

Fisheries in Somali waters: Reconstruction of domestic and foreign catches for 1950–2015



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ABSTRACT

The Somali region, at the Horn of Africa, has experienced a high degree of political and social instability at various times since 1950, through various regimes and an extended period of a lack of national government institutions during civil war. This study documents and extends prior reconstructions of domestic and foreign fisheries catch data for Somali waters between 1950 and 2015, including the industrial, artisanal, and subsistence sectors. Reconstructed domestic catch was nearly 1.8 times the landings reported by the Food and Agriculture Organization (FAO) on behalf of Somalia for the time period, and most of this discrepancy was attributed to the reconstructed small-scale sector (artisanal plus subsistence). The substantial removals by foreign fisheries dwarf domestic catches, and they were estimated here as 1.3 times the reconstructed domestic catches. This article provides an updated estimate of foreign and domestic fisheries removals from Somali waters from 1950 to 2015 to establish a historical baseline for fisheries catch statistics. This baseline could be used to update national-level fish landings data reported to the FAO, and such an update would be a useful starting point for improving quantitative treatments, such as stock assessments, of fisheries in Somali waters.

1. Introduction

The Somali Exclusive Economic Zone (EEZ) is a productive upwelling ecosystem in the north-western Indian Ocean (Fig. 1) that supports many fish and invertebrate species of interest to fisheries. However, due to a lack of governance (especially in past decades) and the decentralized, underdeveloped economy, Somali waters have been subject to incursions by illegal or unauthorized fishing vessels, joint ventures, and licensing schemes that left little benefit for Somalis. While the Somali people historically have depended largely on terrestrial resources for food [1], this was beginning to change through government interventions [2–4].

Somalia declared a 200 nm territorial sea in 1971, but this declaration did not follow accepted international law [5]. Even though Somalia ratified the United Nations Convention on the Law of the Sea (UNCLOS) in 1989, their EEZ was not formally declared until the Somali federal government did so in 2014. Here, for the purposes of this study, it includes the waters off the coasts of the semi-independent areas Puntland and Somaliland in Somalia's EEZ.

Somalia's Siad Barre government took power in 1969 through a

coup d'état and was in power until the national government fell in 1991. From this period until 2012, Somalia did not have an internationally recognized central government. In 2012, a Federal Government of Somalia was re-established following several transitional governments in part organized by the international community. Herein, we refer to this new state as the national government in contrast to the Siad Barre government.

The lack of government enforcement and legal ambiguity of Somali waters has facilitated foreign incursions for many decades [6]. Many have argued that piracy in Somalia developed in response to illegal fishing in the EEZ [7,8]. Regardless of motivation, the existence and levels of piracy has had the effect of driving away some foreign fishers who considered the waters too dangerous [9]. In the mid-2000s, international military forces (e.g., from the North Atlantic Treaty Organization) began a concerted effort to reduce piracy in the region. Patrols by these fleets made waters safer, and large commercial vessels adopted defensive tactics (adjusted travel routes, armed guards, etc.) which halted or at least reduced piracy for a time. That success appears to have allowed foreign fishing to increase again in Somali waters [10]. As fisheries have become more important to the region [11], it is vital to

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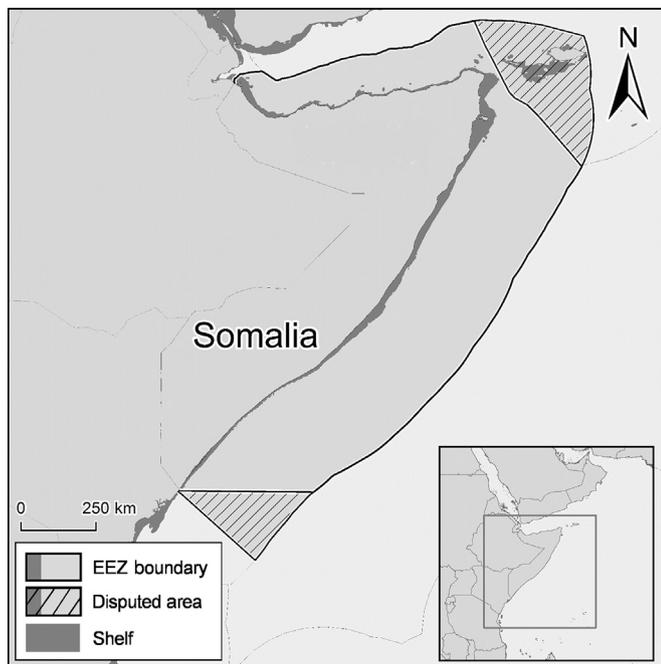


Fig. 1. The Somali Exclusive Economic Zone (EEZ), and shelf waters to 200 m depth.

understand the historical baseline of domestic and foreign fisheries in Somalia. Such a baseline provides a more comprehensive understanding and documentation of the levels of historical catches taken by both domestic as well as foreign fleets from Somali waters. This can contribute to a better understanding of the choices and potential benefits, as well as economic, social and environmental trade-offs being faced by Somali policymakers as it moves forward with controlling resource access in its waters. Baselines such as the one suggested here provide industry-independent and thus likely less biased data and knowledge on which better-informed policy decisions can be made.

1.1. Small-scale fisheries

The domestic fisheries of Somalia have always been fairly small-scale in nature. Development programs for small-scale fisheries and the formation of fishing co-operatives were instituted during the Siad Barre era (1969–1991), and were supported by the former Soviet Union and other countries through foreign aid. However, the desired growth of the sector failed to materialize. Marketing of fish from co-operatives was centralized during the 1970s and early 1980s, diminishing incentives for increased production [12]. Fishing activities increased when the Siad Barre government started to liberalize the sector during the 1980s [13].

After the collapse of the central Siad Barre government in 1991, and during the ensuing civil war, the already existing shortage of spare parts and infrastructure was amplified and much of the existing small-scale fishing sector was reduced [4]. Small-scale fishers also suffered from the cessation of government support [14] and their catches declined in the early 1990s [6]. However, later in the 1990s, the absence of government control of the fishing industry resulted in increased influence of the private sector and entrepreneurs which was the main force behind the gradual revival of the fishing trade [14]. Since 2000, investment from the private sector together with foreign aid, and also the change in consumption habits of Somalis, seem to have resulted in an expansion of the small-scale fisheries sector and substantially increased small-scale catches in the post-war period beginning in 1996 [2–4]. Small-scale fisheries have also been affected by anti-piracy actions that sometimes mistook small-scale fishers for pirates [15].

1.2. Industrial fisheries

Somalia has never had a large domestic industrial fishing fleet, and most of the industrial fishing in Somali waters has largely been carried out by foreign fleets, for many years through so-called ‘joint ventures’. These joint ventures and foreign licenses have been used by Italy, Japan, Greece, Singapore, Egypt, the former USSR, and China, among others. These agreements were most common between 1974, when the former USSR’s joint venture of SOMALFISH started, and 1991 when the agreements generally collapsed with the fall of the Siad Barre government. From 1950 to 1991, Somalia’s EEZ was host to at least 60 different trawlers from at least 14 different joint venture operations [summarized in 10,16].

When the Siad Barre government collapsed in 1991, Somali waters were left unmonitored and unguarded, and fishing vessels from various countries exploited this lack of oversight [1,4,5,17–21], generally in flagrant disregard of flag-state responsibility by these countries [Section 4 in 22]. This unauthorized and illegal exploitation by foreign vessels has been proposed as a major reason for the initial rise of piracy in the waters of Somalia [23]. It is argued that local fishers who were deprived of their livelihoods, and the warlords who saw an opportunity to make money, formed so-called ‘coast guards’ to enforce the waters of their perceived territories. These coast guards attacked foreign fishing vessels and demanded compensation for fish caught. Local warlords also started to sell licenses for fishing [18,24], thus creating unauthorized or informal licensing schemes for foreign vessels. Additionally, one could argue that it was the plundering of Somali fish stocks by illegal foreign vessels that should be considered the initial acts of piracy [25].

1.3. Lack of reliable data

While there are many reports of developments in foreign and joint-venture fisheries in Somalia, published catch statistics are sparse and usually restricted to three taxonomic groups. Thus, the absence of workable government institutions since the late 1980s has prolonged and exacerbated the problem of unreliable data [1]. In line with the general practise by the Food and Agriculture Organization of the United Nations (FAO), the internationally reported catch data for Somalia was estimated by FAO from 1991 to 2015 [26], although the methods and assumptions used for this estimation are not documented.

The existing national fisheries statistics from the 1970s and the 1980s are thought to be incomplete. For example, the category ‘production from all sectors’ in 1985, as reported by the Somali government [27], was based solely on catches by the 23 co-operatives and resettlements, the offshore catches, and the purchases by companies from small-scale artisanal fishers. The reported production from the co-operatives and resettlements was deemed to represent the artisanal (i.e., small-scale, commercial) production and was reported as 6223 t in 1985. This is thought to be an underestimate, since it excluded data from fishing villages along the coast that were not part of a co-operative. For example, Jennings [28] reported 31 fishing communities, while Mohamed and Herzi [4] suggested that before the civil war there were about 50 fishing villages.

To aid the establishment of comprehensive historical catch data baselines that address unreported fisheries components, the reconstruction method of Zeller, Palomares [29], first applied in Zeller, Booth [30], has now been applied to reconstruct fisheries catches for all countries in the world [31,32]. Catch reconstructions improve the completeness of fisheries statistics by accounting for under-represented and ignored sectors (e.g., subsistence fisheries), practices (e.g., discards), and illegal fisheries. This is particularly important for the Somali region that lacks data from large parts of unregulated and illegal foreign fisheries [10].¹ Earlier studies reconstructed the domestic [16] and

¹ We consider the widely used term “Illegal, Unreported, and Unregulated (IUU)” as

foreign [10] fisheries for 1950–2010 and 1981–2013, respectively. Here, these two pieces of research that have previously not been published in the scientific literature are combined, as well as updated with new information and extended time coverage to 2015. As the Federal Government of Somalia has previously taken steps to better regulate their fisheries [33], the information in this study can improve the currently available national and FAO statistics. As the Somali government decides how to develop and manage its domestic fisheries and how to license and control revenue-generating foreign fisheries, these data could be a useful correction of those currently available to the FAO. They could also more reliably inform future stock assessments.

2. Methods

2.1. Somalia's domestic fisheries

The following methods are adapted from Persson, Lindop [16] but are adjusted to better account for the very small domestic industrial sector and developments in Somali waters from 2004 to 2015. Furthermore, the reconstruction of Persson, Lindop [16] has been updated for the 2011–2015 time period. Landings data as reported by FAO on behalf of Somalia, were reported using the taxonomic categories of 'marine fishes nei', 'cephalopods nei' and 'tropical spiny lobster nei'. These represented industrial catches, the production from the co-operatives, and purchases of some artisanal catches by smaller companies. In this study, total reported landings were assigned to small-scale or industrial fisheries based on a breakdown of landings between 1974 and 1987 reported by the Ministry of Fisheries [34].

2.1.1. Industrial

Prior to 1974, there were likely no domestic industrial fisheries operating in Somali waters and thus all catches from 1950 to 1973 were assumed to be small-scale. The number of operational domestic vessels was already low by the mid-1980s [34], and it was assumed domestic industrial fishing essentially ended (or was extremely low) when the last joint venture was reflagged in 1998. However, at least one domestic industrial vessel operated in Somaliland in recent times (S. Glaser, pers. obs.). Thus, domestic industrial fishing was set to zero in 1998, and linearly interpolated backward from the last anchor point available (1987). All domestic cephalopod catches were determined to be small-scale, and this was factored into the proportions of sector assignment. The reported industrial sector was accepted as reported, while a separate reconstruction of the small-scale fisheries was conducted and the difference between it and the FAO reported catch was categorized as 'unreported' catch. For this reconstruction, the 2017 FAO data version was used for the reported landings (data from 1950 to 2015) as this is the only source of official, reported data available for Somali fisheries over the timeline of this study. Where necessary, these data are corrected based on additional sources of information on fisheries catches.

2.1.2. Small-scale catches

Based on Persson, Lindop [16], small-scale catches (i.e., artisanal and subsistence catches) were estimated using the number of operational boats (see Section 2.1.3) and the estimated catch rate (i.e., the catch amount per operational boat per year; see Section 2.1.4). The earliest reported small-scale catch [35] was taken at face value.

For 1962, Thurow and Kroll [35] report small-scale catches of 16,500 t, which was carried back to 1950 unaltered (Table 1) as we found no evidence of changes to the small-scale fisheries sector during this time period. The small-scale catches between 1963 and 2004 were estimated by deriving anchor points for the number of operational boats

(footnote continued)

misleading and unhelpful, as it is increasingly used erroneously to only refer to 'illegal' fishing. Instead we prefer to refer to the individual components directly, as "unregulated" and "unreported" fisheries may be perfectly legal.

Table 1
Reported and estimated (italics) small-scale catches for 2005 for Somali waters.

Region	Fish (t)	Shark (t)	Total (t)	Shark (%)	Source
South-central Somalia	14,825	6113	20,938	29	Sabriye [3]
Puntland	2144 ^a	8990	11,134	81	Mohamed and Herzi [4]
Somaliland	6030	2486 ^b	8516	29	Gulaid [2]
Total	22,999	17,589	40,588	43	

^a A substantial part of the finfish catches from Puntland are sold to Yemeni vessels and not included in the reported catches for Puntland.

^b Estimated using the fraction of shark catches from south-central Somalia. These catches need validating or correcting.

Table 2
Anchor points used for interpolation of small-scale catches for Somali waters. Values in italics are interpolated.

Year	Operational boats ^a	Catch anchor points (t)	Source
1950	n/a	16,500 ^b	
1962	n/a	16,500	Thurow and Kroll [33]
1978	1874	18,740 ^c	Thurow and Kroll [33], Haakonson [10]
1980	1725	17,250 ^c	Lawrence [35]
1988	1725	17,250 ^c	
1995	792	7920 ^c	Kelleher [6]
2004	3627	40,588 ^d	Gulaid [2], Mohamed and Herzi [4], Sabriye [3]
2005	2804		Burale [36]
2010	4097 ^e		Kulmiye [37]
2012	4305 ^f		Kelleher [38]
2014	4617 ^f		Kelleher [38]

^a See text for sources.

^b Assumed equal to 1962 value.

^c Based on average catch rate of 10 t boat⁻¹ year⁻¹ [34].

^d Estimated shark catches for Somaliland were added.

^e Vessels estimated based on Puntland.

^f Growth of fleet based on Kelleher [38].

for 1978, 1980, 1988, and 1995 based on available information and assumptions (see below and Table 2). The number of operational boats was then multiplied by a catch rate based on Elmer [36] to create anchor points for small-scale catch (Table 1). For 2005–2015, a catch rate was calculated based on 2004 catch estimates and applied to information on the number of active boats (see Section 2.1.4). The number of operational boats was then multiplied by a catch rate (Table 1).

The most recent catch estimates for Somalia available were reports for the fisheries in the three main coastal regions: South-Central Somalia [3], Puntland [4] and Somaliland [2]. The reported catches for Puntland and southern central Somalia were taken at face value. For the third region, Somaliland, shark catches were missing and were estimated based on the fraction of shark in catches in South-Central Somalia. The estimated shark catch was then added to the reported fish catch for Somaliland (Table 2), and these data were used as the 2004 anchor point. There are suggestions that shark fishing is not as prevalent in Somaliland as in southern central Somalia, thus, this may lead to a slight overestimate of shark catches for Somaliland. However, given the conservative nature of these estimations, this does not result in an overestimate for the Somali region as a whole.

2.1.3. Number of operational boats

The traditional boats in Somali waters are the wooden canoe called *hour*, and the less common sail boats called *beden* or *mashua* [14]. According to Thurow and Kroll [35], the small-scale fishing fleet in the early 1960s consisted of 1875 *hour*s of which 1500 were always active, 175 *beden* of which 150 were always operating, and 25 other boats called *dunnis*, together accounting for a total catch of 16,500 t

(Table 2). Thus, the fraction of traditional boats that were operational at any one time was about 80%. This fraction was applied to the reported total number of traditional fishing boats in later years (see below).

During the 1970s, a number of motorized boats were issued through fisheries development programs. Haakonsen [12] reported that 685 motorized boats had been provided during the previous years and that 500 of those boats were issued during the five year development program 1974–1978. According to Hariri [37], 700 motorized boats were issued from 1972 onward, and by the late 1970s only 40% were working. The United Nations Development Programme (UNDP) and the FAO [38] reported 600 motorized boats were issued between 1974 and 1978 and in 1979, 150 new engines were provided by the United Kingdom to rehabilitate some of these boats. Jennings [28] reported 600 motorized boats were issued and within five years only 20% were working. According to Lovatelli [14], 450 boats had been issued by 1982. As the number of motorized boats reported by the above sources are all in the same range, the earliest source was used [i.e., 12]. The year 1978 is in the middle of the 10-year period reported on by Haakonsen [12] for the distribution of 685 boats, hence it was assumed all boats were distributed by 1978 to create an anchor point. By the time the report was written (1983), more than 50%, and maybe as much as 75%, of the distributed motorized boats were not operating due to lack of spare parts and knowledge on maintenance [12]. Hence, it was assumed 40% were working and applied this to the total number of motorized boats to derive a total of 274 operational motorized boats for 1978 (i.e., $685 * 40\% = 274$).

A much higher fraction of traditional boats were likely operational, due to lower mechanization and easier, more traditional maintenance requirements. Therefore, the fraction of operating traditional boats (80%) from Thurow and Kroll [35] was used. Haakonsen [12] reported the traditional fleet was 2250 boats, but he also mentioned the use of traditional boats was declining due to the introduction of motorized boats and lack of maintenance. Therefore, for 1978, it was assumed 2000 traditional boats and a working rate of 80%. Together with the assumed 274 working motorized boats, this resulted in an anchor point in 1978 of a total of 1874 operational boats (Table 2).

In 1980, Lawrence [39] reported about 125 motorized boats were working and the traditional fleet was about 2000. Hence, 1725 working traditional and motorized boats was derived as a 1980 anchor point ($[2000 * 80\%] + 125 = 1725$; Table 2).

Kelleher [6] reported the artisanal fleet in 1995 was made up of 627 *houris* and sailboats (i.e., $627 * 80\% = 502$ operational traditional boats) and 290 functional motorized boats. This was used to form an anchor point of 792 operational boats in 1995 (Table 2).

The 2004 tsunami greatly affected the Somali fisheries sector and destroyed 630 motorboats and 75% of fishing gear [40]. In 2005, of the remaining 650 motorboats, 60% were out of commission [40]. These details were used to create additional anchor points for the time series of operational boats.

Puntland had 3136 artisanal boats in 2010, although only ~ 75% of them were operational [41]. Using the proportion of boats in Puntland from 2005, the total Somali small-scale fleet was estimated to be 5122 vessels in 2010 with 4097 of these being operational. Artisanal fishing boats increased in Berbera from 40 to 90 boats from 2012 to 2014 [42]. However, this was an extreme case, and thus a conservative assumption was made that this growth was the only growth in Somaliland from 2010–2015 and half this rate of growth was applied over this period for the entire Somali region.

2.1.4. Catch rate

Elmer [36] reported approximately 737 operational boats caught 8288 t. Thus, the average catch rate was 11.25 t per operational boat per year ($8288 / 737 = 11.25$). To remain conservative, a catch rate of 10 t per operational boat per year was used as a default measure to derive the estimated tonnage of small-scale catch for 1978, 1980, 1988

and 1995 (Table 2). The catch per boat was re-estimated based on the 2004 estimated catches and vessel numbers (Table 2). Due to the extensive fishing in the region, it was assumed that catch per boat declined by 10% from 2004 to 2015, although more independent catch estimates are necessary to support this. For years between anchor points, data were linearly interpolated.

2.1.5. Small-scale sector split: artisanal versus subsistence

Although the majority of data sources used here for estimating small-scale catches relate to artisanal fisheries (i.e., commercial opportunities are the main driver), it was assumed a fraction of these catches can be deemed subsistence, i.e., are not for sale but for direct family consumption or communal gifts or sharing, as is also common in parts of the Red Sea [43]. Thus, it was assumed the estimated total small-scale catches derived here were split into the two sectors as follows: for 2010–2015, it was assumed 80% artisanal and 20% subsistence, while for 1950 it was assumed 60% artisanal and 40% subsistence split. These percentages were interpolated over time to derive full time series for each sector.

2.2. Species composition

The estimated catch was assigned to different taxa, by sector, based on information found in various sources (Table S1).

2.2.1. Industrial

The domestic industrial catch was assumed to consist of demersal species caught by trawl (80%), and pelagic species (20%). The pelagic catch was in turn split between large (80%) and small (20%) pelagic taxa. Individual taxa were assigned percentages within each category (Table S2) based on the general information contained in the sources in Table S1.

2.2.2. Small-scale

Much of the literature suggested sharks and rays make up a substantial part of the small-scale catch in the artisanal sector, as shark fishing is assumed to be a commercial endeavour. Therefore, they were treated as their own category. Thurow and Kroll [35] reported sharks made up 21% of the total catches in the early 1960s. The fraction of sharks and rays in the artisanal catch increased to about 40% during the 1980s [44], and to 55–65% by the 1990s [14]. It was assumed 55% of the catch in the mid-1990s was sharks. Each of these anchor points was assumed to apply to the artisanal catch only. There is a large discrepancy in the estimates of shark catches by region [3,4]. Somaliland's estimate of artisanal catches did not include sharks [2], and were therefore estimated as the same proportion of sharks to other finfish as in South-Central Somalia (Table 1). This additional estimate resulted in sharks being 43% of fishes caught by the Somali artisanal sector in 2005. All of this information was used to create a time series of the shark and ray fraction within the artisanal sector. Linear interpolation was done between the anchor points in 1962 (21%), 1985 (40%), 1995 (55%) and 2005 (43%). The fraction for 1962 was carried back to 1950 unaltered and the fraction for 2005 was carried forward to 2015 unaltered. Species composition of shark catches were derived from a variety of sources (Table S1) and applied in seven taxonomic groups (Table S3).

The remaining, non-shark artisanal catch was split into demersal (40%) and pelagic (60%) catches (Table S1). Artisanal finfish catch is dominated by pelagic taxa (60%), in contrast to industrial catch, in which demersal taxa (80%) predominate (Tables S2 and S4). The individual taxonomic assignment was derived for the artisanal finfish catch (Tables S1 and S4). The breakdown for the subsistence catches was derived from the artisanal breakdown, taking into account sectoral differences. Sharks and rays were excluded and the proportion of large pelagic fish was greatly reduced (Table S5).

The FAO reported catches include cephalopods; however, there was

no specific information on domestic cephalopod catches in surveyed sources included in Table S1. Therefore, the reported domestic cephalopod catches were proportionally assigned to the artisanal and subsistence sectors using the same proportional split applied to the total small-scale catches. The tonnage determined for each sector was then assumed to be contained within the ‘marine fishes nei’ tonnage which was estimated above and subtracted out to determine the remaining amount of that category for each sector.

2.3. Adjustments to reported data

From 1990 to 1999, reported catches were greater than reconstructed total domestic catches. Therefore, catches in these years were assumed to be 100% reported [except for discards which are known to be unaccounted for in reported data; 45] and a negative adjustment of the over-reported landings data was undertaken. Previously, when the reported cephalopod catches were subtracted from the total artisanal and subsistence ‘marine fishes nei’, the result was a negative catch in these years (1990–1999). Therefore, the cephalopods were adjusted independently of the rest of the catch. All of the ‘marine fishes nei’ were assigned as cephalopods for 1990–1999 and the difference was allocated as a negative adjustment to the reported cephalopod catches. Tropical spiny lobster catches were left unadjusted as they were assumed to be well reported. The remaining catch was compared to the ‘marine fishes nei’ reported catch. The difference between these totals represents the negative adjustment applied to that category of the reported data. Please note all comparisons of reconstructed data to the reported FAO data refer to the adjusted reported landings as derived here.

2.4. Foreign fisheries in Somali waters

Foreign fishing in Somali waters was originally reconstructed from 1981 to 2013 by Glaser, Roberts [10]. Here, these estimates were extended and modified in the following ways. First, the Glaser, Roberts [10] reconstructions of catch by certain countries were adopted. Second, their estimates of highly migratory species (HMS), mainly tuna, billfishes and pelagic sharks, were replaced with estimates stemming from the global reconstruction of industrial fisheries for large pelagic species by the *Sea Around Us* [46]. Third, all relevant time series were extended back to 1950 and forward to 2015. Finally, estimates of discards were added.

Foreign fishing in Somalia falls into two distinct groups: fisheries for HMS and fisheries for demersal and small-pelagic species, including near-demersal sharks and shrimp. To estimate catch of HMS, the spatialized industrial large pelagic catch data of the *Sea Around Us* was used [46], which is a harmonized version of spatially reported data of all Regional Fisheries Management Organizations with a mandate for large pelagic species fisheries (in the present case, the Indian Ocean Tuna Commission) and reconstructed discard estimates of these fisheries.

Many joint ventures operated in Somalia during this period. For this article, joint ventures were assumed to be reported by Somalia to the FAO and the catch resulting from them is included in reported domestic catch statistics. In comparison, foreign vessels licensed by Somalia were assumed to represent true foreign catch not reported to the FAO under Somalia, and that catch was reconstructed and attributed to the country operating these vessels (see Table S6).

Estimates for fishing by Italy in Glaser, Roberts [10] for 1981–2015 were used. Italy's fishing in Somali waters dates back to its colonial period in the country and its pre-independence period as a United Nations Trustee. For 1950–1959, the Italian fisheries were assumed to be reported as Somali domestic catches and thus considered to be included in the domestic industrial catch data.

South Korea's trawlers began operating in 2007 and at least two still operated in 2015 [47]. Using EU import records and AIS-data tracking

trawler activity in the Somali EEZ, Glaser, Roberts [10] derived the taxonomic composition (Table S7) and the average annual catch of these trawlers as 785 t per vessel per year. These estimates were adopted here.

Egypt began trawling in the Somali EEZ in the early 1980s [12], and was operating 36 trawlers between 2003 and 2006 [48], and 34 in 2007 [49]. The catch estimates and taxonomic breakdown reported in Glaser, Roberts [10] were adopted here.

Greece began fishing operations in the mid-1960s with “a few” trawlers [12], and “a number” of Greek trawlers operated in 1983 [50]. Since 2010, Greece has trawled Somali waters with two vessels, GREKO 1 and GREKO 2, flagged as Belize but owned by a Greek parent company. These vessels are known to have operated for 2010–2015, but it is believed they stopped operating thereafter, as they were fined for underreporting their catches in 2016 [51]. Estimates of fish catch reported in Glaser, Roberts [10] were adopted here.

Kenya has trawled for shrimp in Somali waters since 2004 [52], and following the assumptions of Glaser, Roberts [10], 800 t of shrimp were assigned to Kenya per year. Kenya's landings are assumed to consist solely of shrimp (*Penaeus* spp.), and discards were calculated in addition to these landings. Kenya's government banned their fishing vessels from fishing near the Somali border after 2011 [53], and to remain conservative, it was assumed this represented a complete cessation of Kenyan fishing in Somalia's EEZ.

Following Glaser, Roberts [10], a catch rate of 785 t per vessel per year was assumed for the seven Thai trawlers known to have operated in the Puntland region between 2005 and 2009. The taxonomic composition of the Korean trawlers operating during this same time period was used (Table S7).

Yemen and Iran operated tuna fisheries but grossly underreported to the Indian Ocean Tuna Commission (IOTC) during this time period, and they are known to fish intensively in the Somali EEZ [54,55]. Glaser, Roberts [10] conducted Monte Carlo simulations of catch by Yemen and Iran based on several documented estimates of the number of boats and catch. Here, their estimates [10] were adopted. For 2015, Yemen's catch was assumed to decline to a quarter of pre-2015 catches, as a blockade of port cities by Saudi Arabia stopped fishing boats from leaving to Somali waters in April of 2015. Iran's catch was not modified. Catch composition and associated by-catches for Yemen were disaggregated here based on Yemen's reported IOTC catch (Table S7), but it is known that some of the Yemeni catch is comprised of small pelagic fishes like Indian oil sardine.

To the estimates of foreign catch reported in Glaser, Roberts [10], earlier fishing by Japan, Singapore, and Romania were added. Japan operated two vessels under a license that caught a total of 5646 t of fish and 76 t of deep water lobsters in 1985 [34]. The fish catch was disaggregated according to the Korean trawler breakdown of finfishes.

Romania undertook experimental pelagic trawling in the Somali EEZ, and Singapore had licenses for several pelagic pair-trawlers [34,36]. Romania caught 6112 t of small pelagic fish over two months in 1983 and 10 months in 1984. This catch was proportionally split assuming the catch was the same each month, and used the reported taxonomic breakdown (Table S7). Singapore was known to have a license in 1985, and to remain conservative it was assumed they only operated in this year. As they operated “several” pair trawlers, this was assumed to be four vessels with the catch per vessel equal to the Romanian catches and of the same taxonomic breakdown.

The Siad Barre regime formally gave China fishing rights in 1989², but little is known of their operations from then until more recently, when longliners are known to fish for HMS inside the EEZ. Thus, the spatialized catch of HMS by China [46] is likely an underestimate, but it was retained until better estimates become available.

² <http://www.country-data.com/cgi-bin/query/r-12055.html>.

2.5. Discards

2.5.1. Domestic industrial fisheries

Due to a lack of gear-specific information in the Somali domestic industrial fisheries of the 1970s and 1980s, it was assumed half of the pelagic fish in the industrial catch was caught with longlines and half with purse seiners, and applied associated discard rates (21.7% for longliners and 5% for purse seiners) reported by Kelleher [56]. For the demersal fraction of the domestic industrial catch, the global average discard rate for demersal finfish trawlers of 19.6% [56] was used, as specific discard rates for demersal fisheries in the Western Indian Ocean were not available. The by-catch of sharks in industrial trawlers has been estimated to be 5% of the total weight of the catch. Of this by-catch, only the fins were kept and the rest was discarded [57]. The discard of shark meat was assumed to be included as part of the 19.6% discard rate of Kelleher [56]. The demersal discard rate was disaggregated into sharks (4.5%) and fishes (15.1%). The sharks were taxonomically disaggregated using the artisanal shark breakdown, and fishes were disaggregated by family using the industrial demersal breakdown (Table S8). Pelagic discards were broken down using the proportions shown in Table S8.

The crustacean fishery had a small amount of discards as well [28,58]. However, there is no quantification of the scale of these discards, and it is known that crustaceans have a high survival rate when discarded [56]. Therefore, discards (deemed not surviving) were conservatively assumed to be 1% of the crustacean landings.

2.5.2. Small-scale fisheries

Although reference has been made to some discarding of fish in the small-scale fisheries [e.g., 4, 14, 28], discards may be low except for artisanal fisheries which supply Yemen's mother boats. Here, the focus was specifically on discards in the artisanal shark fin fishery. In the mid-1990s, Lovatelli [14] reported only a small percent of fishers retained the meat, and Gulaid [2] reported only fins were retained by fishers in Somaliland. Thus, overall discards of sharks (except fins) were assumed to be relatively large. To estimate the shark discards in the artisanal fisheries, data from the International Union for Conservation of Nature (IUCN) [59] and Mohamed and Herzi [4] were used. According to IUCN [59], the community of Eyl produced 200 t of shark fins, which requires about 10,000 t of live-weight (wet-weight or whole-weight) sharks. In addition, Mohamed and Herzi [4] estimated Eyl's annual locally landed and utilized shark catch (not finned) as 1830 t in 2004. Thus, it was assumed the discards of shark carcasses in Eyl due to shark finning alone were about 8170 t ($10,000 - 1830 \text{ t} = 8170 \text{ t}$), which was 69% of the total estimated shark and ray catch in 2004 in Eyl ($8170 \text{ t} / 11,830 \text{ t} = 0.69$). In order to remain conservative, and also because the retained fin weight was not taken into account in this calculation, it was reduced to 49%, and used as a total artisanal shark carcass discard rate in 2004 for all of the Somali region. Half of the 2004 discard rate was used as an anchor point in 1990 (i.e. 24.5%) to reflect the rapidly growing demand for shark fins reported during the 1990s [60]. Thurrow and Kroll [35] reported dried sharks were exported and shark fins fetched a higher price. However, there were no indications of shark meat discards in Thurrow and Kroll [35]. Therefore, it was conservatively assumed shark discards due to finning were 0% in 1960, i.e., it was assumed a generally complete utilization of shark catches at that time. Linear interpolation was done between the 1960, 1990 and 2004 discard rates to derive the fraction of artisanal shark carcass discards over time, and the 2004 rate was carried forward to 2015 unaltered.

2.5.3. Foreign fisheries

Discards were estimated for foreign fisheries in the region. For bottom trawlers, the same discard rates as for the domestic demersal fisheries were applied (see above). For Kenyan shrimp trawlers, the finfish discard rate of 62.6% for the region as reported by Kelleher [56] was used, but the same taxonomic breakdown as for domestic demersal

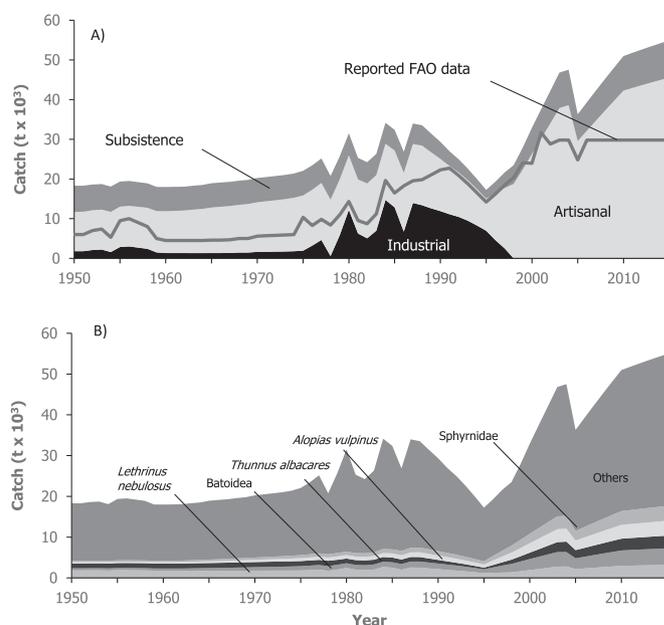


Fig. 2. Total reconstructed domestic catches in Somali waters, 1950–2015, a) by fisheries sector with reported catches overlaid as a line; and b) by major taxa. 'Others' includes 38 additional taxonomic categories available online at www.seaaroundus.org.

discards (Table S8). As the pelagic trawler fisheries of Romania and Singapore were short-lived, it was conservatively assumed they had zero discards.

3. Results

3.1. Reported domestic catches

To provide context for reconstructed domestic catches reported below, the total landings reported by FAO on behalf of Somalia are described. Such landings varied between 5000 and 15,000 t year⁻¹ from 1950 to the early 1980s, before increasing rapidly to around 25,000 t year⁻¹ by the early 1990s (Fig. 2). Following a decline in landings during the 1990s, reported landings increased again to ~30,000 t year⁻¹ in the early 2000s and have been fixed at this amount since (Fig. 2). The goal in reconstructing catch is to improve the estimates of domestic landings, and to do so these data were split into assumed industrial and small-scale components of reported landings, and added unreported catches as well as discarding to both components.

3.2. Total reconstructed catches

The reconstructed total domestic catch was around 1.8 million t from 1950 to 2010, which was 80% larger than the adjusted landings of 1,016,231 t reported by FAO on behalf of Somalia for the same period (Fig. 2). For the first 20 years (1950–1969), total reconstructed catches averaged around 18,300 t year⁻¹. During the 1970s and the 1980s, catches increased to around 22,200 t year⁻¹ and 47,500 t year⁻¹, respectively. After the Siad Barre government collapsed in 1991, domestic catches decreased to an all-time low in 1995, while foreign catches increased by nearly 16,000 t in this short period. Domestic and foreign fisheries grew after 1995, exceeding 100,000 tonnes in 1998 and reaching a recent peak of 150,400 t in 2014. Current fishing in the Somali EEZ is estimated to be over 125,000 t year⁻¹.

3.3. Domestic

Reconstructed total small-scale catches were over 1.6 million t for

the entire period (Fig. 2a), which was just over 1.8 times the volume of FAO landings assumed to represent small-scale catches. The reconstructed total small-scale catches during the colonial era (1950s) were estimated to be 16,500 t year⁻¹. After 1960, total small-scale catches started to increase to almost 20,500 t year⁻¹ by 1977, before declining during the 1980s to about 19,400 t year⁻¹. After the collapse of the Siad Barre government in the early 1990s, catches dropped substantially to a low of 10,200 t year⁻¹ in 1995. Small-scale catches increased thereafter to approximately 48,000 t year⁻¹ by the late 2000s. Small-scale catches were estimated to consist of 75% artisanal catches and 25% subsistence catches. Discards contributed 11% to the overall artisanal catch. The species breakdown of domestic fisheries suggested at least 40 taxa contributed (Fig. 2b).

Of the total FAO reported landings, about 125,000 t, or 9.4%, were assigned to domestic industrial landings from 1950 to 2015 (Fig. 2a). Industrial landings began in 1974 with the first joint venture of SOMALFISH. In 1987, industrial landings peaked at around 10,300 t year⁻¹, or 53% of total FAO reported landings (Fig. 2a). The erratic nature of reported industrial landings, especially during the 1980s, was largely driven by serial failures of joint venture operations. The only source of unreported catch examined and estimated for the industrial fishery was discards, which contributed 25% of the total reconstructed industrial catch (75,200 t).

3.4. Foreign

These estimates of foreign catch in Somali waters are largely as documented and reported in Glaser, Roberts [10], who found foreign catch was about 132,000 t in 2013. As combined here with domestic catches, foreign catches accounted for 56% of total catches taken in Somalia's EEZ, with the majority of foreign catches occurring after the Siad Barre government collapsed (Fig. 3). Currently, Iran accounts for the most (reconstructed) foreign fishing in Somalia's EEZ (Fig. 4) due to their underreported tuna fisheries occurring there. This is followed by Yemen and Egypt (Fig. 4). When including catches reported to the IOTC, the most common species caught are: yellowfin tuna (36%), narrow-barred Spanish mackerel (7.0%), and longtail tuna (6.8%). Apart from tuna fisheries, trawlers account for the large majority of catches. Emperors (family Lethrinidae), and barracudas (*Sphyraena* spp.) and grunts (*Haemulon* spp.) dominate trawler catches.

4. Discussion

From the early 1990s, Somalia had been a failed state without a functioning central government [61], but the formation of the new Federal Republic of Somalia in 2012 has supported the framework for fisheries management going forward. The country has suffered extensively from poverty and violence, and its fisheries statistics are highly unreliable [62]. Based on the information and data available to us, and the assumptions outlined in the methods, catches from 1950 to 2015 were reconstructed in an attempt to gain a better understanding of

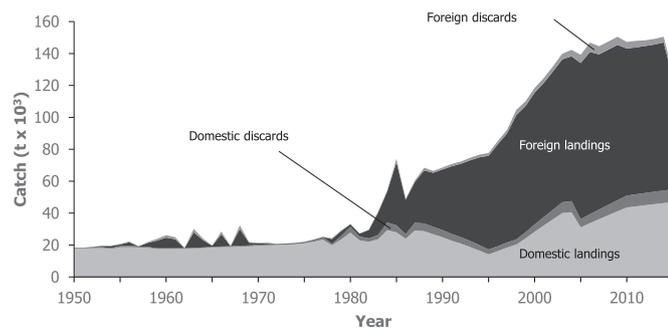


Fig. 3. Total reconstructed domestic and foreign landings and discards from Somali waters.

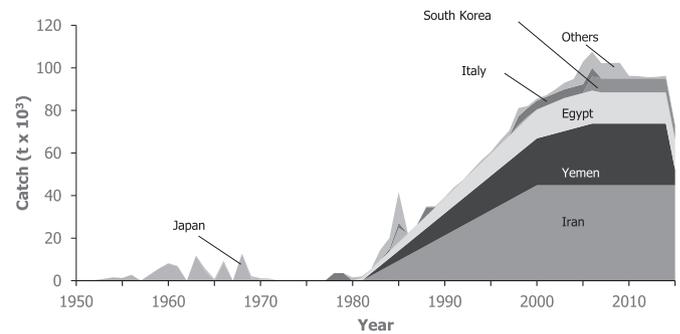


Fig. 4. Total reconstructed foreign catches in Somali waters, 1950–2015 by fishing country. 'Others' includes 14 other foreign countries. This excludes all joint ventures flagged to Somalia.

total catches, both foreign and domestic, within Somali waters. The reconstructed domestic catch estimates were nearly 1.8 times the data reported by FAO on behalf of Somalia, with reconstructed small-scale catches as the major contributor to the difference.

The landings data reported by FAO on behalf of Somalia were for many years incomplete or highly uncertain. This is not surprising, given the lack of a central government and administration, and FAO is to be commended for being able to provide any estimates at all, given that national reporting of catches collapsed in the late 1980s due to civil unrest [62]. As a stable central government has taken hold and has passed relevant fisheries legislation [10,33], these efforts could be assisted by adoption of a proper baseline of historical catches for building a suitable policy framework leading to effective management of their fisheries. The comprehensively reconstructed domestic and foreign catch data described herein and provided freely at www.seaaroundus.org may serve as such a data resource. The authors welcome any opportunity to assist the Somali government in providing these data to FAO and requesting retroactive data reporting changes.

4.1. Foreign illegal and unauthorized fishing

The Somali EEZ has been host to a large amount of foreign fishing over the past ~ 60 years, including legally licensed vessels, joint ventures, substantial illegal foreign incursions, and vessels operating under dubious licenses. Numerous vessels from various countries have in the past exploited the lack of institutional enforcement by fishing in Somali waters [e.g. 5,18,19,20]. The exact numbers of foreign vessels and the extent of their actual catches are not known, but this article provided best possible estimates based largely on the work of Glaser, Roberts [10]. Thus, this establishes a historical baseline which can inform the Somali government for future fisheries management decisions.

It has been suggested that illegal foreign fishing in Somali waters has been a primary driver of piracy in the region during the 2000s [7,18,23,24]. This catch reconstruction illustrates domestic artisanal catches did decline after the start of the civil war and the collapse of central government control. At the same time, foreign fishing fleets started to substantially increase their unregulated fishing activities in Somali waters, thereby themselves pirating the Somali marine resources. The initial decline of artisanal catches was most likely caused by the lack of gear and boats, as well as the increased risk due to civil war, but might also have been impacted by foreign fleets. It has been reported that some foreign vessels, particularly trawlers, fished very close inshore and destroyed local fishing gears [23], which would have fueled anger toward foreign fishers. Irrespective of the initial reasons and drivers for the rise of piracy, it did not take long for it to grow into big business for warlords and criminals utterly unrelated to domestic fisheries, who increasingly used foreign fishing as an excuse to hijack commercial vessels and demand ransoms [24]. The peak in piracy activities in the 2000s may have reduced foreign fishing in coastal waters, permitting and enabling an increasing domestic artisanal sector to re-

emerge [47].

Separate from the issue of piracy, the problem of foreign fishing fleets exploiting Somali waters illegally or without federal authorization illustrates a severe failure of flag-state control, and further illustrates that illegal fishing is a matter of international, trans-boundary criminal activity rather than a fisheries management failure [63,64]. The value of illegal catches taken out of Somali waters in 2005 was estimated as being at least US\$300 million [23], and this figure is supported elsewhere [10]. This lucrative illegal business is thought to have contributed to the prolongation of instability in the country, since local authorities would not have benefited as much as they would have from properly controlled and licensed, legal operations [18,65]. Importantly, the value taken out of Somali waters by foreign fleets was not available to the Somali people and society [10].

In contrast, with fully transparent and legal licensing through foreign fishing access agreements, a functional national government should strive to derive benefits for Somali society from this large natural resource that has the potential to be self-sustaining [i.e., be sustainable, 66]. Such controlled access, which must complement, not replace or threaten domestic small-scale fisheries [67], could be an important source of foreign exchange income for legal national authorities, and contribute to enhanced maritime security and greater overall stability in the country [1]. The sale of offshore fishing licenses has the potential to generate resources which can then be invested to sustainably develop the sector and broader socio-economic goals, and external investments should complement this effort and support Somali financial independence. The revenue generated by a foreign licensing scheme can support governance efforts throughout Somali states and regions, especially when a revenue sharing agreement is transparent and mutually agreed. Likewise, the lack of a legal framework that adheres to international standards undermines sustainable fisheries management and deters investment by credible investors in the sector.

If one examines unauthorized fishing, i.e., foreign fishing based on licenses and protection bought from local or regional authorities in contravention of international law, one finds fishing companies that bought these licenses were often treading a thin line, as being licensed by one warlord or local authority did not ensure safe treatment by another if the vessel entered the perceived local territories of another warlord [10,15]. Furthermore, the United Nations Monitoring Group on Somalia documented misuse of revenues generated from the sale of unauthorized fishing licenses to the benefit of local warlords to maintain militias and purchase weapons [68].

Informal fishing arrangements have also existed, especially between Somaliland and Yemen. Since the late 1990s, Yemeni fishers have operated in Somaliland waters, exchanging access to fishing grounds for fuel, ice, and other goods [14,25]. The arrangement was mutually beneficial: Yemeni fishing boats also bought fish directly from Somali fishers who operated in the Gulf of Aden and Yemeni people relied heavily on fish for food security. Today, this exchange has been interrupted by the on-going war in Yemen and foreign naval presence in the region.

4.2. Limitations

This study is inherently limited by the scarcity of data on fisheries in Somali waters. A major aim of this study is to tackle the inherent problem of officially reported data in all countries, namely that any component of fisheries that has no 'hard data collection system' is often considered as data deficient, leading to it being treated as having 'no-data' and hence receiving no data entry in official records. However, this approach to official data reporting leads to the automatic assignment of a statistically very precise, but inaccurate, catch of zero tonnes in the place of missing data items [32,69]. Thus, reconstructions such as the current study address this inherent negative bias in reported catch data (i.e., the 'accuracy' of data) and not the replicability of data collection (i.e., the 'precision' of these estimates), which is what 'uncertainty'

estimates (e.g., confidence limits) are generally used for. Nevertheless, we do recognize that any unreported catch estimate includes a certain amount of uncertainty due to the assumptions and information sources applied. However, so do officially reported data, which in most countries in the world make use of sampling schemes, estimations and raising factors to derive their official national catch data, all without estimates of the uncertainty inherent in the numbers being reported as official data [32,69]. Reconstructions strive for conservative use of information sources and underlying assumptions, thus, any uncertainty associated with these estimates will likely err on the side of caution, resulting in a low likelihood of overestimation and a higher potential for underestimation. However, we freely acknowledge that some uncertainty will always be associated with the data presented here.

5. Conclusions

Overall, the likely total catches taken from Somali waters, as derived through this catch reconstruction, increased from 16,500 t year⁻¹ in 1950 to 127,800 t year⁻¹ in 2015, and catches were 80% higher than officially reported data. The occurrence of extensive foreign fishing, some of it illegal, in the waters of a sovereign state, mainly during a time of severe internal instability, illustrates an astounding lack of flag-state control by predominantly Asian fleets, and a global failure of control over rampant unregulated fisheries exploitation. This foreign fishing dwarfed domestic fishing and likely contributed to the decline in stock status of fisheries observed by Glaser, Roberts [10]. It is thus important that future fisheries in Somali waters, both domestic and foreign, be undertaken with consideration of the likely baseline of catches and with the aim of sustainable yields (both in terms of domestic small-scale fisheries livelihoods as well as foreign exchange earnings) to benefit the Somali people.

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Author contributions

Lo Persson and Dirk Zeller originally reconstructed domestic catches, and Sarah Glaser and Paige Roberts originally reconstructed foreign catches. Tim Cashion, Sarah Glaser and Dirk Zeller harmonized and updated these to the time series of 1950–2015. Tim Cashion, Sarah Glaser, Lo Persson, Paige Roberts, and Dirk Zeller contributed to both the writing and editing of the paper.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.marpol.2017.10.025>.

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