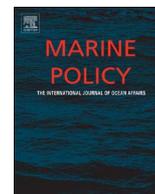




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War, fish, and foreign fleets: The marine fisheries catches of Sierra Leone 1950–2015



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ABSTRACT

In countries like Sierra Leone, where stock assessments based on fisheries-independent data and complex population models are financially and technically challenging, catch statistics may be used to infer fluctuations in fish stocks where more precise data are not available. However, FAO FishStat, the most widely-used time-series data on global fisheries 'catches' (actually 'landings'), does not account for Illegal, Unreported, and Unregulated (IUU) catches and relies on statistics provided by the national agencies of each member country. As such, reported FishStat data is vulnerable to changes in monitoring capacity, governmental transitions, and budgetary constraints, and may substantially underestimate the measure of extracted marine resources. In this report, Sierra Leone's total catches by all marine fishing sectors were estimated for the period 1950–2015, using a catch reconstruction approach incorporating national data, expert knowledge, and both peer-reviewed and grey literature. Results demonstrate that a substantial amount of marine resource exploitation is not represented in official statistics, and reconstructed catches represent more than 2.25 times the recorded FAO Fishstat values. Notably, foreign fleets take the vast majority of industrial catch in Sierra Leone's EEZ, indicating that most of the resource catch and revenue is diverted to foreign companies and export markets. While foreign actors dominate the industrial sector, the small-scale sector represents the majority of domestic catch. Illegal fishing is also a substantial challenge in Sierra Leone, and extracts a large amount of the country's marine fish resources. Reconstructing catches in Sierra Leone also highlights the impacts of various historical events such as Sierra Leone's civil war and post-war reconstruction on the development of the fisheries sector. The results found in the reconstruction present a large discrepancy from FishStat data, with considerable implications for assessment of stocks and management of Sierra Leone's marine resources.

1. Introduction

The fisheries sector in Sierra Leone is critically important as a source of employment, income, and household nutrition in a largely underdeveloped country [1,2]. Though a relatively small country by African standards, Sierra Leone has an Exclusive Economic Zone of 104,850 km², of which 21,700 km² consist of continental shelf (www.seaaroundus.org; Fig. 1). Situated within the Guinea Current, Sierra Leone's fisheries lie within one of the world's most productive marine ecosystems [3,4]. Between 300,000–400,000 people are employed as

workers, fishers, processors, and marketers in the fisheries sector [5,6], fish represent 75% of dietary animal protein for the country's population, and 9.4% of Sierra Leone's GDP is derived from fisheries [7,8].

Despite their importance, Sierra Leone's fisheries have been less studied and are less understood than those of other countries in the region [9,10]. This is largely due to political upheavals following independence from British colonial rule in 1961. Weak governance and marginalization prompted several military coups that culminated in the 11 year-long Civil War from 1991 to 2002 [11,12].

During this time, the already poorly equipped fisheries science and

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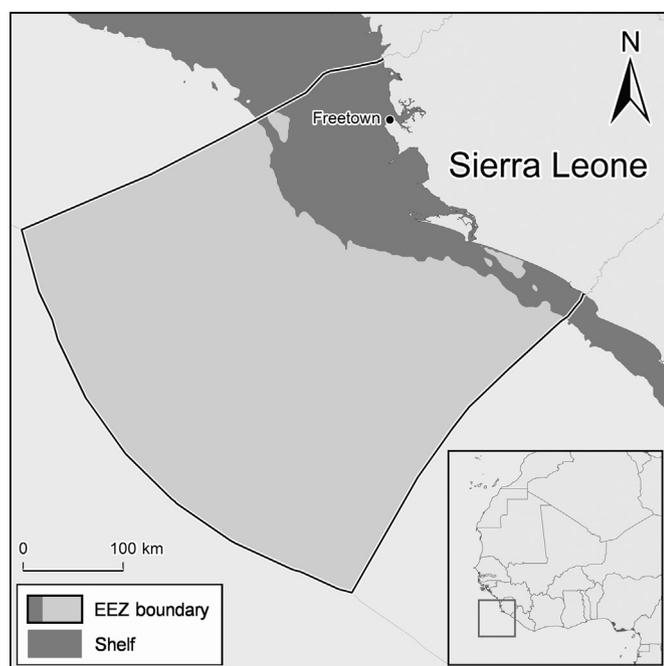


Fig. 1. Sierra Leone Exclusive Economic Zone (EEZ) and shelf waters to 200 m depth. Based on www.seaaroundus.org.

management institutions were unable to adequately operate, and the information on Sierra Leone's fisheries which did exist was largely destroyed during the conflict. The Civil War, though attributable to a combination of factors, was in large part driven by the wealth disparities generated by the exploitation of natural resources [13]. The conflict, emerging from a context of environmental degradation, also generated a tremendous amount of environmental destruction, and the country was ranked 162 out of 180 on the 2016 Environmental Performance Index [14]. Economically, Sierra Leone is also one of the poorest countries in the world, ranking 181 out of 188 countries included in the UN Development Program (UNDP) 2015 Human Development Report [15]. With a *per capita* gross national income (GNI) of \$1780 USD and 59% of the population living in or close to severe poverty [16], fisheries provide a critically important and affordable source of protein and micronutrients for local populations [17].

In developed countries, fishery policies and management decisions are often based on robust data from fisheries-independent stock assessments and complex population models. However, in countries such as Sierra Leone, these techniques are impractical due to the high associated costs and technical demands; in such cases, catch statistics can serve to approximate potential trends in fish stocks where other data are not available [18,19]. FAO FishStat provides time-series data on global fisheries catches (actually 'landings' [20]) beginning in 1950 [21]. The data rely on self-reported statistics provided to the Food and Agriculture Organization (FAO) by the national agencies of each member country [22]. However, since many countries do not have the capacity to monitor catches landed in remote or decentralized areas—such as those in artisanal or subsistence fisheries—FAO fisheries statistics have been shown to underestimate catch in most countries [20]. Catch statistics also do not account for Illegal, Unreported, and Unregulated (IUU) catches, and therefore may substantially underestimate the measure of extracted marine resources [23,24]. Variations in data gathering and reporting are also of particular concern in self-reported time series, as policy priorities, management approaches, and monitoring and enforcement capacity may change over time [20,25]. This is especially true for countries such as Sierra Leone, which have been persistently disrupted by civil conflict. Since these data are often used in formulating fisheries policy and management approaches, these underestimations may lead to inappropriate and detrimental policies

and management measures [26].

Here, total marine catches by Sierra Leone within its Exclusive Economic Zone (EEZ) were re-estimated from 1950 to 2015. Estimates of foreign and IUU fishing are also included. The goal of this reconstruction is to provide a more accurate characterization of all marine fisheries sectors in the Sierra Leone EEZ, in order to understand the historical development of the sector and better inform policy and management measures.

2. Materials and methods

The catch reconstruction method utilized here followed the reconstruction approach described in Zeller et al. 2007 [18], as updated in Zeller et al. 2015 and Zeller et al. 2016 [27,28]. The Sierra Leone total catch reconstruction, including details not described here (e.g. full taxonomic breakdown of reconstructed catches), are fully documented in the technical report underlying the present study [29].

2.1. Human population data

Human population data from 1950 to 1959 was obtained from the Central Intelligence Agency (CIA) World Factbook 2011 [30]. Time series population data 1960–2015 were obtained from the World Bank Population Database [31]. Fishers' censuses were conducted as part of the Sierra Leone national frame surveys in 1974, 1981, 1991, 2003, and 2009, from which it was possible to derive the percentage of artisanal fishers in the population at those anchor points in time. Linear interpolations were made between anchor point proportions, assuming similar proportions to population data.

2.2. Fisheries sub-sectors

The data that served as the reported catch data baseline for this study were extracted from the FAO FishStat database [21]. A thorough analysis of peer-reviewed, government, and non-government organization (NGO) publications, as well as other grey literature, enabled us to identify sectors with missing or incomplete information. To supplement this literature, local and scholarly expertise was sought in each of these fisheries sub-sectors, in order to formulate the best possible assumptions. Utilizing these sources, catches were then derived for 1950–2015, based on anchor points in the literature and knowledge-based assumptions.

2.2.1. Small-scale fisheries: subsistence and artisanal catches

2.2.1.1. Artisanal fisheries. For the early artisanal fishery, defined as small-scale commercial fisheries, very little data were available regarding catch, fisher population, or fleet size, although several national data sources were identified from the 1970s onward [12,32–35]. While these national catch data were generally higher than those reported to FAO, consultation with local experts indicated that they were likely still low, considering the substantial limitations on monitoring and reporting during those years. With this in mind, catches from the small-scale sector were determined using estimated catch per unit effort (CPUE) rates, summarized in Appendix A Table 1, based on expert knowledge and national data [33,35,36]. Derived CPUE rates are considered very conservative in comparison to neighboring countries and in-country expert estimates [37,38].

2.2.1.2. Subsistence fisheries. Only scarce information is available regarding the subsistence aspect of marine fisheries in Sierra Leone, and what little there is pertains solely to inland or marginal fisheries (e.g. mudskippers) [12,39–41]. All available *per capita* consumption estimates were secondarily derived from FAO reported landings, and literature suggests that few if any studies have been undertaken to determine actual *per capita* intake of fish in Sierra Leone [1]. However, evidence suggests that marine fish caught in the artisanal fishery are

sold to fish processors immediately upon landing the catch. Virtually all small-scale catch is landed in local markets, and very little is set aside for household consumption *before* landing and sale [34,42,43]. Therefore, for the purpose of the reconstruction, subsistence was calculated as a subset of reconstructed small-scale landings. As information on the quantity of non-market fish consumed by households was unavailable, estimates were derived using a 1993 study of household consumption, which stated that 95% of nationwide respondents consumed fish daily, and 7% of those respondents accessed their fish by catching it [1]. Applying these percentages to a time series of population data, an estimate of subsistence fishers was derived, and catch estimates were determined by applying an annual per capita consumption rate of 20.8 kg-person⁻¹·year⁻¹ from the artisanal marine fisheries sector [2]. For the years 2014–2015, the estimate of subsistence fishers was assumed conservatively to have increased by ten percent from the baseline methodology. This increase represented the lower bound of expert in-country observations, as national policies and local advice during the Ebola epidemic led to a decrease in bushmeat consumption, decrease in market activity, and increase in fishing for household consumption [44].

2.2.2. Domestic industrial fisheries

The majority of industrial fishing in Sierra Leone has been conducted by foreign vessels. However, beginning in the late 1970s and early 1980s, a concerted effort was made to increase the capacity of the national industrial fleet, eventually leading to the establishment of the Sierra Fishing Company (SFC) and the Marine Development Company (MDC) [36,45,46]. Although both companies have mixed ownership (at its conception, SFC's ownership was 25% Government of Sierra Leone, 10% National Development Bank, 20% Franco-Soviet company, and 45% private Sierra Leone entrepreneurs), they are considered to be domestic vessels in the literature and are counted as such in the reconstruction [36,47]. National industrial fleets are comprised primarily of shrimping vessels, with a small number of demersal trawlers active during some years [36,48]. Thus, the reconstruction of the Sierra Leonean domestic industrial fishery was separated into two sectors: the shrimp fleet and demersal fish trawler fleet (Table 2).

2.2.2.1. Industrial shrimp fishery. Evidence suggests that there was no domestic industrial shrimp fishery in Sierra Leone prior to the late 1970s [36,48,49]. However, due to its high market value in relation to other fisheries, shrimp and prawns were the subject of numerous studies in the late 1970s and early 1980s, with emphasis on the potential for developing a fishery [36,50,51]. Following this rise in interest, the domestic industrial fishery was created, and national statistics on shrimp catches in the domestic fishery are available beginning in 1977 [47,49,52]. For 1977–1979 and 1984–1986, reported shrimp catches in national data were utilized for the purposes of the reconstruction. During the years 1980–1983, estimates were created by combining the reported catches of the Sierra Fishing Company and the Marine Development Company, using a headless to head-on conversion ratio of 1.6 [36,53,54]. For the period 1987–1993, national estimates were only available from the Sierra Fishing Company catches, and FAO FishStat data were considered to be more accurate than reconstructed landings. Beginning in 1994, several sources mention the virtual disappearance of the domestic industrial fishing fleet, due to declining catches, declining foreign support (primarily Soviet), logistical challenges, civil war, and poor economic conditions [48,55]. Considering the fact that this period also coincides with some of the highest reported catches of shrimp in the FAO data, shrimp catches beginning in 1994 were not considered to be caught by a domestic fleet, but rather foreign vessels under joint ventures or access agreements (i.e., majority foreign beneficial ownership).

Discards for the domestic industrial shrimp fishery were calculated

at 1:1.085 (landed shrimp to total discards) from national data sources [41]. This discard ratio is considered conservative in comparison to neighboring countries [55–57]. However, discards in Sierra Leone may indeed be lower than the regional average, since industrial vessels are legally obligated to land a portion of bycatch, and a substantial amount is in fact locally marketed [9,34,55,58,59].

2.2.2.2. Industrial demersal trawl fishery. In addition to the shrimp fleet, a domestic demersal trawler fleet was active during some years in Sierra Leone. Although information on the development of the early fishery is limited, landings data from the national demersal fishery were available for the years 1971–1982 [36]. For 1983–1986, reconstructed catches are the catches reported by the Sierra Fishing Company trawler fleet only. The value of the reconstructed catches is likely to be an underrepresentation of actual catches, as data were unavailable for other participants in the fishery. After 1986, estimates of domestic industrial catches—distinct from foreign industrial catches—are not available, and estimates were derived from vessel data. Anchor points for domestic industrial demersal fleet size were available for 1988 and 1994 [9,47], and fleet size was interpolated between anchor points. A catch per vessel rate of 446.584 t·vessel⁻¹·year⁻¹ was applied, which was derived from the average annual rate observed in the entire industrial fleet (foreign and domestic vessels) over the period 1994–2007. This estimate was considered conservative, as several sources indicate a decline in CPUE after the late 1980s, and so the applied CPUE of 446.584 is likely lower than the true CPUE for 1987–1994 [60] (Appendix A Table 3).

Discards for the demersal trawler fleet were calculated at 1:0.132 (landed fish to total discards) from national data sources [41]. Similar to the shrimp fishery, the ratio is considered conservative for the region [55–57].

2.2.3. Other fisheries

Other sectors that were examined for potential reconstruction included shark fisheries, recreational fisheries, and non-shrimp invertebrate fisheries. Although sharks have been caught by artisanal fishers in Sierra Leone for decades, the majority of these landings were incidental bycatch, and targeted shark fishing only emerged in the 1980s, corresponding with the global rise in demand from East Asia [21,32,61]. While a specialized artisanal shark fishery has been identified in Sierra Leone for the marketing of fins, the impacts of this dedicated fishery are considered to be minor, as discards are minimal and carcasses are marketed locally or to migrant Ghanaians, Senegalese, and Gambians [32].

Non-shrimp invertebrate fishing and shore-based gleaning has occurred throughout Sierra Leone's history, and while several species are exploited, the characteristics of the fishery are poorly known [62,63]. Similar to shark fishing, these invertebrates are also targeted for the market, and are typically part of the mixed species of the artisanal catch and industrial bycatch [43,47,62]. Regarding Sierra Leone, it was stated that “there are a number of under-utilized resources which may have a high commercial potential, but commercial exploitation depends on improved shore facilities... these [resources] include mangrove crab, bivalve molluscs, shrimp aquaculture, and recreational fishing” [9]. While evidence suggests that a specialized sea cucumber fishery has recently emerged in response to the growing Chinese population in Sierra Leone, this is an area in acute need of study, and no data on catch or effort are currently available (Sawyer 2011). Utilizing data on sea cucumber dry weight exports (MFMR, unpub. data) covering six months between 2011 and 2012 (Appendix A Table 4), the figures were converted to wet weight by multiplying by a factor of 9 [64], and catches were extrapolated linearly from the estimated start of the fishery in 2005.

Although there has been substantial interest in the potential for recreational fishing, and game fish outfitters have operated intermittently in the past, the sector is minimally developed, in large part

due to the civil war and lack of development and infrastructure [3,9].

2.2.4. Foreign fishing in Sierra Leone's waters

The vast majority of industrial fishing in Sierra Leone's waters has been conducted by foreign vessels, whether legally through access agreements, joint ventures or reflagging, or illegally [34,35,60,65]. Vessels from numerous countries have been documented fishing in Sierra Leone's EEZ or EEZ-equivalent (prior to EEZ declaration) waters, some as early as the 1940s [9,36,41,66]. In the absence of reliable foreign catch data, estimates of foreign industrial production were derived from vessel data. National sources were available for the demersal trawler fleet from 1958 to 2015, and anchor points were identified from various sources for the shrimper, long liner, and purse seiner fleets (Appendix A Table 5). Fleet size was interpolated between anchor points, and domestic fleet estimates were subtracted from the industrial fleet, in order to capture foreign vessels only. Using Kaczynski's (1989) estimate of foreign fleet performance in Guinea of 240 fishing days per vessel, and 10 t per day, a conservative 100 fishing days per vessel at 8 t per day was assumed based on expert observations and evidence that marine resource exploitation in Sierra Leone is slightly lower than in other countries in the region [33,52,65]. Additionally, information was gathered from several sources regarding the various flags of vessels fishing in Sierra Leone throughout the time series, and catches were allocated to all nationalities active in each year. A summary of active vessel nationalities is available in Appendix A Table 6.

Illegal foreign fishing is a major issue in Sierra Leone's waters, with illegal catches previously estimated to reach 103,000–127,000 t per year [67]. Aerial surveys in 2000–2001 found that 30–51% of actively fishing vessels were found to be operating illegally, and some reports have estimated that illegal fishing may account for over 26% of total fish catch in Sierra Leone [9,67,68]. While it is not possible to reconstruct illegal catches from observation data, illegal catches were estimated using approximate ratios of illegal to total industrial fishing, summarized in Appendix A Table 7, based on expert knowledge and published anchor points. The relationship to total industrial catch was considered preferable to other proxies such as illegal activity in neighboring countries, licensed vessels, or interdictions, which demonstrate both positive and negative relationships with illegal activity based on various factors. Derived ratios are considered very conservative in comparison to other estimates of illegal fishing in Sierra Leone [9,67].

3. Results

3.1. Small-scale fisheries: Subsistence and artisanal catches and artisanal catches

Reconstructed catches from the small-scale fishery in Sierra Leone rose steadily from 1950 to 1960, until the influx of several thousand Ghanaian refugee fishers led to a sharp increase in small-scale landings in the early 1960s. Catches remained high until the repatriation of the Ghanaians led to a drop in catch from around 116,000 t year⁻¹ in 1966 to 103,000 t year⁻¹ in 1969. However, catch levels began to increase again in the following years, reaching a peak of nearly 134,000 t in 1977, before declining again in the 1980s (Fig. 2A). This latter decline is largely attributed to increased technology and motorization, which led to increased competition, overcapitalization and decline in CPUE in the 1980s [12,33,35,48]. Furthermore, catches declined substantially during the period of Sierra Leone's Civil War from around 124,000 t year⁻¹ in 1990 to just under 80,000 t year⁻¹ in 1999, due largely to population displacement and labor redeployment [12,69,70]. However, a tremendous increase in post-conflict development support to the small-scale fishery sector led to dramatic increases in effort, and increases in catch from around 123,000 t year⁻¹ in 2000 to over 296,000 t year⁻¹ in 2015 [48].

3.2. Industrial shrimp fishery

Sierra Leone's industrial shrimp fishery was established in the 1970s and catches rose to 1740 t year⁻¹ in 1982, as domestic companies increasingly invested in vessels and infrastructure. However, following the initial investment, the active domestic fleet declined due to decreasing CPUE, scarcity of foreign exchange, lack of local infrastructure, and increases in license and royalty fees collected following the entry into force of the 1990 Fisheries Regulations [49]. Catches steadily declined to 573 t year⁻¹ in 1993, the same year in which sources indicate the virtual disappearance of the domestic industrial fleet (Fig. 2B).

3.3. Industrial demersal trawl fishery

The domestic demersal trawl fleet in Sierra Leone emerged in the 1970s, in response to growing international interest in the sector. Catches from the industrial demersal trawl fishery peaked in 1978 at around 5700 t year⁻¹, spiked again in 1985 at just under 4300 t year⁻¹, and declined steadily to the mid-1990s. For the period 1994–2015 (Fig. 2D), catches were considered to be zero, as evidence suggests that there was no domestic industrial trawl fishery active during or after the civil war [9,48].

3.4. Foreign fishing in Sierra Leone's waters

3.4.1. Legal foreign fishery

In contrast to the minimal domestic industrial fishing, sizeable foreign fleets have been active in the Sierra Leone EEZ and wider Eastern Central Atlantic (CECAF) region for decades. Although foreign vessels have been documented in the area since at least the 1940s, foreign activity is said to have increased substantially in the late 1960s, in response to UN exploratory surveys of the fishing resources [35,66,71]. Effort from foreign fishing vessels again increased in the late 1970s, and the number of foreign vessels licensed in Sierra Leone peaked in 1987 [36] with associated catches estimated at 200,800 t year⁻¹ (Fig. 3). After this peak, vessel numbers again declined, due principally to declining catches, the withdrawal of Russian vessels following the dissolution of the Soviet Union, and onset of the Sierra Leonean Civil War in 1991 [12,41]. In the last several years, Sierra Leone increased the number of licensed foreign vessels in order to increase revenue from the sector, and 2015 has the highest number of foreign vessels since 1990.

3.4.2. Illegal foreign fishery

Estimated illegal fishing remained low through the 1950s–1960s, and was only associated with the area within 12 nm from shore during this period, as the Sierra Leone EEZ had not yet been declared. However, catches increased from around 5700 t year⁻¹ in 1969 to a peak of just over 99,000 t year⁻¹ in 1987, spurred by a rise in foreign fishing interest in the area following UN exploratory surveys of fishing resources [35,66] (Fig. 2C). With the exception of 1991 (19,000 t year⁻¹), when monitoring, control, and surveillance activities were increased for a short time, illegal catches oscillated between 85,000–20,000 t year⁻¹ from the 1980s through 2001 with the end of the civil war. Following the war, decreases in licensed vessels, coupled with increases in enforcement against illegal vessels, led to a decline in the estimated amount of illegal fishing (13,800–20,800 t year⁻¹). With the exception of the period of civil war, estimated illegal foreign industrial fishing reached its lowest level since the 1960s at around 16,000 t year⁻¹ in 2009, when substantial monitoring, control, and surveillance (MCS) efforts led to a reported decline in illegal activity. However, since 2009, illegal foreign fishing has grown, attributed in large part to decreasing MCS and fisheries development aid as well as increases in MCS in neighboring Guinea. Illegal foreign fishing is estimated to have exceeded 42,000 t year⁻¹ in 2015.

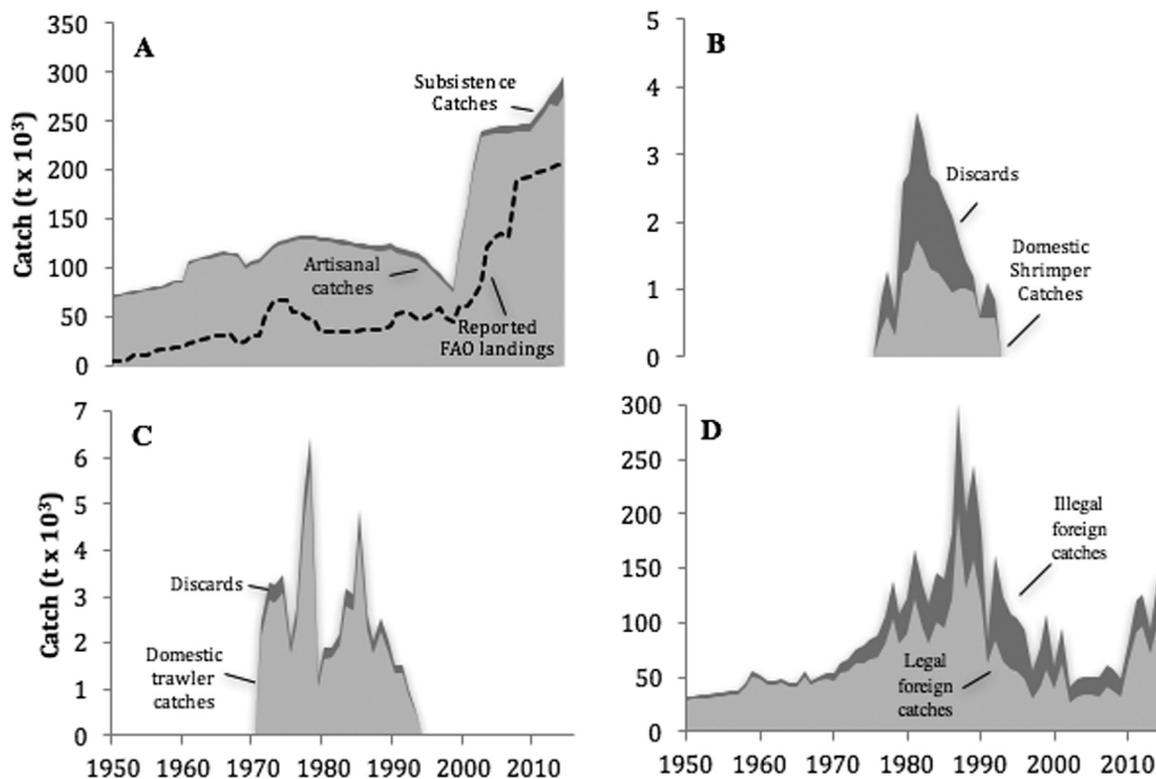


Fig. 2. A) Reconstructed domestic small-scale catches compared to total FAO landings (dotted line); B) Domestic industrial shrimper catches and discards; C) Domestic industrial trawler catches and discards; and D) Estimated illegal foreign industrial catches.

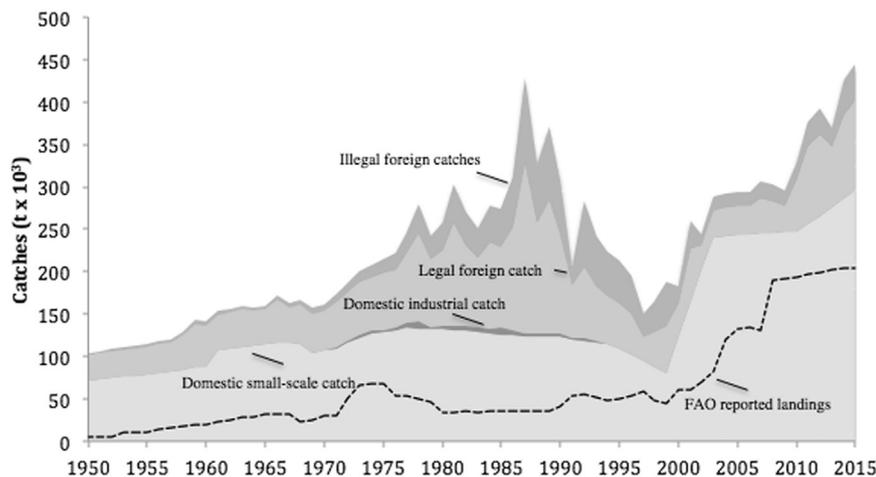


Fig. 3. Total reconstructed catches (both domestic and foreign) in Sierra Leone's EEZ 1950–2015 compared to total FAO FishStat catches reported for Sierra Leone (domestic catch only, dotted line).

3.5. Total reconstructed catches

Over the period 1950–2015, total reconstructed catches of the domestic fishery within the Sierra Leone EEZ amounts to 9.4 million tonnes, or 2.27 times that of reported FAO data (Fig. 3). In addition to the domestic fishery, legal and illegal foreign catches amounted to a total of 5.4 million tonnes.

4. Discussion

Historical development of Sierra Leone's marine fisheries is particularly difficult to assess. The data which did exist regarding the social, ecological, and economic aspects of exploitation in past

decades were largely destroyed in the burning of the Ministry of Fisheries and the Institute of Marine Biology and Oceanography (IMBO) during the civil war [9,12]. Although efforts have been exerted in the past to assess the marine fisheries potential in Sierra Leone [36,72,73]—and several recent endeavors have produced stock

assessments and biomass estimations [74]—quantitative data on the characteristics of historical exploitation are largely absent or destroyed.

However, despite limited quantitative information, four themes emerge from the literature giving insight into the historical development of Sierra Leone's marine fisheries sector. The first is the profound importance to the population of Sierra Leone of small-scale fishing, which was found to be greater than three times the national catch data reported to FAO in some years. This finding supports evidence from many countries, especially in West Africa, that fisheries and other harvested foods provide one of the most affordable and easily accessible sources of nutritious food to some of the most vulnerable populations [17,75–78]. Furthermore, since FAO often computes fish consumption from fish landing statistics, this finding suggests that fisheries may represent an even more essential component of Sierra Leonean diets than the already high estimates by FAO [7].

The second theme found to be strongly influential in Sierra Leone's fishing sector is the prominent role of foreign fishing, and the challenges of discerning legal from illegal operations. The case of Sierra Fishing Company highlights the complex arrangements of ownership, licensing, and ultimate beneficiaries of Sierra Leone's domestic resource, and renders realistic assessment of stocks and effort highly challenging. In this assessment, illegal foreign fishing estimates fluctuated between 5000–100,000 t·year⁻¹, in addition to legal foreign fishing estimated at 20,000 to 200,000 t·year⁻¹. In Sierra Leone, these foreign catches exceed the total domestic catch and in some years approach or surpass estimates of the total fishable biomass in Sierra Leone's EEZ [36]. If these estimates are correct, then foreign fishing in Sierra Leone has historically represented a major threat to fisheries sustainability, and by extension, to domestic food security and livelihoods. Furthermore, since Sierra Leone lacks the infrastructure and enforcement capacity to exclude illegal actors and optimize domestic fisheries, [79], these catches by foreign actors represent a substantial share not captured for domestic economic and nutritional benefits.

Third, evidence suggests that the civil war had a profound and diverse array of consequences for marine resource exploitation. Some examples include migration both into and out of coastal areas, displacement of traditional fishers, increases in foreign illegal fishing, decline of fishing infrastructure, decreases in commercial fishing, breakdown of fisheries management institutions, the dissolution of the domestic industrial fishing fleet, and increases in subsistence harvesting [48,69]. These consequences demonstrated both positive and negative effects on fisheries resources; for example, the displacement of traditional fishers may have created a temporary refuge effect for inshore stocks, while the breakdown of management institutions and increases in foreign illegal fishing may imperil stocks and challenge resource management in the long term [12,70]. This assessment of Sierra Leone's fisheries catches improves our understanding of the role of history in the country's fisheries sector development, and provides a broader understanding of the consequences of civil conflict for harvested food systems [70,75].

Lastly, following the civil war, there has been a dramatic increase in effort in the small-scale sector. This is attributed to massive increases in development aid in the form of outboard engines and fishing gears, as well as the commercial incentives that entice small-scale fishers into illegal partnerships with industrial fishers (acting as transshipment vessels and extensions of the foreign industrial fleet in nearshore areas) [48]. In this context, the initial increases in CPUE observed by fishers following the civil war may be undermined by the development goal of increasing capacity in marine fisheries. While fisheries sector reform has been seen as a positive contributor to post-conflict peacebuilding and development, increases in employment in the sector may not be sustained in the long term if fishing effort surpasses the productive

capacity of the resource.

Between 2010 and 2013, many Sierra Leonean fishers noted an increase in both the availability and size of catches, which was attributed to the decreased competition from foreign vessels resulting from the introduction of a vessel monitoring system (VMS) in 2011 and the extension of the Inshore Exclusion Zone (IEZ) beyond 5 nm in 2012 [12,80,81]. However, from 2014 to the present, Sierra Leone has again witnessed substantial increases in illegal foreign fishing, leading to a rise in competition with artisanal fishers and the termination of major development projects aimed at reducing illegal activities. Despite these challenges, Sierra Leone has demonstrated steady improvement in FAO reporting over the time series (e.g. reconstructed catches represented more than ten times that of FishStat in 1950, compared to a difference of only 36% in 2010). While these improvements are the result of great effort by the authorities concerned, and represent major achievements in the management of Sierra Leone's marine resources, continued and consistent progress in monitoring, surveillance, enforcement, and reporting will be critical to ensuring the persistence of the country's marine resources.

5. Conclusion

While fisheries management in Sierra Leone is hindered by a lack of data and historical documentation, this study has combined various data sources in order to create the most accurate representation of Sierra Leone's historical marine resource exploitation. Results from this work have demonstrated the influence of various events and trends on fisheries catch levels over time, including Sierra Leone's civil war, post-war development, and national and international management and policy approaches. This work has also assisted in disaggregating catches in Sierra Leone into small-scale, domestic industrial, and foreign sectors, facilitating a greater understanding of exploitation patterns and beneficiaries. In identifying, and providing estimates for, missing and incomplete information on Sierra Leone's marine fisheries catches, this study enhances our knowledge of the historical trends and current status of a critical sector in Sierra Leone's culture, economy, and food sovereignty. The results of this reconstruction have been validated by extensive in-country consultation with the Ministry of Fisheries and Marine Resources, fishers, and various stakeholders, and may hopefully contribute to the growing literature on Sierra Leone's marine resources.

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Appendix A

See Tables 1–7 here.

Table 1
Summary of data, assumptions & sources used for CPUE estimates of small-scale fishing in Sierra Leone.

Year	Number of fishers	Catch (t)	CPUE (t fisher ⁻¹ year ⁻¹)	Comments	Source (s)
1950–1957	12,033–13,626	72,201–81,758	6.0	Pelagic stocks virtually un-fished except by a few drift and cast netters, artisanal exploited demersal species only by hook and line, traps, and weirs	[35]
1962–1966	16,884 –17,882	109,747–116,235	6.5	2–3000 Ghanaian fishers immigrated in the early 60 s, specialized with pelagic stocks, introduced ring nets, gill nets, and larger boats	[33,35]
1968	18,436	115,228	6.25	Ghanaians repatriated in late 60 s, fish production dropped	[33]
1970	16,519	107,376	6.5	Fish production reported to have reached prior levels within approx. 3 years of Ghanaian repatriation	[33]
1977	17,857	133,930	7.5	increase in motorization in the 1970s which is reported to have greatly increased the total landings	[33]
1987–1989	17,654 –17,551	123,583–122,859	7.0	under pressure and intense competition from the foreign mechanized fleet, the small-scale fishery showed a decline in their contribution of <i>Sardinella</i> but increased its <i>Ethmalosa</i> landings.	[33,48]
1999–2000	10,000–15,453	80,000–123,624	8.0	following the RUF entrance into Freetown in 1997, international support projects were halted, boats were destroyed, and fishing as a coping strategy simply ceased to exist at in many sites, following the prohibition of all fishing activity on 27th May 1998	[12,48]
2010	37,053	240,845	6.5	post-war recovery programmes reactivated artisanal fishing activities, and it is widely believed that the small-scale fishery is now well over capacity	[12,48]
2015	42,341	296,389	7.0	With the enforcement of the Inshore Exclusion Zone (IEZ), local fishers report improved catches, and improved revenue is observed in terms of boat building and investment in outboard motors.	Author pers. obs.
1958–1961, 1967, 1969,	13,870–16,655		interpolation		
1970–1976	18,155				
1978–1986	16,224				
1990–1998	16,519–17,830				
2001–2009, 2011–2014	17,884–17,706				
	17,500–11,069				
	20,906–285,927				

Table 2

Summary of data, assumptions and sources used for the reconstruction of the domestic shrimp trawler catches in Sierra Leone.

Time period	Industrial shrimp catches (t/year)	Parameters	Sources
1977–1979, 1984–1986	313–1300		[47].
1980–1983	1234–1741	1:1.6 ^a	[36,49,53,54]
1976, 1987–1993	600–1741		[21]
1977–1993	340–1889	1:1.085 ^b	[41]

^a Headless to Head-on Conversion Ratio^b Shrimp catch:discard ratio**Table 3**

Summary of data, assumptions and sources used for the reconstruction of the domestic demersal fish trawler catches in Sierra Leone.

Time period	Industrial demersal trawl catches (t/year)	Parameters	Sources
1971–1982	1071–5699		[36]
1983–1986	2686–4295		[21]
1987–1993	0–4466	446.584 ^a	[6,9,47,82]
1971–1993	59–753	1:0.132 ^b	[41]

^a Derived Catch Rate (t/vessel/year)^b Landed demersal catch: discard ratio**Table 4**

Sea cucumber exports in dry weight (kg) and conversion to wet weight using a factor of 9 [64].

Month	Exports (kg)	Wet weight (t)
01/03/2011	500	4.5
01/04/2011	500	4.5
01/05/2011	500	4.5
01/02/2012	148	1.3
01/05/2012	100	0.9
01/08/2012	100	0.9

Table 5

Summary of vessel data and sources used to estimate foreign catches in Sierra Leone*.

Years	Fleet	Number vessels	Sources
1958–2015	Demersal Trawl Vessels	7–140	[33,35,36,82,83]
1968–2015	Shrimp Vessels	1–67	[33,35,36,82] [6,41,49,83]
1950–2015	Purse Seine Vessels	4–60	[6,9,33,36,41,66,82,83]
1950–2015	Longline Vessels	0–32	[6,33,36,41,83]

* Assumptions: 100 fishing days, 8 t/day (Kaczynski 1989)

Table 6
Flag allocation of Foreign Catch Estimates.

Foreign flag	Derived years present in Sierra Leone EEZ	Sources
USA	1959–1963	[9,36,41,66]
Belize	2014	[83]
Cape Verde	2014	[83]
China	1985–2015	[9,41,82,84–87]
Curacao	2014	[83]
Egypt	2014	[83]
France	1952–1969	[9,36,41,66]
Ghana	1977–1981	[41]
Guinea	2002, 2014	[9,83]
Guinea-Bissau	2002	[9]
Greece	1977–2015	[9,36,41,82,83]
Guatemala	2014	[83]
Italy	1952–1981	[36,41]
Japan	1950–1998	[9,36,41,57,66,88,89]
Korea	1964–2015	[9,36,41,66,82,83]
Liberia (Korea) ^a	1977–1981	[36,41,89,90]
Libya	1988–1993	[89]
Nigeria	1991–1995	[91]
Norway	2002	[9]
Panama (Korea) ^a	1976–1981, 2015	[41,68,83,90]
Senegal ^b	1976–1981	[36,41]
Ukraine	1959–1993	[9,36,41,57,66,89,92]
Russia	1959–1993	[9,36,41,57,66] [89,92]
Spain	1955–2015	[9,36,41,66,82,83]
Yugoslavia	1973–1977	[57]

^a Sources indicate that ships flagged to Panama and Liberia are generally under Korean ownership and operation (www.grosstonnage.com Accessed on 27/08/2013).

^b Although there is some indication that Senegalese small-scale fishers exploit significant amounts of fish as far as Sierra Leone, estimates of these catches are considered a different classification of foreign fishing, and are not included in this estimate (Binet et al. 2012)

Table 7
Summary of data, assumptions and sources used for estimating illegal foreign industrial catches in Sierra Leone.

Year	Total estimated industrial catch (Domestic + Foreign)	Fraction of total industrial fleet operating illegally	Estimated illegal catch	Comments
1950–1968	28,800–50,400	0.10	2880–5040	Industrial fishing begins in the early 1950s with a small number of foreign vessels. Since the Sierra Leone EEZ was not declared yet, illegal was estimated at the ratio that fished within 12 nm from shore
1969–1988	46,600–133,172	Interpolation	5736–99,434	1969 surveys reveal rich fish resources, leads to massive increase in legal and illegal industrial fishing
1989	160,465	0.53 ^a	85,046	–
1990	119,767	0.53	63,477	–
1991	63,591	0.30	19,077	Increases in monitoring, control, and surveillance activities led to a temporary decrease in illegal activity
1992–1999	29,600–86,005	0.90	22,200–64,503	Illegal fishing increased during the civil war, when iforeign nvestors withdrew and monitoring, control, and surveillance activity was impeded
2000	39,200	0.51 ^a	19,992	–
2001–2009	27,200–63,200	0.51	13–872–32,232	Illegal activity remained high through the 2000s
2010–2013	64,000–96,800	0.30	19,200–29,040	Increases in monitoring, control, and surveillance activities and implementation of VMS technology led to a decrease in illegal activity
2014–2015	100,000–105,600	0.4	40,000–42,240	The termination of a major fisheries development program, decreases in MCS, and increases in MCS in neighboringGuinea led to increases in illegal fishing activity

^a Sources provide anchor points of ratios for illegal vessels: total industrial fishing vessels.

References

- [1] P. Green, E.D. Mason, G. Carrol, The role of fish for consumption and nutrition in Sierra Leone, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), *The Marine Fisheries Environment of Sierra Leone in: Belated Proceedings of the National Seminar Held in Freetown, 25–29 November 1991*, Vancouver, 2012.
- [2] Oceanic Developpement, MegaPesca Lda, Ex Ante Evaluation of Existing Conditions in the Fisheries Sectors of Sierra Leone and Liberia, Concarneau, France, 2008.
- [3] GCLME Regional Coordinating Unit, Guinea Current Large Marine Ecosystem (GCLME) Transboundary Diagnostic Analysis, GEF/UNIDO/UNDP/UNEP/US-NOAA/NEPAD, 2006.
- [4] J.J. Heymans, J.M. Vakily, Structure and dynamics of the marine ecosystem off Sierra Leone for three time periods: 1964, 1978 and 1990, Vancouver, 2004.
- [5] Interim Guinea Current Commission, Sierra Leone: Nation's Marine Environment, Resources Protected, (2010) 1–5. <<http://allafrica.com/stories/printable/201011191106.html>> (accessed 6 February 2011).
- [6] Ministry of Fisheries and Marine Resources (MFMR) Sierra Leone, Fisheries Sector

- of Sierra Leone, Freetown, 2008.
- [7] FAO, FAO Yearbook: Fishery and Aquaculture Statistics, Rome, 2009.
- [8] FAO, National Aquaculture Sector Overview: Sierra Leone, Fisheries and Aquaculture Department, Rome, 2011. <www.fao.org/fishery/countrysector/naso_sierraleone/en>.
- [9] K. Kelleher, Robbers, Reefers and Ramasseurs, Sub-Regional Fisheries Commission Project, 2002.
- [10] D.J. Agnew, S.F. Walmsley, F. Leotte, C. Barnes, C. White, West Africa Regional Fisheries Project, Estimation of the cost of illegal fishing in West Africa: Final Report, 3rd ed, 2010.
- [11] Government of the Republic of Sierra Leone, An Agenda for Change, 2nd ed., 2008. <http://unipsil.unmissions.org/portals/unipsil/media/publications/agenda_for_change.pdf>.
- [12] A. Thorpe, D. Whitmarsh, E. Ndomahina, A. Baio, M. Kemokai, T. Lebbie, Fisheries and failing states: the case of Sierra Leone, Mar. Policy 33 (2009) 393–400, <http://dx.doi.org/10.1016/j.marpol.2008.09.002>.
- [13] UNEP, Sierra Leone; Environment, Conflict and Peacebuilding Assessment, UNEP, Geneva, 2010.
- [14] A. Hsu, Environmental Performance Index, in: C. Rosengarten, T. Rosengarten (Eds.), New Haven, 2016: pp. 1–123, 2016.
- [15] S. Jahan, Human Development Report 2015, New York, 2015.
- [16] UNDP, Human Development Report: 20th Anniversary Edition, Palgrave Macmillan, New York, 2010.
- [17] C.D. Golden, E.H. Allison, W.W.L. Cheung, M.M. Dey, B.S. Halpern, D.J. McCauley, et al., Nutrition: fall in fish catch threatens human health, Nature 534 (2016) 317–320, <http://dx.doi.org/10.1038/534317a>.
- [18] D. Zeller, S. Booth, G. Davis, D. Pauly, Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years, Fish. Bull. 105 (2007) 266–277.
- [19] C. Costello, S.D. Gaines, J. Lynham, Can catch shares prevent fisheries collapse? Science 321 (2008) 1678–1681, <http://dx.doi.org/10.1126/science.1159478>.
- [20] D. Pauly, D. Zeller, Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining, Nat. Commun. 7 (2015) 1–9, <http://dx.doi.org/10.1038/ncomms10244>.
- [21] FAO, Fishstat Plus: Universal software for fishery statistics time series, 2009.
- [22] L. Garibaldi, The FAO global capture production database: a six-decade effort to catch the trend, Mar. Policy 36 (2012) 760–768, <http://dx.doi.org/10.1016/j.marpol.2011.10.024>.
- [23] U.R. Sumaila, J. Alder, H. Keith, Global scope and economics of illegal fishing, Mar. Policy 30 (2006) 696–703, <http://dx.doi.org/10.1016/j.marpol.2005.11.001>.
- [24] G. Hosch, G. Ferraro, P. Failler, The 1995 FAO code of conduct for responsible fisheries: adopting, implementing or scoring results? Mar. Policy 35 (2011) 189–200, <http://dx.doi.org/10.1016/j.marpol.2010.09.005>.
- [25] R. Welcomme, D. Lymer, An audit of inland capture fishery statistics-Africa, FAO, Rome, 2009.
- [26] J. Jacquet, H. Fox, H. Motta, A. Ngusaru, D. Zeller, Few data but many fish: marine small-scale fisheries catches for Mozambique and Tanzania, Afr. J. Mar. Sci. 32 (2010) 197–206, <http://dx.doi.org/10.2989/1814232X.2010.501559>.
- [27] D. Zeller, M.L.D. Palomares, A. Tavakolie, M. Ang, D. Belhabib, W.W.L. Cheung, et al., Still catching attention. Sea Around Us reconstructed global catch data, their spatial expression and public accessibility, Mar. Policy 70 (2016) 145–152, <http://dx.doi.org/10.1016/j.marpol.2016.04.046>.
- [28] D. Zeller, S. Harper, K. Zyllich, D. Pauly, Synthesis of underreported small-scale fisheries catch in Pacific island waters, Coral Reefs. 34 (2014) 25–39, <http://dx.doi.org/10.1007/s00338-014-1219-1>.
- [29] K. Seto, D. Belhabib, D. Copeland, M. Vakily, H. Seilert, A. Baio, et al., Colonialism, conflict, and fish: a reconstruction of marine fisheries catches for Sierra Leone, 1950–2010, Vancouver, 2015.
- [30] CIA, CIA World Factbook 2011, 2011.
- [31] The World Bank, World Bank Population Database, (n.d.). <<http://data.worldbank.org>>.
- [32] M. Diop, J. Dossa, 30 Years of shark fishing in West Africa, FIBA-PRCMN-CSRP, Condé-sur-Noireau, 2011.
- [33] D. Chaytor, E.T. Ndomahina, The small pelagic and demersal fish stocks of Sierra Leone, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), The Marine Fisheries Environment of Sierra Leone: in: Belated Proceedings of the National Seminar Held in Freetown, 25–29 November 1991, Vancouver: pp. 28–37, 2012.
- [34] S. Etoh, Domestic Fish Marketing in Sierra Leone, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), The Marine Fisheries Environment of Sierra Leone: in: Belated Proceedings of the National Seminar Held in Freetown, 25–29 November 1991, Vancouver: pp. 81–89, 2012.
- [35] E. Golley-Morgan, The Fisheries Sector of Sierra Leone, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), The Marine Fisheries Environment of Sierra Leone: in: Belated Proceedings of a National Seminar Held in Freetown, 25–29 November 1991, Vancouver: pp. 17–21, 2012.
- [36] G.W. Ssentongo, M. Ansa-Emmim, Marine fishery resources of Sierra Leone: a review of exploited fish stocks, FAO, Rome, 1986.
- [37] D. Belhabib, A. Doumbouya, I. Diallo, S. Traore, Y. Camara, D. Copeland, et al., Guinean Fisheries, Past, Present and...Future? in: D. Belhabib, S. Harper, D. Zeller, D. Pauly (Eds.), Marine Fisheries Catches in West Africa, Vancouver: pp. 91–104, 2012.
- [38] D. Belhabib, A. Mendy, Y. Subah, N.T. Broh, A.S. Jueseah, N. Nipey, et al., Fisheries catch under-reporting in The Gambia, Liberia and Namibia and the three large marine ecosystems which they represent, Environ. Dev. 17 (2016) 157–174, <http://dx.doi.org/10.1016/j.envdev.2015.08.004>.
- [39] I. Turay, J.M. Vakily, M. Palomares, D. Pauly, Growth, food and reproduction of the mudskipper, *Periophthalmus barbarus* on mudflats of Freetown, Sierra Leone, in: D. Palomares, K.I. Stergiou, D. Pauly (Eds.), Fccr: pp. 49–54, 2006.
- [40] P.B. Browne, Women Do Fish, A. Case, Study on Gender and the Fishing Industry in Sierra Leone, in: Global Symposium on Women in Fisheries Sixth Asian Fisheries Forum: pp. 169–172, 2001.
- [41] Ministry of Fisheries and Marine Resources (MFMR) Sierra Leone, Fisheries Sector of Sierra Leone, (2001) 1–11.
- [42] E. Aryeetey, 23 Socio-economic aspects of artisanal marine fisheries management in West Africa, in: The Gulf of Guinea Large Marine Ecosystem, Elsevier Science B.V.: pp. 323–344. doi:[http://dx.doi.org/10.1016/s1570-0461\(02\)80045-3](http://dx.doi.org/10.1016/s1570-0461(02)80045-3), 2002.
- [43] E. Mason, Potential for diversification of fisheries products in Sierra Leone, in: Proceedings of the Fisheries of Sierra Leone Proceedings of a National Seminar on Fishery Industries Development, - November, Freetown, Sierra Leone, Freetown, 1993.
- [44] J.S. Brashares, P. Arcese, M.K. Sam, P.B. Coppolillo, A.R.E. Sinclair, A. Balmford, Bushmeat hunting, wildlife declines, and fish supply in West Africa, Science 306 (2004) 1180–1183, <http://dx.doi.org/10.1126/science.1102425>.
- [45] A.I. Payne, The exploitation of African fisheries, Oikos 27 (1976) 356–366.
- [46] J.M. Vakily, Assessing and managing the marine fish resources of Sierra Leone, West Africa, Naga, the ICLARM Quarterly, 1992.
- [47] FAO, The Potential for Expansion of the Industrial Fisheries of Sierra Leone, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), The Marine Fisheries Environment of Sierra Leone in: Belated Proceedings of the National Seminar Held in Freetown, 25–29 November 1991, Vancouver, 2012: pp. 69–77.
- [48] A. Baio, Governance of the Marine Capture Artisanal Fisheries of Post-war Sierra Leone, University of Portsmouth, 2009.
- [49] J. Cole, The Shrimp Trawler Industry of Sierra Leone, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), The Marine Fisheries Environment of Sierra Leone in: Belated Proceedings of the National Seminar Held in Freetown, 25–29 November 1991, Vancouver: pp. 64–68, 2012.
- [50] P. Showers, Escalation in Shrimp Production in the Sierra Leone Industrial Fisher, Naga, the ICLARM Quarterly. 22 (1999) pp. 1–3.
- [51] W. Okera, Fishes taken by the beach seines fishing at Lumley, Freetown (Sierra Leone), J. Fish. Biol. 12 (1978) 81–88, <http://dx.doi.org/10.1111/j.1095-8649.1978.tb04153.x>.
- [52] P. Showers, The shrimp stocks of Sierra Leone, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), The Marine Fisheries Environment of Sierra Leone in: Belated Proceedings of the National Seminar Held in Freetown, 25–29 November 1991, Vancouver: pp. 45–54, 2012.
- [53] J.H. Kutkuhn, Conversion of "whole" and headless Weights in Commercial Gulf of Mexico Shrimp, 1962.
- [54] FAO, Conversion Factors: Landed weight to live weight, Rome, 2000.
- [55] K. Kelleher, Discards in the World's Marine Fisheries, Food & Agriculture Org, Rome, 2005.
- [56] A. Sidibé, Les ressources halieutiques démersales côtières de la Guinée: exploitation, biologie et dynamique des principales espèces de la communauté à Sciaenidés, Thèse de Doctorat de l'ENSA de Rennes thesis, 2003.
- [57] J. Weber, H. Durand, Le secteur des peches dans les pays d'Afrique 1–136. <<http://archimer.ifremer.fr/doc/00000/2544/>>, 1986.
- [58] J. Mammie, Stock Assessment of Shrimp *Pandalus borealis* (KRØYER 1838) In Skjálíandi Bay Northern Iceland, United Nations University, Reykjavik, 2008 (Retrieved 8 January 2012 from), <www.unuftp.is/static/fellows/document/josephus08prf.pdf>.
- [59] A. Emanuelsson, Bycatch and Discard in Senegalese artisanal and industrial fisheries for Southern Pink Shrimp (*Penaeus notialis*), 2008.
- [60] P.C. Coutin, A.I. Payne, The effects of long-term exploitation of demersal fish populations off the coast of Sierra Leone, West Africa, J. Fish. Biol. 35 (1989) 163–167, <http://dx.doi.org/10.1111/j.1095-8649.1989.tb03058.x>.
- [61] S. Vannuccini, Shark Utilization, Marketing, and Trade, Food & Agriculture Org, Rome, 1999.
- [62] W. Okera, Observations on some population parameters of exploited stocks of *Senilia senilis* (= *Arca senilis*) in Sierra Leone, Mar. Biol. 38 (1976) 217–229, <http://dx.doi.org/10.1007/bf00388935>.
- [63] D. Chaytor, A.A. Aleem, Project summary: marine mollusca of Sierra Leone, Bull. Inst. Mar. Biol. Oceanogr. 1 (1976) 22–23.
- [64] K.W. Cummins, J.C. Wuycheck, Caloric Equivalents for Investigations in Ecological Energetics, E. Schweizerbart, 1971.
- [65] V.M. Kaczynski, Foreign fishing fleets in the subSaharan West African EEZ: the coastal state perspective, Mar. Policy 13 (1989) 2–15, [http://dx.doi.org/10.1016/0308-597X\(89\)90037-7](http://dx.doi.org/10.1016/0308-597X(89)90037-7).
- [66] J. Cole, Exploitation of Tuna and Other Large Pelagic Fish in Sierra Leone's EEZ, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), The Marine Fisheries Environment of Sierra Leone in: Belated Proceedings of the National Seminar Held in Freetown, 25–29 November, Vancouver: pp. 38–47, 1991.
- [67] MRAG (Marine Resources Assessment Group Ltd), Review of Impacts of Illegal, Unreported and Unregulated Fishing on Developing Countries FINAL REPORT July 2005, (2005) 1–178.
- [68] Environmental Justice Foundation, Dirty Fish: How EU hygiene standards facilitate illegal fishing in West Africa, Environmental Justice Foundation, London, 2009.
- [69] C.S. Hendrix, S.M. Glaser, Civil conflict and world fisheries, 1952–2004, J. Peace Res. 48 (2011) 481–495, <http://dx.doi.org/10.1177/0022343311399129>.
- [70] K. Gaynor, K.J. Fiorella, G. Gregory, D. Kurz, K. Seto, L. Withey, et al., War and wildlife: pathways through which armed conflict affects fauna, Front. Ecol. Environ. (2016) 1–41.
- [71] D. Zeller, R. Froese, D. Pauly, On losing and recovering fisheries and marine science data, Mar. Policy 29 (2005) 69–73, <http://dx.doi.org/10.1016/j.marpol.2004.02.003>.
- [72] A. Longhurst, The Bionomics of the Fisheries Resources of the Eastern Tropical Atlantic, Her Majesty's Stationary Office, London, 1963.
- [73] G.A. Steven, Report on the sea Fisheries of Sierra Leone, Crown Agents for the Colonies, London, 1945.
- [74] GOPA Consultants, Institutional Support for Fisheries Management for Sierra Leone: Second Annual Report, 2009.
- [75] J.S. Brashares, B. Abrahms, K.J. Fiorella, C.D. Golden, C.E. Hohnowski, R.A. Marsh, et al., Wildlife decline and social conflict, Science 345 (2014) 376–378, <http://dx.doi.org/10.1126/science.1256734>.

- [76] C. Béné, R. Arthur, H. Norbury, E.H. Allison, M. Beveridge, S. Bush, et al., Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence, *World Dev.* 79 (2016) 177–196, <http://dx.doi.org/10.1016/j.worlddev.2015.11.007>.
- [77] FAO, *The State of the World Fisheries and Aquaculture 2014, Food & Agriculture Org, Rome, 2014*.
- [78] N. Kawarazuka, C. Béné, Linking small-scale fisheries and aquaculture to household nutritional security: an overview, *Food Sect. 2* (2010) 343–357, <http://dx.doi.org/10.1007/s12571-010-0079-y>.
- [79] European Commission, Fighting illegal fishing: Warnings for Kiribati, Sierra Leone and Trinidad & Tobago, while Sri Lanka is delisted, [Http.europa.Eurapidpress-releaseIP-en.Htm](http://europa.eu/rapid/press-releaseIP-en.htm). Enrico BRIVIO (2016) pp. 1–2.
- [80] Government of the Republic of Sierra Leone, *The Fisheries (Management and Development) Decree, 1994, 1994*.
- [81] Government of the Republic of Sierra Leone, *Draft Fisheries and Aquaculture Bill, 2011*.
- [82] A. Baio, Show me the way: inclination towards governance attributes in the artisanal fisheries of Sierra Leone, *Fish. Res.* 102 (2010) 311–322, <http://dx.doi.org/10.1016/j.fishres.2010.01.003>.
- [83] Ministry of Fisheries and Marine Resources (MFMR) Sierra Leone, *Licensed Vessels 2014*, (n.d.).
- [84] A. Dobo, *Illegal Chinese Fishing in West African Waters*, Stockholm Resilience Centre, 2009.
- [85] G.T. Mallory, V. Panel, China as a distant water fishing nation, *US-China Economics and Security Review ...*, 2012.
- [86] T.G. Mallory, China's distant water fishing industry: evolving policies and implications, *Mar. Policy* 38 (2013) 99–108, <http://dx.doi.org/10.1016/j.marpol.2012.05.024>.
- [87] M.R. Wildman, *World fishing fleets: An analysis of distant-water fleet operations, Past-present-future*, 1993.
- [88] W.K. Swartz, *Global Maps of the Growth of Japanese Marine Fisheries and Fish Consumption*, University of British Columbia, 2004, <http://dx.doi.org/10.14288/1.0074898>.
- [89] FAO, *FAO's fisheries agreements register (FARISIS)*, in: *Committee on Fisheries, Rd Session, 99 ed.*, Rome, 1999: pp. 1–4.
- [90] www.grosstonnage.com, (n.d.). www.grosstonnage.com (accessed 27 August 2013).
- [91] F.H. Beaudry, W.B. Folsom, D.J. Rovinsky, *World Fishing Fleets: An Analysis of Distant-water Fleet Operations Past-Present-Future*, Silver, Spring, 2013.
- [92] J.C.F. Wang, *Handbook on Ocean Politics & Law*, Greenwood Publishing Group, 1992.
- [93] J. Alder, U.R. Sumaila, Western Africa: a fish basket of Europe past and present, *J. Environ. Dev.* 13 (2004) 156–178, <http://dx.doi.org/10.1177/1070496504266092>.
- [94] D.C. Graham, B.R. Booth, Fisheries Monitoring, Control, and Surveillance in Sierra Leone Waters, in: J.M. Vakily, K. Seto, D. Pauly (Eds.), *The Marine Fisheries Environment of Sierra Leone in: Belated Proceedings of the National Seminar Held in Freetown, 25-29 November 1991*, Vancouver: pp. 22–27, 2012.