around \$3,000 US·fisher^{-1}·month^{-1} after Ghanaian domestic and joint venture boats entered the industry. These values, although decreasing, greatly contrast the landed value per small-scale fisher.

The average net monthly income for artisanal fisheries was estimated at \$360 US·month^{-1}, with a profitability of 16% for 2010 compared to 27% estimated for 1995 (Lery et al., 1999). This low profitability is further illustrated by net monthly income estimated at \$184 US·fisher^{-1}·month^{-1} for boat owners and less than \$20 US·fisher^{-1}·month^{-1} which is lower than the poverty line of \$1.25 US a day for Ghana (OPHI 2010). In contrast, both tuna and other industrial fisheries were profitable, with returns ranging between 52% for the tuna fisheries and 76% for the other industrial fleets. It is, however, worth noting that boat owners receive the bulk of the income for industrial and tuna fisheries with around \$2000 US·owner^{-1}·month^{-1} and as high as \$86,400 US·owner^{-1}·month^{-1} for tuna boats, while the income of the crew ranges between \$33 US·fisher^{-1}·month^{-1} and \$161 US·fisher^{-1}·month^{-1}. Thus, these crew salaries, although slightly higher than the income received by artisanal fishers, are still considerably lower than the boat owners' income, particularly that of the foreign-owned tuna boats. Today pair-trawlers, small-pelagic purse-seiners and bait-boats are profitable, and the profitability of tuna vessels has increased over time (Table 1).

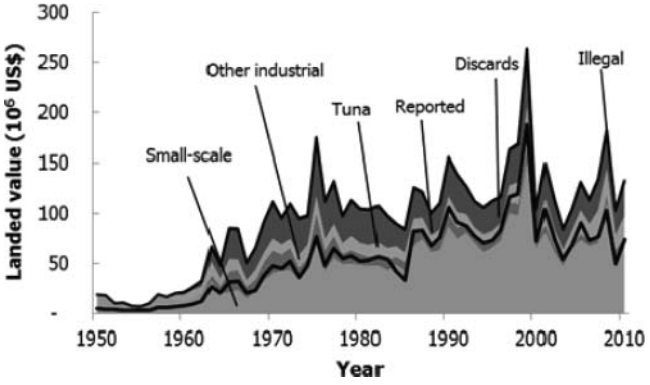

Figure 6. Economic indicators for Ghana's fisheries showing the real landed value of the reported and total reconstructed catch by sector, 1950–2010.

The number of fishers (all sectors) employed by the Ghanaian fisheries increased from 479,000 fishers in 1950 to 645,000 fishers in 2010 (Table 2). The labor-intensive artisanal and subsistence fisheries contributed to 99% of the total employment. The average number of dependents presented in Table 2 was estimated at 3.7 million people, which together with a total employment of 645,000 people for 2010, represented around 18% of the Ghanaian population compared to 61% in the 1950s. These figures are much higher than what is assumed officially with the fishery-dependent population in Ghana, which is estimated at around 652,500 people (i.e., 10% of the coastal population).

Each US dollar produced by Ghanaian fisheries injects \$3.14 US into the economy. Thus, the total current landed value estimated at \$86 million US·year^{-1} generates a potential economic output of \$270 million US·year^{-1}, of which 65% were generated by small-scale fisheries. Discards and illegal fisheries could have contributed an additional \$112 million US·year^{-1}, had the fish in question been landed in Ghana.

Table 2. Employment in the fisheries of Ghana (10^3 people), 1950–2010

Decade	Total population	Small-scale employment	Total employment	Total dependents	% (total population)
1950s	5400	480	490	2800	61
1960s	7600	520	530	3200	49
1970s	9600	550	560	3400	42
1980s	12,500	530	550	3300	31
1990s	16,500	550	560	3500	25
2000s	21,500	610	620	3700	20

CONCLUSIONS

Main outcomes of the reconstruction of fisheries catches for Ghana included important under-reporting and the significant contribution of non-commercial sectors and discards to total catches which were equivalent to a third of the latter. This discrepancy between the reported and reconstructed total is mainly due to a large amount of unreported subsistence catch, tuna baits of anchovy harvested along the inshore waters, and discards by industrial vessels. This study shows conservative results since it does not include the part of catches that is exported at-sea by artisanal fishers (Bromfield, 2010). Moreover, the emergence of Ghanaian tuna purse seiners increased discarding in Ghanaian waters, as the more powerful purse seiners discard large quantities of juveniles of target species, as well as much of their bycatch (Mensah, 1977). Bottom trawlers are also notorious for generating large quantities of discards. While it may be feared that the decreasing sizes of fish in industrial catches may lead to increasing discarding rates, the opposite trend is also observed in West Africa, with increasing resource scarcity leading to an increased retention rate and utilization of previously discarded fish (see, e.g., Behabib et al., 2013, 2014).

The present study illustrates that the marine fishing sector is a far more important asset to national food security for Ghana and the magnitude of resource extraction much greater than has been previously recognized. Thus, this reconstruction provides impetus for the reconsideration of the role of fish in domestic food security, and for caution in allowing international agreements (such as those with China) to stimulate additional fishing effort, especially through ill-conceived foreign access agreements. The reliance on incomplete and substantially under-reported national data puts the fisheries authorities under serious risk of over-licensing, increased fishing access, underestimating the contributions of Ghanaian fisheries and mismanaging the marine ecosystems thereby affecting national food security. The growth rate of the fishing sector has increased from −8.7% in 2011 to 5.8% in 2013 which is higher than the growth rate in forestry and logging sector (−14% in 2011, 0.0% in 2013) (GSS, 2014). The fisheries sector accounted for 6% of Ghana agricultural GDP and 1.4% of her national GDP in 2013 (GSS, 2014). This is the lowest among all of the other agricultural sectors (namely, crops, cocoa, livestock, forestry, and logging) contributing to GDP of Ghana. One reason for this low reported figure is the under-reported data recorded by the fishing sector which must be corrected.

Economically, higher reconstructed catches also meant a higher landed value as compared to the value of reported landings which was at least 30% lower. Small-scale fisheries contributed the most to the landed value with about 70% of the estimated (cumulated) $3.25 billion US. Despite this overwhelming contribution of small-scale fisheries to the total landed value, the value received by small-scale fishers is low compared to other sectors, and continues to decrease since the late 1990s. In strict economic terms, this might indicate a deteriorating livelihood situation of small-scale fishing communities in Ghana in the absence of alternative livelihood choices as the over-exploitation situation continues to prevail.

Furthermore, the low and decreasing profitability of artisanal fisheries illustrated above makes artisanal fishers relatively more vulnerable to this generalized over-exploitation and the presence of unregulated/unmonitored legal and illegal industrial fishing vessels. Indeed, it appears herein that, the profitability of artisanal fisheries has decreased overall since the late 1970s, while industrial fisheries (excluding tuna) have become more profitable. This can be easily explained by the fact that the Ghanaian fleets that operated in the 1990s consisted mainly of the previous distant water trawl fleet operating in the drastically over-exploited Ghanaian continental shelf.

The small-scale fishery contributed to the bulk of employment in Ghana, and the very underestimation of the population-dependent upon Ghanaian fisheries puts a further strain on poverty issues, up to 80% in the small-scale fishing communities (Asiedu et al., 2013). Indeed, the underestimation along with the prevailing poverty and the increasing conflicts with industrial fisheries could lead to the crisis of fisheries in Ghana having much more widespread impact than what the current situation shows. This raises serious concern, particularly when considering that 99% of 3.7 million people depend on these same small-scale fisheries that are getting poorer.

The marine fishing sector is a very important asset to national food security and livelihood for millions of Ghanaians. The incomplete and underestimation of the total marine fish catch of Ghana for the period 1950–2010 and its contribution to the economy are worrying as this could affect the formulation of effective fisheries policies, better fisheries agreements, management of the marine ecosystem, achieving food security, and reducing marginalization of the fisheries sector. A precautionary approach to managing marine fisheries in Ghana is recommended in the present circumstances.

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