Marine Fisheries in Mozambique: Catches Updated to 2010 and Taxonomic Disaggregation*

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Abstract

Reconstructed catch and discard estimates for Mozambique's marine fisheries sectors (small-scale and industrial) were updated from a 2007 contribution by J. Jacquet and D. Zeller to encompass the entire 1950–2010 period. The species composition of the reconstructed catches was also estimated for each year. The total reconstructed catch for 1950–2010 was approximately 8.2 million tonnes (t), which is 4.6 times the official data reported to the Food and Agriculture Organization of the United Nations (FAO), i.e., landings of 1.8 million t over this 61-year period. However, significant improvements have occurred in the data reported to FAO for recent years (2003–2010), specifically in 2009 and 2010, when small-scale catches were comprehensively reported. FAO data prior to 2003 remain incomplete, with large unreported catches and poor taxonomic resolution for small-scale fisheries. Mozambique's total marine fisheries catch for the 1950–2010 period were composed largely of the families Clupeidae (11%), Engraulidae (9%), and Penaeidae (8%). However, historical data from the 1970s suggest significant changes in overall species composition of small-scale fisheries that are unaccounted for in official catch statistics.

Introduction

Mozambique stretches along the coast of East Africa, between South Africa and Tanzania (Figure 1), where its mangroves, coral reefs, and seagrass beds support a variety of marine life (Bandeira *et al.* 2002). Of the 1,425 marine finfish species known to occur within Mozambique's Exclusive Economic Zone (EEZ), nearly 300 are of commercial importance (www.fishbase.org). At least 14 species of shrimps are of commercial importance (Appendix Table A1), while other valuable fisheries are conducted for *Metanephrops mozambicus* (African lobster), *Palinurus delagoae* (Natal spiny lobsters), *Chaceon macphersoni* (pink geryons), holothurians, and sharks (contributions in Pauly 1992; Groeneveld and Melville-Smith 1995; Fennessy and Groeneveld 1997; Abdula 1998; Kroese and Sauer 1998; de Sousa 2001; Pierce *et al.* 2008). A listing of valuable species across Mozambique's different fishing sectors is presented in Appendix Table A1.

Officially, marine capture fisheries account for more than 90% of Mozambique's total fish catch (FAO 2007) and coastal communities depend on the sea and its resources for survival, with fish accounting for 50% of the population's protein intake (Hara *et al.* 2001; van der Elst *et al.* 2005). National catch data show that small-scale fisheries account for over 80% of landed marine captures and thus play a significant role in the national economy (e.g., providing direct employment in fishing, fish processing and marketing). Industrial/semi-

Figure 1. Map of Mozambique and its Exclusive Economic Zone (EEZ), as well as the extent of the continental shelf (in darker blue). The various districts are also delimited by dotted lines.

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industrial fisheries are mostly export-oriented, targeting mainly penaeid shrimp, and represent an important source of export income (Pinto 2001; FAO 2007).

Despite the importance of marine fisheries for food security and the national economy, fisheries statistics for Mozambique and much of the region remain underreported, mainly due to underestimates of landings by the small-scale fisheries (van der Elst *et al.* 2005; Blythe *et al.* 2013). FAO catch statistics for Mozambique's industrial fisheries are also underreported (Jacquet *et al.* 2010) and do not include discards, which are substantial for the industrial crustacean fisheries (Fennessy 1994; Fennessy and Groeneveld 1997; Pinto 2001). A shallow-water shrimp fishery has been present since the 1950s (FAO 2013), mostly operating at depths below 50m off Sofala Bank (Fennessy and Isaksen 2007). On average about 15% of the landings are shrimp, while about 85% is bycatch (Brito and Abdula 2008). Most shrimp catch is composed of *Fenneropenaeus indicus* (Indian white prawns) and *Metapenaeus monoceros* (speckled shrimp), but *Marsupenaeus japonicus* (Kuruma shrimp), *Melicertus latisulcatus* (western king prawns), *Penaeus monodon* (giant tiger prawns), and *P. semisulcatus* (green tiger prawns) are also landed (Fennessy and Groeneveld 1997; IIP 2003; Pinto 2001). Since *circa* 1986 (FAO 2013), Mozambique has also had a deep-water crustacean fishery that fishes at depths around 300–500 m (Groeneveld and Melville-Smith 1995), landing predominantly *Haliporoides triarthrus* (knife shrimp), African lobster, and pink geryons (Tortensen and Pacule 1992; de Sousa 1992; IIP 2008, 2009). A bottom trawl fishery targeting *Decapterus russeli*, *D. macrosoma*, and *Selar crumenophthalmus* (three species of scads), and *Rastrelliger kanagurta* (Indian mackerel) also operated in Sofala Bank and Boa Paz from 1977 to 1992 as part of the Mozambique-USSR joint venture, MOSOPESCA (Silva and Sousa 1988; Sousa 1992).

Mozambique began its sampling program for multi-national industrial and semi-industrial fisheries with the founding of the *Instituto Nacional de Investigação Pesqueira* (Fisheries Research Institute) in 1977 (Bandeira *et al.* 2002). Since the early 1980s, the program has included the collection of fishery-dependent data *via* logbooks of commercial catch categorized taxonomically (by order, family, or species), and publications of the *Revista de Investigação Pesqueira* (Fisheries Research Journal; Bandeira *et al.* 2002). This program was broadened during the 1980s to include an onboard observer-sampling component. Fishery-independent data have also been collected through a series of scientific surveys that were conducted occasionally between 1976 and 1991 depending on the availability of vessels, but have been conducted systematically after 1991. Collection of data (catch, effort, and species composition) from Mozambique's small-scale fisheries began in 1997 in two provinces (Inhambane and Nampula), but has now been expanded to cover all coastal provinces (Dias and Afonso 2011). The composition of species discarded from industrial shallow-water shrimp fisheries was first reported in 2008 and 2009 (IIP 2008, 2009). Additional studies for South African shrimp fisheries also provided valuable information for Mozambique fisheries (Fennessy 1994; Fennessy *et al.* 1994; Groeneveld and Melville-Smith 1995; Fennessy and Groeneveld 1997; Fennessy and Isaksen 2007; Olbers and Fennessy 2007), as they have historically fished in Mozambique, and have similar target species and bycatch compositions (Groeneveld and Melville-Smith 1995; Fennessy *et al.* 2004).

The sustainable management of fisheries is imperative for food and job security in Mozambique. In many countries, catch data are often the only data available for such management (Kleisner *et al.* 2012; Pauly 2013) and may be underreported by 100% or more (see, e.g., Zeller *et al.* 2007; Wielgus *et al.* 2010; Le Manach *et al.* 2012). Historical baselines and improved catch statistics, such as those presented in this study, are needed to better understand the impacts of Mozambican fisheries on its diverse marine ecosystems and inform fisheries policies (Pauly 1998, 2007; Pandolfi *et al.* 2003; McClenachan *et al.* 2012). The previous catch reconstruction for Mozambique (Jacquet and Zeller 2007; Jacquet *et al.* 2010) included reconstructed catches from domestic small-scale fisheries, industrial fisheries and discards from 1950–2004. Jacquet *et al.* (2010) total reconstructed catches over this period were 6.2 times those supplied to FAO by Mozambique, largely due to a lack of resources for collecting catch statistics for small-scale fisheries and their consequent under-reporting. This research updates the original work, extending catch estimates up to 2010 and providing an improved taxonomic disaggregation by sector. This work focuses on Mozambique's domestic fisheries and does not include estimates of industrial fishing by foreign-owned vessels operating in Mozambique's EEZ, although these are substantial (see, e.g., Silva and Sousa 1988; van der Elst *et al.* 2005).[1]

Methods

Update of marine catches

Catch data for marine fisheries for 1950–2010 were extracted from FishStatJ (FAO 2012), the fisheries database of the Food and Agriculture Organization of the United Nations (FAO). The most recent FAO dataset shows significant increases in the reported catches for 2003 and 2004, compared to the FAO landings data used in the original catch reconstruction (Jacquet *et al.* 2010). FAO landings for 2005–2010, which were not reviewed in Jacquet and Zeller (2007) and Jacquet *et al.* (2010), have also significantly increased compared to previous levels and are further discussed herein.

[1] There are significant catches by industrial purse seiners (mostly European) and longliners (mostly Central and Eastern Asian) targeting tuna, billfish and sharks in Mozambique (www.transparentsea.co). The Mozambique government issues licenses to many of these vessels, however, it is also thought that there is up to 100 unlicensed longline vessels fishing illegally in the Mozambique channel (Anon. 2008; www.transparentsea.co).

Sectoral catch as defined by the Sea Around Us

The *Sea Around Us* uses the following fishing sectors in its global catch database: 'industrial' (i.e., large-scale commercial), 'artisanal' (i.e., small-scale commercial), and 'subsistence' (i.e., small-scale non-commercial activities whose primary purpose is self- or family-consumption). For this study, small-scale fisheries are defined as fisheries that use small (or no) vessels, have a low capital investment, and generally fish inshore waters of Mozambique. Industrial fisheries are defined as fisheries that use larger vessels with more advanced equipment and have a higher capital investment (www.fao.org). This study classified both semi-industrial and industrial fisheries as industrial.[2]

National fisheries catch statistics from 2000–2010 (obtained from the *Instituto Nacional de Desenvolvimento de Aquacultura;* National Institute of Aquaculture Development) form the basis of the FAO landings data and are separated into 3 sectors, i.e., 'commercial', 'artisanal', and 'aquaculture'. The national commercial catches include Mozambique fisheries classified as both industrial and semi-industrial, while the artisanal catch data were considered representative of small-scale fisheries. With the freshwater taxa and aquaculture production removed, both sector's catches were segregated into 10 separate taxa and the total catches matched exactly with FAO landings data from 2000–2010. Landings data from the *Direcção Nacional das Pescas* (Fisheries Department; DNP 1976), Krantz *et al.* (1986), and Charlier (1994) also provided an indication of the catch by industrial and semi-industrial sectors. Based on these data we allocated reported FAO landings for different taxa to small-scale (clams, holothurians, miscellaneous marine crabs, and elasmobranchs) or industrial sectors (penaeid shrimp, knife shrimp, lobsters, pink geryons, and cephalopods) for the 1950–1999 period. Unidentified marine fish in FAO landings were allocated to both small-scale and industrial sectors, based on the portion of industrial catch reported in DNP (1976), Krantz *et al.* (1986), and Charlier (1994).

Small-scale fisheries

Jacquet *et al.* (2010) estimated that the nationally reported catches from the *Instituto Nacional de Investigação Pesqueira* (National Institute of Fisheries Research; IIP) for 2003 and 2004 accounted for approximately 62% of small-scale fishers. Therefore, they assumed that 38% of catches within the small-scale sector had been unreported and adjusted the catch accordingly. We applied the same approach as Jacquet *et al.* (2010) to small-scale catches from 2003–2007 as the methods of national data collection did not change over this period and small-scale catches were in the same range (58,000–65,000 t·year-1).

In 2008, a new methodology was introduced to extrapolate surveyed catches to a larger geographical area in the Sofala bank region and, since 2009, this method has been used for all areas. Small-scale catches in 2009 and 2010 showed substantial increases and were in the same range (93,000–112,000 t) as reconstructed catches for years 2002–2007. As such, the 2009 and 2010 small-scale catches were considered fully-reported and no adjustment was made for these years. As the new extrapolation methodology in 2008 was not applied to all areas, 2008 catches were considered underreported. To estimate 2008 catches we applied an average catch rate of 0.69 t·fisher^{-1}·year^{-1} in conjunction with estimates of small-scale fishers (see Table 1).

Table 1. Mozambique inhabitants, fishers and associated catch rates for 2007–2009

Year	Population[a]	Number of fishers	Catch rate (t·fisher^{-1}·year^{-1})	Method for calculating catch rates
2007	21,811,326	135,529[b]	0.69	Reconstructed catches/# fishers
2008	22,332,900	138,687[c]	0.69	Average of 2007 and 2009 catch rates
2009	22,858,607	141,952[c]	0.69	Reconstructed catches/# fishers

[a] Source: http://data.worldbank.org.
[b] Source: IDPPE (2009).
[c] Estimate based on 2007 ratio of 6.21 fishers for every 1,000 inhabitants.

Industrial fisheries

We assumed industrial landings form the basis for most taxa in the FAO landings (other than those reported as 'unidentified marine fish') prior to 2000, and comparison with other data sets confirms this (DNP 1976; de Freitas 1989; Charlier 1994; de Sousa 2001). The FAO landings data did not contain MOSOPESCA catches of small pelagics (unless they are allocated as 'unidentified marine fish') from 1977–1987 (Sousa 1992) and 1988–1992 (unpub data, provided by L. Sousa),[3] nor did they contain a small amount of catches for select taxa (demersals, sharks and large pelagics) reported in Charlier (1994). Thus we supplemented the FAO data in the 1970s-1990s with unreported industrial catches from the MOSOPESCA shad fishery from Sousa (1992) and Charlier (1994) to create an industrial time-series (Table 2).

Table 2. Source of reported industrial catches from 1950–2010

Period	Catch (t)	Source
1950–1954	3,300	Jacquet *et al.* (2010)
1955–1960	3,300–3,900	Krantz *et al.* (1986)
1961–1975	3,285–15,655	DNP (1976)
1976–1999	13,893–31,207	FAO (2012); Sousa (1992); Charlier (1994); unpub. data, provided by L. Sousa)
2000–2010	7,724–13,723	FAO (2012); National Statistics from INAQUA[a]

[a] *Instituto Nacional de Desenvolvimento de Aquacultura*.

[2] Depending on the fidelity of coverage and sampling procedures, the lines of distinction between catch removals from industrial/semi-industrial and small-scale fisheries may become blurred. Since the 1970s, there are accounts of small-scale fishers in Nampula, Zambézia, and Sofala provinces collecting bycatch from industrial/semi-industrial shrimp trawlers. These collections are realized through an exchange program: artisanal fishers or collectors exchange their agricultural produce or money for the fish bycatch of industrial/semi-industrial vessels. The fish is either sold fresh for local consumption or dried for more distant markets (Menezes 2008).

[3] Catches from the scad fishery for the 1988–1992 period were obtained from unpublished data presented at the 1993 Master Fisheries Plan seminar.

Discards

Estimates of bycatch to landings ratios from South African and Mozambique shallow-water shrimp fisheries range from 2.3:1 to 5:1 (Fennessy and Groeneveld 1997; Pinto 2001). Most bycatch is comprised of small non-marketable fish and juvenile shrimp that are discarded (Schultz 1992). We used these studies to develop estimates of discard to landings ratios for the 1950–2010 period (Table 3).

Table 3. Discards to shrimp landings (D/L) rates used to estimate discards in Mozambique shallow water shrimp trawl fisheries

Period	D/L	Source
1958–1979	2.9	Carried back 1980 rate
1980	2.9[a]	Pelgröm and Sulemane (1982)
1981–1982	2.9–3.0	linear interpolation
1983–1984	3.1[a]	Gislason (1985), in Pinto (2001)
1985	3.5	linear interpolation
1986–1990	3.8[b]	Pacule and Baltazar (1995), in Pinto (2001)
1991	3.8	Fennessy and Groeneveld (1997)
1992	2.9	Fennessy and Groeneveld (1997)
1993	4.5[b]	Anon. (1994), in Pinto (2001)
1994–1999	4.3–3.0	linear interpolation
2000–2010	2.8	Jacquet *et al.* (2010)

[a] Assuming 5% of bycatch is retained (Pelgröm and Sulemane 1982).
[b] Assuming 11% of bycatch is retained (Anon. 1994).

The FAO landings data included catches for three different shrimp groupings: 'Penaeus shrimps', 'knife shrimp', and 'Tsivakihini paste shrimp' (*Acetes erythraeus*). Discards associated with shallow-water shrimp fisheries were calculated by multiplying the discard to shrimp landings ratios from Table 3 by FAO 'penaied shrimp' landings, present in FAO data since 1958.

Discard and catch data from Fennessy and Groeneveld (1997) indicated a ratio of target landings (knife shrimp, African lobster, deep-sea crab) to discards of 1:2.7 in 1992. Discards associated with deep-water crustacean fisheries were calculated by multiplying this ratio by FAO landings of knife shrimp, African lobster and pink geryons, present in the FAO data since 1986. We ignored any discards from Tsivakihini paste shrimp fisheries, as these are generally caught in coastal areas using push nets, bag nets and seines by small-scale fisheries with lower bycatch rates (Chen 1994; Chan 1998; Gillett 2008).

Bycatch data for MOSOPESCA were available from 1980–1985 (Krantz *et al.* 1986), and we applied the median discard to landings ratio of 0.4 to estimate bycatch for years without data (1977–1979, 1987–1996).

Taxonomic disaggregation

The FAO landings data extracted from FishStatJ (FAO 2012) were allocated to 30 different taxa. The taxonomic allocation of the FAO landings were accepted without further disaggregation, with the exception of the 'marine fishes nei' category, which accounted for 34–99 % of reported landings per year.

The IPP began regular publication of industrial/semi-industrial and small-scale fisheries statistics in 2001. These reports (IIP 2001–2010) were used to estimate the catch composition for Mozambique's marine fishing sectors during the 2000s (Table 4). They included bycatch composition of shallow-water industrial shrimp fisheries and catch composition of small-scale fisheries from select provinces from 2001–2010. Additional available information included: a Portuguese Research Report to the International Commission for the South-East Atlantic Fisheries (ICSEAF) that provided estimates of percent catch composition by family for 1972–1973 (Monteiro 1973), and additional bycatch studies from shallow-water shrimp fisheries in the region (Fennessy *et al.* 1994; Pinto 2001).

Reported estimates of species catch composition were therefore unavailable for periods extending from 1950–1971 and 1974–1999. Accordingly, assumption-based estimations, interpolations, extrapolations and averaging have been used to derive estimates for these periods, with input and expert advice from experienced senior scientists at the IIP (Table 4).

Table 4. Reconstructed catch compositions for small-scale fisheries and industrial crustacean fisheries discards in Mozambique from 1950–2010.

Taxa	Catch Composition (in %)			
	Small-scale			Discards
	1950–1973	2003[a]	2004–2010[a]	1950–2010
Invertebrates				
Brachyura	-	-	-	1.7
Cephalopoda	0.8	0.6	0.4–1.3	1.5
Nephropodidae	0.1	-	0.0–0.2	-
Penaidae	5.3	8.7	1.5–8.7	3.8
Portunidae	0.4	0.5	0.2–0.8	4.4
Chondrichthyes				
Elasmobranchii	1.1	0.6	0.2–2.8	1.0
Teleosts				
Ariidae	0.9	1.3	1.3	5.3
Caesionidae	1.4	1.9	2.0	-
Carangidae	7.8	10.9	11.1–11.6	0.6
Clupeidae	12.3	17.2	17.4–18.2	2.3
Cynoglossidae	-	-		1.5
Drepaneidae	-	-		2.2
Engraulidae	9.8	13.7	13.9–14.5	2.8
Haemulidae	10.7	2.9	3.0–3.1	3.7
Leiognathidae	0.1	0.2	0.2	0.5
Lethrinidae	8.5	3.1	3.2–3.3	-
Lutjanidae	6.4	0.3	0.3–0.4	-
Mugilidae	1.2	1.6	1.6–1.7	-
Mullidae	1.1	1.5	1.5–1.6	1.7
Polynemidae	-	-	-	2.0
Scaridae	3.0	1.1	1.1	-
Sciaenidae	2.2	3.1	3.1–3.2	25.9
Scombridae	3.4	4.7	4.8–5.0	-
Serranidae	<0.1	<0.1	<0.1	-
Siganidae	6.3	2.0	2.0–2.1	-
Synodontidae	-	-	-	2.2
Trichiuridae	1.5	2.1	2.1–2.2	4.7
Tetraodontidae	-	-	-	2.7
Others[b]	15.6	21.9	22.1–23.1	29.6

[a] A separate breakdown for 7 major groups was available for the small-scale sector for each year from 2003–2010. The values for 5 major groups and the disaggregated teleost component are shown for 2003 as well as the range of maximum and minimum values for 2004–2010.
[b] Small-scale includes 10 taxa, each occupying <1%, and marine fishes not identified. Discards includes 6 families and unidentified species.

Small-scale sector

Small-scale FAO landings of specific taxa were left unadjusted, while unreported landings and FAO catches allocated as 'unidentified fish' were assigned to specific taxa (Table 4). We assigned 500 t and 700 t of unreported catch in 1990 and 1993, respectively, as holothurian catch based on estimates reported in Abdula (1998) which are missing from the FAO database.

The *IIP Relatório Anual* report series contained annual estimates of catch composition by family for small-scale fisheries for select coastal provinces between 2001 and 2010. These reports provided national catch compositions for the small-scale sector from 2003–2010 that separated catches into seven groups; shrimps, cephalopods, crabs, lobster, sharks, fish and others. The latter two groups were combined as teleosts (encompassing both the 'fish' and 'others' categories) as shown in Table 4, and these annual catch compositions were used to further disaggregate unidentified taxa in the reconstructed small-scale catches from 2003–2010. The average catch composition from 2003–2010 was applied to disaggregate the 1950–1973 small-scale reconstructed catches and catch compositions from 1974 to 2002 were interpolated between the assumed 1950–1973 and 2003 breakdowns. The catches were composed mostly of teleost families (90–95% of total catches) and a further disaggregation of the teleost component was attempted.

Mozambique's national data have only provided complete estimates covering all coastal areas for 2009 and 2010, and as a result, these years were considered the best representation of catch composition for Mozambique's small-scale fishing sector. Mozambique's national fisheries surveys (IIP 2009, 2010) provide small-scale catch compositions for all coastal provinces (Cabo Delgado, Nampula, Zambezia, Sofala, Inhambane, and Maputo) except Gaza. We converted these provincial catch compositions into a national catch composition,[4] which was weighted proportionally to the reported 2010 small-scale catches by province (IIP 2010). This 2010 small-scale catch composition was used to disaggregate the teleost component from 2003–2010 (Table 3).

There was little information regarding the catch composition of Mozambique's fisheries prior to 2000; however, a survey by Monteiro (1973) provided some indication of the major taxa present in catches during the earlier period. Monteiro (1973) recorded the catch composition of 39 beach seines, hauled by tractor winches, in the province of Inhambane between September 1972 and September 1973. Their catch composition was compared with the 2010 small-scale catch compositions for Inhambane in an attempt to estimate a 1973 national catch composition. Based on this comparison, the 5 major taxa (Haemulidae, Lethrinidae, Lutjanidae, Scaridae and Siganidae) observed by Monteiro (1973) were adjusted to levels which were assumed more representative for the entire coastline (Table 5). This left approximately 62% of catches as 'others', which were allocated proportionally to other families in the 2010 small-scale teleost catch composition. This 1973 catch composition was used to disaggregate the teleost component from 1950–1973 (Table 4), and catch compositions from 1974 to 2002 were interpolated between the assumed 1950–1973 and 2003 breakdowns.

Table 5. Development of the 1973 teleost breakdown (%) for Mozambique's small-scale fishery

Taxa	1972/1973 catch composition for Inhambane[a]	2010 teleost catch composition for Inhambane[b]	1972/1973–2010 ratio	2010 national teleost catch composition[b,c]	Estimated 1973 national teleost catch composition[d]
Haemulidae	11.3	3.2	3.5	3.3	11.6
Lethrinidae	28.7	10.8	2.7	3.5	9.3
Lutjanidae	4.5	0.25	18.3	0.38	6.9
Scaridae	12.3	4.6	2.7	1.2	3.2
Siganidae	24.2	7.8	3.1	2.2	6.9
Other taxa	19	73	-	90	62

[a] Source: Monteiro (1973).
[b] Source: IIP (2010).
[c] See Table 3.
[d] 1973 national catch composition was estimated based on the ratio of the 2010 Inhambane catch composition to the 1973 Inhambane catch composition. These are the percentages used to disaggregate the teleost component and thus are not equivalent to the percentages of total catch shown in Table 4.

For the purposes of the *Sea Around Us* database, small-scale catches were further subdivided into artisanal and subsistence components. It is often difficult to distinguish between these two sectors as most small-scale fishers fish for both subsistence and artisanal purposes, selling the more valuable species landed and taking the rest home for consumption. The collection of landings data did not record this information and we found no other studies that distinguished between these sectors in Mozambique. We thus employed the same approach as Le Manach *et al.* (this volume), assigning 90% of catch from taxa associated with higher commercial values (Decapoda, Elasmobranchii, Haemulidae, Istiophoridae, Lethrinidae, Lutjanidae, Scaridae, Sciaenidae, Scombridae, Serranidae, Siganidae and Sparidae) as 'artisanal' and the remaining 10% as 'subsistence' to account for spoilt and undersized catches. The remaining taxa were considered less commercially important and we allocated 80% of these catches as 'subsistence' and 20% as 'artisanal'. For species where the distinction was less obvious, i.e., Carangidae and unidentified marine fish, we used an even split, allocating 50% to each small-scale sector. All holothurian catches were considered 'artisanal' (Abdula 1998).

Industrial sector

Catches from the MOSOPESCA shad and mackerel trawl fishery were disaggregated based on the 1986 and 1987 species compositions reported in Sousa (1992). These two years were then averaged to estimate species composition for all other years.

[4] The 2010 catch composition (IIP 2010) was used for all provinces except Maputo, which used the 2009 catch composition (IIP 2009) since it was not available in the 2010 report.

Discards

The *IIP Relatório Anual* reports contained bycatch data from 2000–2010, and discard data for 2008–2009 from select industrial shrimp fishing companies sampled. The 2004 bycatch data and the 2008 discard data were disregarded as they contained high penaeid shrimp discards, which were not considered representative of the entire fleet.

The annual 2000–2003, 2005–2008, 2010 bycatch and 2009 discard compositions were averaged to estimate an average composition of discards (Table 4). The average was composed of 11% invertebrates and 89% teleosts, 1/3 of which were unidentified species listed as 'others'. A small amount of the unidentified component (5%) was redistributed to 'missing' teleost families (Ariommatidae, Congridae, Platycephalidea, Pristigasteridae, Soleidae and Tetraodontidate) based on the proportions observed in commercial prawn trawls in Tugela Bank in the early 1990s (Fennessy *et al.* 1994). Another 1% was allocated to elasmobranchs[5] based on estimates by Schultz (1989) and Sousa (1990; see also Le Manach *et al.* 2012).

Results

Total marine fisheries catches, 1950–2010

The total catch for Mozambique during the 1950–2010 period, as reconstructed here, was nearly 8.2 million t, i.e., 4.6 times the 1.8 million t reported by FAO on behalf of Mozambique for the same period (Figure 2). The total reconstructed catch (including discards) ranged from 55,000 t·year^{-1} in 1950 to 138,000 t·year^{-1} in 2010, and reached a peak of nearly 208,000 t·year^{-1} in 1986.

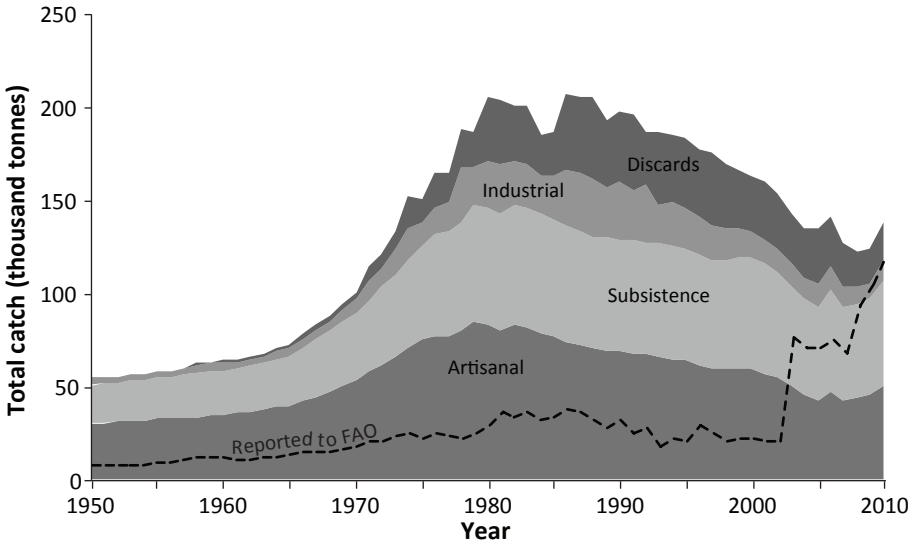

Figure 2. Total reconstructed catches by sector (subsistence, artisanal, industrial catches, and discards) for Mozambique compared to the landings reported by FAO (dashed line). Total small-scale catches are the sum of 'artisanal' and 'subsistence'.

Total small-scale catch for the 61-year period from 1950 to 2010 was over 6.2 million t, of which 55% was deemed artisanal (i.e., mainly for commercial purposes) and 45% was subsistence (Figure 2). Small-scale catches (i.e., artisanal and subsistence combined) increased from nearly 52,000 t·year^{-1} in 1950 to 108,000 t·year^{-1} in 2010. Catches from this sector peaked in 1982 at 148,500 t·year^{-1}, and accounted for 76% of the total reconstructed catches for the 1950–2010 period (annual reconstructed catches by sector are available in Appendix Table A2).

Discards and landings from industrial fisheries contributed 14% and 10% to total reconstructed catches, respectively (Figure 2). Industrial catches peaked at around 32,000 t·year^{-1} in 1988, ranging from around 3,300 t·year^{-1} in 1950 to 10,000 t·year^{-1} in 2010. Discards from industrial fisheries were also highest in 1988 at 44,000 t·year^{-1}, and ranged from around 1,500 t·year^{-1} in 1958 to 20,000 t·year^{-1} in 2010 (Figure 2).

Noteworthy is the significant improvement in the data provided to the FAO for the 2003–2010 period since the previous reconstruction (see Jacquet and Zeller 2007 and Jacquet *et al.* 2010). Annual reconstructed catches for years 2003–2010 were on average 1.6 times the reported FAO landings for the same period, while they were on average 6.4 times the reported landings for the 1950–2002 period (Figure 2).

Taxonomic disaggregation

Reconstructed catches were allocated to one of 83 taxa or higher order groupings. Results for the total catches from 1950–2010 for all of Mozambique's marine fishing sectors indicate Clupeidae (11%), Engraulidae (9%), Penaeidae (8%), Carangidae (7%), Haemulidae (6%), Sciaenidae (5%) and Lethrinidae (5%) families have historically composed large portions of the catch (Figure 3). Annual reconstructed catches grouped by important taxa are shown in Appendix Table A3.

[5] See Fennessy (1994) for common elasmobranch species in shrimp bycatch.

The catches of the small-scale sector were dominated by 28 groups of teleosts (92%), followed by shrimps (6%). The five most important taxa in small-scale catches were Clupeidae (14%), Engraulidae (12%), Carangidae (9%), Haemulidae (7%) and Lethrinidae (6%). The reconstructed catch composition, based on Monteiro (1973) study, suggests that the familes Haemulidae, Lethrinidae, Lutjanidae, Scaridae, and Siganidae were more prominent in the catches in early years, accounting for 35% of small-scale catches from 1950–1973 compared to 10% of catches for 2000–2010.

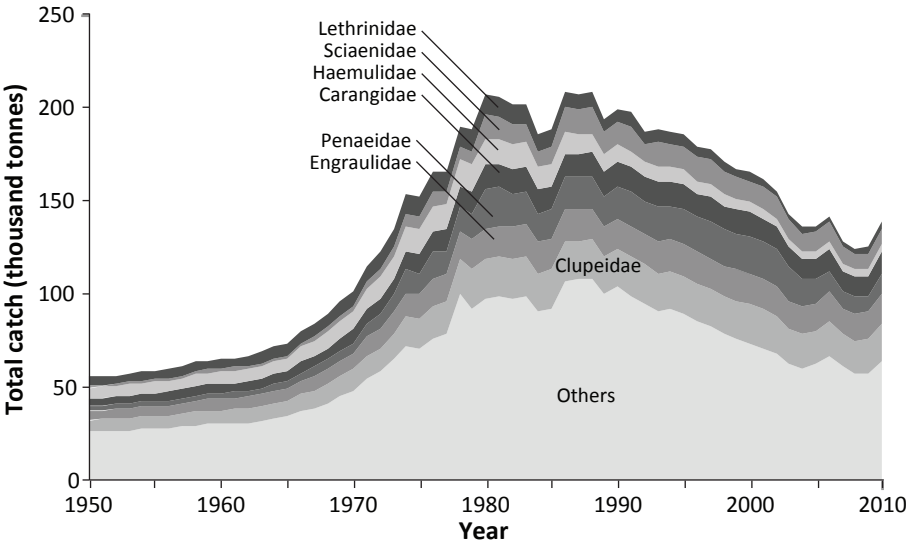

Figure 3. Taxonomic breakdown of total marine fisheries catches by major taxa for Mozambique (includes small-scale fisheries, industrial fisheries and discards). 'Others' includes 58 taxonomic groupings.

The taxonomic breakdown of Mozambique's industrial sector indicated that total catches during the 1950–2010 period were dominated by penaeid shrimp (34%), scads (*Decapterus* spp.; 7%) and knife shrimp (6%), with other teleost species composing most of the remaining catches (49%). Discards from shrimp fisheries consisted primarily of teleosts (88%), with Sciaenidae (26% of discards) being the most common family discarded.

Discussion

The 2003 and 2004 FAO reported landings have increased since the previous reconstruction by Jacquet *et al.* (2010), as have the reported catches for the 2005–2010 period in comparison with earlier years. It is evident that Mozambique's IPP has substantially improved their system of national data collection for small-scale fisheries and has retroactively adjusted the 2003 and 2004 data reported to FAO. The small-scale catch component within the FAO data for 2009 and 2010 were in the same range as the reconstructed small-scale catches (90,000–120,000) for the last decade and were considered fully reported. This is a significant improvement and Mozambique is one of the few countries in the world where this change has been observed by the *Sea Around Us*.

The FAO landings data, however, still do not account for many sources of fisheries removals, particularly from the small-scale sector prior to 2003 and discards from industrial fleets. Discards from industrial shrimp fisheries — which have one of the largest discard rates of any fishing gear (Kelleher 2005) — have historically been responsible for significant removals from Mozambique's marine ecosystems and are not included in FAO landings data. This is the case for *Otolithes ruber* (tigertooth croaker) from the highly discarded Sciaenidae family (Olbers and Fennessy 2007). The decline of this species and potentially other bycatch species that are targeted by small-scale fishers, such as *Thryssa vitrirostris* (Mualeque and Santos 2011), may have important implications for food security in the region (Olbers and Fennessy 2007). Practices such as the collecting of bycatch from industrial shrimp trawlers by small-scale fishers, may serve as a means of reducing overall waste and improving food security for coastal fishers (Olbers and Fennessy 2007; Le Manach *et al.* 2012). In fact, Mozambique regulations require that a 2:1 bycatch to shrimp ratio is landed for this purpose, however the measure is not enforced (Banks and Macfayden 2011). It is clear that monitoring of discards is still inadequate among industrial fisheries in Mozambique, and this component requires further study.

Although there has been an improvement in the total small-scale catches reported to FAO, much of the catch is still reported only as unidentified marine fishes. Despite the lack of a full time-series data for Mozambique's coastal provinces, this study attempted to disaggregate historical catch into more specific taxonomic groups (e.g., families, genus, species). Catch estimates for Inhambane, home to 15% of the country's artisanal fishers (IDPPE 2004, in Jacquet and Zeller 2007), indicate that there have been shifts in the dominant species removed by capture fisheries during the 1950–2010 time period. Reports from this province indicate that catches from the small-scale beach seine fishery during 1972–1973 were dominated by demersal species from the families Haemulidae, Lethrinidae, Lutjanidae, Scaridae, and Siganidae (Monteiro 1973). The proportions of each of these families in Inhambane beach seine catches are now less than half of what they were in the 1970s (IIP 2010). Surveys of fisherman on Inhaca island (de Boer *et al.* 2001) confirmed this trend as fishers noted that *Carangoides* spp. and *Scomberoides* spp. (both from the Carangidae family), *Pomadasys* spp. (Haemulidae), *Lutjanus* spp. (Lutjanidae), *Rhabdosargus* spp. (Sparidae), Dasyatidae and Myliobatidae (rays), squid and cuttlefish were more abundant in historical catches. De Boer *et al.* (2001) found that large predatory fish from higher trophic levels were absent from catches and suggested these trends may be indicative of overfishing (see also Pauly *et al.* 1998).

Whereas information on family-level catch composition was available for all sectors between 2000–2010 (IIP 2001–2010), the only detailed catch composition data for the small-scale sector were from the study of Monteiro (1973). A

variety of assumptions were necessary to extrapolate the available catch composition data to the 1950–2010 period, and as there was little catch sampling and reporting from any sectors occurring prior to 2000 these estimates are approximate. It is possible that the catch composition of demersal families from the Monteiro (1973) report, as well as some pelagic families from the 2010 catch composition (IIP 2010) may have been given too much weight in the earlier time series and this will have significantly impacted estimated catch compositions for the small-scale sector from 1950–2002. Groupers (Serranidae) were not listed in the Monteiro (1973) catch composition and made up a small portion of national catches in recent years (IIP 2010). It is quite possible that groupers were more abundant in earlier catches in Mozambique (Kaunda-Arara *et al.* 2003; Sadovy de Mitcheson *et al.* 2013) than what is reflected in the catch compositions used in this study.

Similarly, we used bycatch data from 2000–2010 to estimate taxonomic composition of discards for the 1950–2010 period, which will not reflect changes in bycatch composition over time (Groeneveld and Melville-Smith 1995; Olbers and Fennessy 2007) and should be taken as approximate. For example, the proportion of *Trichiurus lepturus* (largehead hairtail) and *Pellona ditchela* (Indian pellona) were highly variable in bycatch from different surveys between 1995 and 2010 (Fennessy and Groeneveld 1997; IIP 2001–2010; Pinto 2001; Fennessy and Isaksen 2007). Given the limited bycatch data prior to 2000 for Mozambique shrimp fisheries, it is difficult to assess if this variation is due to sampling or indicative of larger spatial and temporal changes in bycatch species composition. Due to lack of data for deep-water crustacean fisheries, we assumed a similar composition of families in the discards of shallow-water shrimp fisheries, and thus differences in their bycatch are not reflected in our estimates.

It is well established that catch data reported by Mozambique to the FAO has historically been underreported (DNP 1976; van der Elst *et al.* 2005; Jacquet *et al.* 2010; Blythe *et al.* 2013). Van der Elst *et al.* (2005) reports that national estimates under Mozambique's National Fisheries Master Plan were actually 200,600 t and 87,700 t for 1988 and 1995, despite catches reported to the FAO of less than 32,200 t and 22,500 t for the same years. In comparison, our reconstructed catches, excluding discards, are 152,000 t and 147,000 t for years 1988 and 1995. It is clear that considerable uncertainty remains regarding the catch totals for Mozambique fisheries, and although we will never know the 'true' catches for most of this period, this study provides estimates that are much closer to the Mozambican reality than those present in FAO data. FAO data suggests that catches in the Western Indian Ocean peaked *circa* 1999 (van der Elst 2005), however, this may be the result of improved reporting and underreporting in earlier years. For example, FAO landings data for Mozambique show that catches peaked in 2010 and 2011, the last two years reported. However, reconstructed estimates peaked in the mid-1980s. Similarly, trends observed for increased numbers of species in catch data in later years (van der Elst *et al.* 2005) are also likely the result of improved reporting of more detailed taxa in the FAO catch data.

There was high variability in the discard rates observed since the 1980s for industrial shrimp fisheries, some of which were based on small sample sizes that may not have been representative of the average discard rate for the entire commercial fleet. Our discard estimates were based on landings reported to the FAO and were likely a minimum estimate for most years given historical under-reporting of industrial fisheries (see Jacquet *et al.* 2010) and that 40% of vessels do not submit their logbooks (Banks and Macfayden 2011). These estimates provide a good starting point for understanding the scale of discards and the major taxonomic groups affected. Future work that considers temporal and spatial variation in discard rates and taxonomic composition (Fennessy *et al.* 1994) could provide more accurate accounting for discards.

Taxonomic compositions in the reconstructed data remain coarse, and was often left at the family level or higher. Despite the uncertainties in historical taxonomic catch compositions for the last six decades, this exercise was valuable given changes in the catch composition that have likely occurred i) in species composition due to fishing pressure, or other changes in the ecosystem (see de Boer *et al.* 2001); and/or ii) in the species targeted by fishers/fishing sectors. For example, the bottom trawl fleet targeting pelagic fishes such as mackerel (*Rastrelliger kanagurta*) and scad (*Decapterus* spp.) during the 1980s (Silva and Sousa 1988) was closed in 1993 (L. Sousa, unpub. data). Similarly, some artisanal fishers may have transitioned from shallow waters to areas with deeper water, in which case species catch composition could have undergone corresponding changes. Increased market demand for new seafood products (e.g., holothurians, sea urchins, shark fins, paste shrimps and other non-traditional species) are rapidly gaining economic importance and changing the focus of fisheries in Mozambique (Abdula 1998; Pierce *et al.* 2008). Since *circa* 2000, there has been a large increase in the number of small-scale fishers targeting sharks for the Asian shark fin trade (Pierce *et al.* 2008; Gekoski 2011; Smith 2013). There is little data specific to the small-scale shark fishery in Mozambique (Pierce *et al.* 2008) and thus elasmobranch catches from this sector may well be underestimated in this study (Kroese and Sauer 1998; Pierce *et al.* 2008). Catch data from bather-protection gillnets off the coast of KwaZulu-Natal showed declines of some shark species that may be attributed to shark bycatch in Mozambique's small-scale and shrimp fisheries (Dudley and Simpfendorfer 2006).

Other forces, such as changing environmental conditions may also impact species composition (Cheung *et al.* 2009; Meyer and Weerts 2009; Cheung *et al.* 2010; P□rtner and Peck 2010; Perry 2011; Blythe *et al.* 2013). However, without accurate catch time series, it is very difficult to assess the magnitude of these changes and what may have caused them (see also de Boer *et al.* 2001 and Blythe *et al.* 2013). Our findings highlight the importance of recording fisheries statistics for all sources of removals (e.g. small-scale fisheries, industrial fisheries and discards), and also retroactively improving catch statistics for earlier years.

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Appendix Table A1. Mozambique common species in capture fisheries by sector.

Family	Scientific name	Common name		Small-scale	Indust.	Discard
		English	Local (Portuguese)			
Crustaceans						
Aristeidae	*Aristeus antennatus*	Blue and red shrimp	alistado/gamba rosada		✓	✓
	A. virilis	Stout red shrimp	gamba vermelho forte		✓	✓
	Aristaeopsis edwardsianus	Scarlet shrimp	gamba carabineira		✓	✓
	Aristaeomorpha foliacea	Giant gamba prawn	gamba vermelha		✓	✓
Geryonidae	*Chaceon macphersoni*	Pink geryon	caranguejo de profundidade		✓	✓
Nephropidae	*Nephropsis stewarti*	Indian ocean lobsterette	lagostim indiano		✓	✓
	Metanephrops andamanicus	Andaman lobster	lagostim comum		✓	✓
	M. mozambicus	African lobster	lagostim		✓	✓
Palinuridae	*Panulirus versicolor*	Painted rock lobster	lagosta pintada	✓		✓
	P. ornatus	Coral crayfish	lagosta costeira	✓	✓	✓
	P. homarus	Scalloped spiny lobster	lagosta escamosa	✓	✓	✓
	P. delagoae	Natal spiny lobster	lagosta de profundidae	✓	✓	✓
Penaeidae	*Fenneropenaeus indicus*	Indian white prawn	camarão branco	✓	✓	✓
	Metapenaeus monoceros	Speckled shrimp	camarão castanho	✓	✓	✓
	M. stebbingi	Peregrine shrimp				
	Penaeopsis balssi	Scythe shrimp	camarão foice		✓	✓
	Penaeus monodon	Giant tiger prawn	camarão tigre gigante	✓	✓	✓
	P. japonicus	Kuruma shrimp	camarão flor	✓	✓	✓
	P. latisulcatus	Western king prawn	camarão real		✓	✓
	P. semisulcatus	Green tiger prawn	camarão tigre	✓	✓	✓
Portunidae	*Scylla serrata*	Green mangrove crab	caranguejo do mangal	✓		✓
	Portunus sanguinolentus	Three-spot swimming crab	caranguejo sangrador	✓	✓	✓
Sergestidae	*Acetes erythraeus*	Tsivakihini paste shrimp	camarão mundehe	✓		✓
Solenoceridae	*Haliporoides triarthrus*	Knife shrimp	gamba rosa		✓	
Bivalves						
Veneridae	*Eumarcia paupercula*	Beaked clam	amêijoa fina	✓		✓
	Meretrix meretrix	Asiatic hard clam	amêijoa dura	✓		✓
Cephalopods						
Octopodidae	*Octopus macropus*	White spotted octopus	polvo manchado	✓		✓
Sepiidae	*Sepia pharaonis*	Pharaoh cuttlefish	choco tigre	✓		✓
Finfish						
Acanthuridae	*Acanthurus leucosternon*	surgeonfish	cirurgião poeirento	✓		✓
Acropomatidae	*Neoscombrops cynodon*	Silver splitfin	maconde sombreado	✓		✓
Anguillidae	*Anguilla mossambica*	African longfin eel	enguia moçambicana	✓		✓
	A. bengalensis labiata	African mottled eel	enguia africana	✓		✓
	A. marmorata	Giant mottled eel	enguia gigante	✓		✓
Ariidae	*Plicofollis dussumieri*	Blacktip sea catfish	bagre	✓		✓
Atherinidae	*Hypoatherina temminckii*	Samoan silversides	rei samoano	✓		✓
Balistidae	*Rhinecanthus rectangulus*	Wedge-tail triggerfish	porco rectangular	✓		✓
Belonidae	*Ablennes hians*	Flat needlefish	agulha lisa	✓		✓
Carangidae	*Alepes djedaba*	Shrimp scad	xaréu camaroneiro	✓		✓
	Decapterus russelli	Indian scad	carapau	✓		✓
	D. macrosoma	Shortfin scad	carapau barbatana	✓		✓
	Selar crumenophthalmus	Big-eye scad	carapau preto	✓		✓
	Carangoides malabaricus	Horse mackerel	malabar cavalla	✓		✓
Centrophoridae	*Centrophorus moluccensis*	Smallfin gulper shark	lixa barbatana curta	✓	✓	✓
Chirocentridae	*Chirocentrus nudus*	Whitefin wolf herring	machope espinhoso	✓		✓
Clupeidae	*Hilsa kelee*	Kelee shad	magumba	✓		✓
Clupeidae	*Herklotsichthys quadrimaculatus*	bluestripe herring	sardinha banda azul	✓		✓
	Sardinella albella	White sardinella	sardinha branca	✓		✓
	S. gibbosa	Gold stripe sardinella	sardinha dourada	✓		✓
	Pellona ditchela	Indian pellon	sardinia de indico	✓		✓
Drepaneidae	*Drepane longimana*	Concertina fish	enxada concertina	✓		✓
Engraulidae	*Thryssa vitrirostris*	Orangemouth anchovy	ocares	✓		✓
	T. setirostris	Longjaw thryssa	ocar cornudo	✓		✓
	Encrasicholina heteroloba	Shorthead anchovy	anchoveta aduaneira	✓		✓
Gerreidae	*Gerres filamentosus*	Whipfin silver-biddy	melanúria filamentosa	✓		✓
Haemulidae	*Pomadasys kaakan*	Javelin grunter	peixe pedra	✓		✓
	P. maculatus	Saddle grunt	gonguri	✓		✓
	P. olivaceus	Olive grunt	roncador oliva	✓	✓	✓
	Plectorhinchus flavomaculatus	Lemonfish	owa-owa		✓	✓
Istiophoridae	*Kajika audax*	Striped marlin	espadim raiado		✓	✓
	Istiompax indica	Black marlin	espadim negro		✓	✓
	Istiophorus platypterus	Indo-pacific sailfish	veleiro		✓	✓
Leiognathidae	*Leiognathus equulus*	Common ponyfish	patana comum	✓		✓
	Gazza minuta	Toothpony	sabonete dentuço	✓		✓
	Secutor insidiator	Pugnose ponyfish	chita boxeira	✓		✓
Lethrinidae	*Lethrinus lentjan*	Redspot emperor	ladrão de lentejoulas	✓	✓	✓

Appendix Table 1. Mozambique common species in capture fisheries by sector (continued).

Family	*Scientific name*	Common name		Small-scale	Indust.	Discard
		English	Local (Portuguese)			
	L. borbonicus	Snubnose emperor	xegugo		✓	
Lutjanidae	*Lutjanus sanguineus*	Humphead snapper	pargo vermelhão	✓	✓	✓
	L. fulviflamma	Dory snapper	thana		✓	
Mullidae	*Upeneus vittatus*	Yellowstriped goatfish	salmonete	✓	✓	✓
	U. japonicus	Bensasi goatfish	salmonete bensasi		✓	✓
Mugilidae	*Chelon macrolepis*	Largescale mullet	tainha godé	✓		✓
Muraenesocidae	*Muraenesox bagio*	Common pike conger	enguia/safio comum	✓		✓
Nemipteridae	*Nemipterus bipunctatus*	Delagoa threadfin bream	baga delagoa		✓	✓
Paralichthyidae	*Pseudorhombus natalensis*	Natal flounder	areeiro		✓	✓
Polynemidae	*Polydactylus sextarius*	Blackspot threadfin	barbudo de mancha	✓	✓	✓
Scaridae	*Scarus ghobban*	Yellowscale parrotfish	papagaio de escamas amarelas	✓	✓	✓
	Leptoscarus vaigiensis	Marbled parrotfish	lundu		✓	✓
Sciaenidae	*Otolithes ruber*	Tigertooth croaker	corvina	✓	✓	✓
	Johnius amblycephalus	Bearded croaker	corvina	✓	✓	✓
	J. dussumieri	Sin croaker	macujana de barba	✓	✓	✓
	Argyrosomus hololepidotus	Southern meagre	corvina real	✓	✓	✓
Scombridae	*Rastrelliger kanagurta*	Indian mackerel	cavala	✓	✓	✓
	Scomberomorus commerson	Narrow-barred spanish mackerel	serra	✓	✓	✓
	Thunnus albacares	Yellowfin tuna	albacora	✓	✓	✓
	T.alalunga	Albacore	voador	✓	✓	✓
	T. obesus	Bigeye tuna	patudo	✓	✓	✓
	Katsuwonus pelamis	Skipjack tuna	gaiado	✓	✓	✓
Serranidae	*Gracila albomarginata*	White-edged grouper	garoupa bordo branco	✓	✓	✓
	Epinephelus andersoni	Catface grouper	garoupa gato	✓	✓	✓
	E. tukula	Potato bass	garoupa batata	✓	✓	✓
Siganidae	*Siganus canaliculatus*	White-spotted spinefoot	babi		✓	✓
Sillaginidae	*Sillago sihama*	Silver sillago	pescadinha comum	✓		✓
Sparidae	*Chrysoblephus puniceus*	Slinger seabream	marreco	✓		✓
	C. gibbiceps	Red stumpnose seabream	marreco		✓	✓
	Crenidens crenidens	Karanteen seabream	esparo	✓		
	Dentex macrophthalmus	Large-eye dentex	cachucho		✓	✓
Sphyraenidae	*Sphyraena* spp.	Barracuda	bicuda	✓	✓	✓
Synodontidae	*Saurida undosquamis*	Brushtooth lizardfish	mbolopfuma	✓	✓	✓
Trichiuridae	*Trichiurus lepturus*	Largehead hairtail	peixe fita	✓	✓	✓
Xiphiidae	*Xiphias gladius*	Swordfish	espadarte		✓	✓
Sharks, rays and skates						
Carcharhinidae	*Carcharhinus amblyrhynchos*	Grey reef shark	Marracho enlutado	✓		
	C. leucas	Bull shark	Marracho touro	✓		✓
	C. limbatus	Blacktip shark	Marracho macuira	✓		
	C. plumbeus	Sandbar shark	Marracho de Milberto	✓		
	Galeocerdo cuvier	Tiger shark	Marracho tigre	✓		
	Negaprion acutidens	Sicklefin lemon shark	Limão foiçador	✓		
	Triaenodon obesus	Whitetip reef shark	Marracho de covas	✓		
Dasyatidae	*Dasyatis kuhlii*	Bluespotted stingray	Uge ponteado	✓		
	D. microps	Smalleye stingray		✓		
	Himantura cf. *uarnak*	Honeycomb stingray	Burá alveolado	✓		
Hemigaleidae	*Hemipristis elongata*	Snaggletooth shark	Tubarão doninha	✓		
Mobulidae	*Manta birostris*	Manta	Jamanta gigante	✓		
Myliobatidae	*Aetobatus narinari*	Spotted eagle ray	Ratau ponteado	✓		
Rhinidae	*Rhina ancylostoma*	Bowmouth guitarfish		✓		
Rhynchobatidae	*Rhynchobatus djiddensis*	Giant guitarfish		✓		
Sphyrnidae	*Sphyrna lewini*	Scalloped hammerhead	Tubarão martelo comum	✓		
	S. zygaena	Smooth hammerhead shark	tubarão martelo liso	✓		✓
Stegostomatidae	*Stegostoma fasciatum*	Zebra shark		✓		

'√' indicates that capture of this species contributes significantly to the total catch.
Sources: Silva and Sousa (1988); Pauly (1992); Sousa (1992); Abdula (1998); Lee *et al.* (1999); de Boer *et al.* (2001); IIP (2001–2010); Motta *et al.* (2002); Kelleher (2005); Béné *et al.* (2007); FAO and WorldFish Center (2008); Jacquet *et al.* (2010); www.fishbase.org; www.sealifebase.org; www.marinespecies.org, http://species-identification.org.

Appendix Table A2. Annual reconstructed catches by sector, and FAO reported landings (t).

Year	Industrial	Discards	Small-scale	Total reconstructed catches	FAO reported landings
1950	3,300	-	51,627	54,927	7,800
1951	3,300	-	52,005	55,305	8,200
1952	3,300	-	52,760	56,060	8,000
1953	3,300	-	53,516	56,816	7,800
1954	3,300	-	54,272	57,572	7,700
1955	3,300	-	55,027	58,327	9,300
1956	3,300	-	55,783	59,083	9,300
1957	4,100	-	56,538	60,638	11,500
1958	4,100	1,450	57,294	62,844	12,100
1959	4,700	1,160	58,050	63,910	12,700
1960	3,900	1,160	59,309	64,369	11,900
1961	3,285	1,380	60,785	65,450	11,300
1962	3,256	1,186	62,262	66,704	11,300
1963	3,425	1,122	63,738	68,285	12,000
1964	4,428	1,282	65,214	70,924	12,400
1965	4,181	1,621	66,690	72,492	14,200
1966	5,347	2,955	71,007	79,309	15,300
1967	5,047	3,007	75,447	83,501	15,000
1968	5,907	3,103	80,010	89,020	15,700
1969	7,328	3,263	84,696	95,287	17,000
1970	7,934	3,271	89,505	100,710	17,600
1971	10,523	7,407	96,459	114,389	20,400
1972	10,513	7,798	103,671	121,982	20,400
1973	13,538	9,982	111,141	134,661	23,300
1974	15,895	17,609	118,869	152,373	25,660
1975	11,636	12,583	126,854	151,073	22,490
1976	13,893	18,850	132,182	164,925	24,900
1977	15,396	15,620	133,584	164,601	23,950
1978	29,146	20,684	138,643	188,473	22,940
1979	21,505	18,070	147,445	187,021	25,130
1980	24,900	34,887	145,907	205,694	30,350
1981	26,699	35,470	142,553	204,722	37,130
1982	23,384	28,969	148,465	200,818	34,680
1983	24,371	30,469	145,720	200,560	37,516
1984	20,734	21,491	142,871	185,096	31,836
1985	23,002	23,842	139,921	186,765	33,306
1986	29,566	41,233	136,875	207,674	38,671
1987	31,207	41,538	133,738	206,482	36,321
1988	32,075	44,117	130,512	206,705	32,185
1989	27,841	35,064	130,221	193,126	27,560
1990	31,473	37,364	129,754	198,591	32,919
1991	26,856	40,145	129,108	196,109	25,536
1992	30,899	27,329	128,277	186,505	27,808
1993	20,066	40,046	127,256	187,368	18,506
1994	23,673	35,959	126,042	185,674	22,531
1995	22,568	37,012	124,630	184,210	21,741
1996	20,993	35,845	121,182	178,020	29,341
1997	18,840	40,072	117,622	176,534	25,658
1998	16,701	34,112	118,847	169,660	21,010
1999	15,295	31,766	119,508	166,569	21,852
2000	13,723	30,849	119,613	164,185	22,198
2001	13,425	30,659	116,042	160,126	21,340
2002	12,685	29,574	112,224	154,483	20,545
2003	12,134	25,933	104,503	142,570	76,926
2004	11,450	26,231	97,384	135,065	71,828
2005	13,257	29,475	93,142	135,874	71,006
2006	11,909	26,111	103,182	141,202	75,882
2007	10,494	24,165	93,056	127,715	68,188
2008	8,382	19,485	95,490	123,357	93,415
2009	7,724	18,419	98,009	124,152	105,734
2010	9,974	20,051	107,876	137,901	117,850

Appendix Table A3. Reconstructed catches (t) grouped by the seven most important taxa.

Year	Clupeidae	Engraulidae	Penaeidae	Carangidae	Haemulidae	Sciaenidae	Lethrinidae	Others
1950	6,389	5,115	2,510	4,071	5,543	1,140	4,445	25,716
1951	6,439	5,155	2,508	4,103	5,586	1,149	4,480	25,884
1952	6,530	5,228	2,559	4,161	5,665	1,165	4,543	26,209
1953	6,621	5,300	2,610	4,219	5,744	1,181	4,607	26,534
1954	6,713	5,374	2,656	4,277	5,824	1,197	4,671	26,861
1955	6,822	5,461	2,611	4,347	5,918	1,217	4,746	27,204
1956	6,915	5,536	2,651	4,406	5,999	1,233	4,811	27,532
1957	7,022	5,622	2,617	4,474	6,092	1,253	4,886	28,673
1958	7,154	5,742	3,179	4,546	6,231	1,645	4,955	29,392
1959	7,240	5,808	3,109	4,604	6,301	1,587	5,019	30,242
1960	7,395	5,932	3,176	4,702	6,435	1,615	5,127	29,988
1961	7,580	6,082	3,352	4,818	6,600	1,704	5,252	30,062
1962	7,761	6,225	3,329	4,935	6,753	1,687	5,381	30,633
1963	7,908	6,342	3,480	5,029	6,880	1,696	5,484	31,466
1964	8,121	6,514	3,536	5,164	7,067	1,775	5,630	33,116
1965	8,327	6,683	3,678	5,293	7,252	1,898	5,768	33,592
1966	8,893	7,149	4,379	5,642	7,766	2,339	6,141	37,000
1967	9,440	7,588	4,633	5,990	8,241	2,450	6,521	38,638
1968	10,002	8,039	4,915	6,347	8,731	2,575	6,911	41,500
1969	10,581	8,503	5,225	6,715	9,236	2,718	7,311	44,997
1970	11,173	8,977	5,484	7,092	9,749	2,826	7,722	47,686
1971	12,106	9,766	7,434	7,651	10,630	4,046	8,306	54,449
1972	13,012	10,495	7,971	8,226	11,423	4,307	8,931	57,618
1973	13,979	11,290	9,202	8,823	12,298	5,036	9,569	64,463
1974	15,303	12,426	12,653	9,602	13,099	7,215	10,016	72,060
1975	16,380	13,239	11,351	10,331	13,406	6,127	10,445	69,793
1976	17,436	14,146	14,070	10,951	13,854	7,912	10,656	75,900
1977	17,742	14,348	12,604	11,183	13,489	6,858	10,527	77,849
1978	18,605	15,033	12,857	11,738	13,591	6,864	10,667	99,118
1979	20,038	16,186	13,640	12,645	14,070	7,268	11,083	92,091
1980	20,493	16,743	21,240	12,771	14,253	12,298	10,691	97,204
1981	20,344	16,615	20,440	12,683	13,605	12,050	10,229	98,757
1982	21,249	17,276	18,224	13,314	13,493	10,591	10,377	96,293
1983	21,146	17,190	17,544	13,252	12,892	10,458	9,940	98,138
1984	20,756	16,797	14,805	13,072	11,967	8,319	9,467	89,913
1985	20,656	16,747	15,102	12,983	11,491	9,081	9,023	91,683
1986	20,837	17,051	17,149	12,963	11,504	13,186	8,588	106,397
1987	20,566	16,830	17,113	12,793	10,899	13,046	8,136	107,097
1988	20,294	16,640	17,288	12,596	10,402	13,717	7,674	108,095
1989	20,236	16,516	15,810	12,626	9,735	11,700	7,402	99,100
1990	20,328	16,620	16,965	12,658	9,431	12,496	7,096	102,997
1991	20,558	16,831	18,221	12,782	9,182	13,230	6,848	98,459
1992	20,318	16,519	17,173	12,732	8,340	10,105	6,557	94,762
1993	20,565	16,861	18,435	12,765	8,444	13,869	6,232	90,197
1994	20,609	16,856	17,689	12,828	7,945	12,835	5,982	90,929
1995	20,569	16,834	18,793	12,793	7,575	13,096	5,677	88,873
1996	20,300	16,607	18,286	12,632	7,076	12,751	5,327	85,041
1997	19,933	16,356	20,229	12,362	6,738	13,762	4,937	82,217
1998	20,158	16,477	19,173	12,556	6,261	12,284	4,767	77,983
1999	20,453	16,689	19,362	12,764	5,906	11,739	4,588	75,067
2000	20,459	16,685	19,880	12,775	5,528	11,507	4,335	73,016
2001	20,121	16,413	19,801	12,562	5,109	11,398	4,012	70,710
2002	19,556	15,950	19,380	12,211	4,637	11,021	3,663	68,064
2003	18,483	15,055	17,956	11,558	4,017	9,902	3,250	62,348
2004	17,852	14,552	14,834	11,153	3,919	9,866	3,134	59,755
2005	17,305	14,147	13,860	10,777	3,932	10,594	3,021	62,237
2006	18,943	15,425	11,739	11,850	4,102	10,030	3,333	65,783
2007	17,200	14,010	9,321	10,756	3,739	9,223	3,024	60,442
2008	17,508	14,210	8,778	10,991	3,638	8,086	3,099	57,048
2009	17,866	14,486	8,538	11,228	3,664	7,878	3,169	57,324
2010	19,354	15,694	10,726	12,163	3,972	8,560	3,432	64,001