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Few Data But Many Fish: Marine Small-Scale Fisheries Catches for Mozambique and Tanzania

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Abstract

The Food and Agriculture Organization of the United Nations (FAO) fisheries landings data, which are fed by national statistics, have served as the primary tool for many global and regional fisheries studies, and are used to determine fish consumption, the value of fisheries to national economies, and the amount of surplus fisheries production. However, it is recognized that these reported data are incomplete and may often underestimate actual catches. This study reconstructed total marine fisheries catches from 1950-present for Mozambique and the United Republic of Tanzania. Since the 1950s, Mozambique has reported primarily industrial catches and has vastly under-reported the nation's small-scale fishing sector due to lack of resources and civil war. In Tanzania, Zanzibar's recorded fisheries statistics are absent from Tanzania's marine fisheries catches reported by FAO, and total mainland catches are at least one-third larger than reported by official data. Based on our reconstructed data, since 2000, the Mozambique fishing sector as a whole caught between 150,000 and 172,000 t per year, while the United Republic of Tanzania likely caught at least 95,000 t of marine fish per year. Overall, reconstructed marine fisheries catches were 6.2 and 1.7 times greater than those reported by FAO for Mozambique and Tanzania, respectively. These results have implications for fisheries management, including negotiations of licenses and fisheries access agreements. Both Mozambique and Tanzania have signed or are in the process of signing fishing agreements with various distant water fishing fleets. However, the lack of data on fisheries catches puts management authorities under serious risk of over licensing fishing access and mismanaging marine ecosystems.

Keywords: access agreements, catch rates, catch reconstructions, food security, Malthusian overfishing, overfishing, small-scale fisheries, Sub-Saharan Africa, subsistence fisheries

Introduction

To assess hunger and malnutrition by country, the United Nations Food and Agriculture Organization (FAO) requires the collection, analysis, interpretation, and dissemination of information relating to nutrition, food, and agriculture, including fisheries (Ward 2004). The FAO FishStat database, which offers time series data on marine fisheries landings from 1950 to the present, is fed by national statistical data compiled by its member countries. Therefore, the quality of global FAO data depends on the capacity of statistical collection within these countries. FAO data have served as the primary tool in many global fisheries studies (e.g., Grainger and Garcia 1996; Garcia and Newton 1997; Pauly et al. 1998; Garcia and de Leiva Moreno 2003) but they are recognized as deficient in many regions (e.g., Pauly 1998; Zeller and Pauly 2007; Zeller et al. 2007), including Africa (van der Elst et al. 2005; Tesfamichael and Pitcher 2007).

Data reported by FAO are unfortunately not readily distinguishable by sector (e.g., commercial vs. subsistence). Domestic, small-scale fishing (both small-scale commercial as well as non-commercial subsistence) often contributes significantly to food security and nutritional needs of coastal communities, particularly in developing countries. However, small-scale fisheries have often been marginalized politically due to their socio-economic, physical, and political remoteness from urban centers (Pauly 1997), resulting in under-representation in official statistics. Instead, government focus and support is often directed toward industrial fishing, which provides foreign exchange earnings. This dichotomy is thus also often reflected in reported data, and hence impacts interpretation of global analyses.

However, the role of small-scale fisheries in local economies and food security must be closely examined, particularly in Sub-Saharan Africa, the only region of the world where child malnutrition is predicted to increase rather than decline (Pinstrup-Andersen et al. 1999). In Mozambique and Tanzania, two of the poorest countries in the world, small-scale fisheries have long contributed to rural livelihoods and food security. Although this is recognized in some instances, it is not clear to what extent this is reflected in concrete policy level action. Clearly, these resources and their habitat need to be protected for local food security purposes.

In both Mozambique and Tanzania, small-scale fisheries greatly resemble those from centuries ago and provide an important source of protein. Small-scale fishing takes place both from shore, and from canoes and dhow-type planked boats, mostly propelled by sails (Mngulwi 2006), and almost exclusively in the nearshore waters of 40 m depth or less (UNEP 2001).

Industrial fishing in the waters off Mozambique and Tanzania began in the 1960s. Fishing vessels were often financed or entirely operated by European countries and allowed to operate in Mozambique and Tanzanian waters in exchange for foreign revenues. In the 1980s, for instance, shrimp became Mozambique's largest earner of foreign exchange after cashews (Anon. 1984). But not without a price.

Similar to the situation in West Africa (e.g., Marquette et al. 2002), Mozambican and Tanzanian industrial shrimp trawlers disobey legal requirements to stay offshore and fish in inshore areas as well. The trawlers damage the ocean bottom and destroy passive fishing gear set by small-scale fishers (Lopes and Gervásio 1999). They also often discard large fractions of their catch as unwanted by-catch (e.g., Kaczynski and Fluharty 2002). But species caught and discarded

by shrimp fisheries often overlap directly with those resources that small-scale fisheries rely on (and almost never discard). In this sense, industrial fishing can threaten food security for the population.

In Mozambique, there are around 120,000 fishers and 658 small-scale landing sites, while in Tanzania there are an estimated 55,000 fishers and more than 400 landing sites for the mainland and Zanzibar combined (Jiddawi and Muhando 1990; Shao et al. 2003; IDPPE 2004). Underestimation of and difficulty in data collection for small-scale marine catches have been recognized repeatedly (e.g., Herrick et al. 1969; Anon. 1988; Mongi 1991; Charlier 1994; Gillet 1995; Guard et al. 2000). In both countries, general underreporting of small-scale catch is thought to be potentially substantial.

The present study reconstructed total marine fisheries catches for both countries for the period 1950-2005 to derive a historic baseline and evaluate the overall magnitude of underreporting.

Material and Methods

Marine fisheries catches have been successfully reconstructed in other regions of the world (Zeller et al. 2003; Pauly and Zeller 2007; Zeller et al. 2007). Here, we follow the basic conceptual framework and approach outlined by these studies to reconstruct historic marine fisheries catches for Mozambique and Tanzania. This required the collection of data and information from published and grey fisheries literature available for both countries (details can be found in Jacquet and Zeller 2007a, 2007b available at www.fisheries.ubc.ca/publications/reports/fcrr.php), combined with interpolations and clearly defined assumptions.

Mozambique

At the national level, Mozambique's fisheries are considered in three sub-sectors: industrial, semi-industrial, and artisanal or small-scale. For this paper, we combine the latter two sectors thus consider Mozambique's fisheries in two categories: small-scale and industrial, where the small-scale sector includes boat-based fisheries as well as 'collectors' (consisting of shore-based collectors and boat-based divers, most often for home consumption).

Small-scale sector

Time-series data on small-scale catches were not available, although unpublished reports provided estimates for the small-scale fleet for certain years (e.g., Krantz et al. 1986; Charlier 1994). However, these studies did not present details of their methods for estimation, nor did they appear to include the 'collector' component in catch estimates. Thus, they were considered as minimal estimates.

The data that were most comprehensive were the 2003 and 2004 national catch data as collected and reported by the Instituto Nacional de Investigação Pesqueira (IIP), which explicitly included estimated small-scale fisheries catches with a clearly described estimation method (IIP 2003, 2004). While the 2004 data were derived from sampling 115 of the larger fishing centers, expansions were never made to the other 543 (smaller) centers (N. Faucher, Instituto Nacional de Desenvolvimento da Pesca de Pequena Escala, pers. comm.). The 2003 data included full coverage of three coastal provinces (Maputo, Sofala, and Zambezia), 70% coverage of two other

coastal provinces (Nampula and Inhambane), and excluded the southern province of Gaza and the northern province of Cabo Delgado, which has the largest number of active boats and the second largest number of fishers (KPMG 2006). This information was combined with the 2002 fisher census (IDPPE 2004) to determine that, overall, approximately 62% of the total number of fishers were included in the national statistics .

Table 1. Number of fishers by province and the proportion of fishers represented in Mozambique's national fisheries statistics data.

Coastal province	2002 census of fishers[a]	Percent represented[b]	Number of fishers represented	Number of fishers not represented
Cabo Delgado	26,609	0	0	26,609
Nampula	39,585	70	27,710	11,876
Zambezia	14,151	100	14,151	0
Sofala	11,838	100	11,838	0
Inhambane	17,784	70	12,449	5,335
Gaza	1,497	0	0	1,497
Maputo	6,783	100	6,783	0
TOTAL	118,247	62	72,930	45,317

[a]IDPPE (2004) bKPMG (2006)

Therefore, it was assumed that the reported catch for 2003 and 2004, being 67,074 and 57,747 t respectively, was caught by 62% of all coastal fishers. Assuming proportionality, we increased the reported catches for 2003 and 2004 by 38% to derive '100% estimates' for these years. This resulted in a reconstructed small-scale catch of 108,184 and 93,140 t for 2003 and 2004, respectively. Based on these adjusted total small-scale catches and the associated fisher population, we derived estimated per fisher catch rates of 2.47 and 2.09 kg·fisher-1·day-1 for 2003 and 2004, respectively.

Anecdotal evidence suggests that, due to additional fishing pressure from refugees, catch rates declined during the civil war, which lasted from 1975 to 1992 (Dutton and Zolho 1990; Lopes and Gervasio 1999). A case study on the small-scale fishery of Inhaca Island (part of the province of Maputo) presented data from fisher interviews, and suggested that catch rates declined by 38% over the last 30 years from 29 to 11 kg·fisher-1·day-1 (de Boer et al. 2001). We applied this 38% inversely to the lower 2003 national catch rate of 2.47 kg·fisher-1·day-1 (derived above) to derive an estimated catch rate of 6.44 kg·fisher-1·day-1 at the start of the civil war in 1975. Thus, the national small-scale catch rate was assumed to decline from the estimated 6.44 kg·fisher-1·day-1 in 1975 to 2.47 kg·fisher-1·day-1 in 2003. To remain conservative, the catch rate was assumed constant (6.44 kg·fisher-1·day-1) for the 1950-1974 pre-war period.

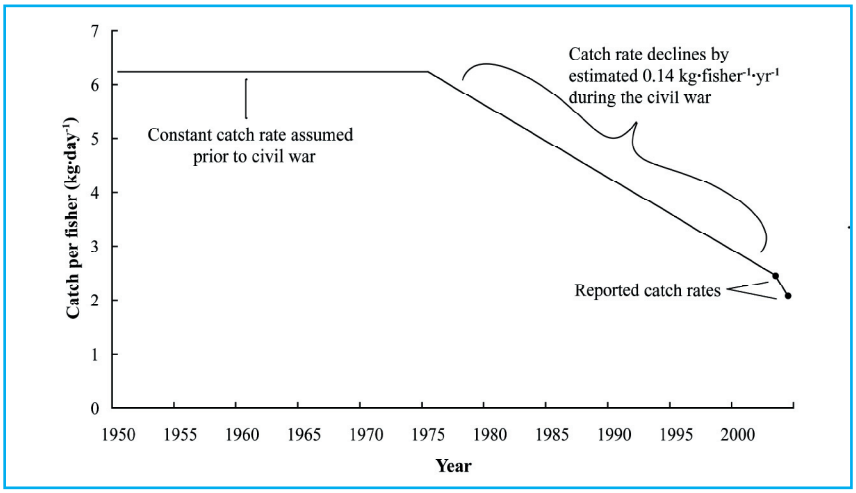

Figure 1. Small-scale catch rate (catch per fisher per day) estimated & reported for mozambique 1950 - 2004

Figure 1: Small-scale catch rates (catch per fisher) estimated and reported for Mozambique, 1950-2004; catch rate was assumed to decline with the start of the civil war in 1976.

Estimates of fisher populations were available for seven different years spanning 1965-2002 , however, estimates prior to 1995 excluded 'collectors'. Therefore, we took the average proportion of 'collectors' to total fishers for 1995 and 2002 (45%), and applied this average proportion to estimate 'collector' populations for the earlier years.

Table 2. Fisher, collector and human population data for Mozambique, and ratio of fishers & collectors to total population with sources and estimates.

Year	Reported fishers	Reported collectors	Source	Collector Estimatesa	Fishers & Collectors	Population (x 106)	Ratio (fishers & collectors/ 1000 people)
1965	16,131	no data	Herrick et al. (1969)	13,198	29,329	7,414	3.96
1979	38,883	no data	Konigson et al. (1985)	32,086	70,969	11,329	6.26
1981	39,609	no data	Debeauvais et al. (1990)	32,407	72,016	11,885	6.06
1982	42,300	no data	Konigson et al. (1985)	34,609	76,909	12,097	6.35
1988	43,876	no data	Debeauvais et al. (1990)	35,899	79,775	13,369	5.97
1995	49,045	47,378	IDPPE (1998)	-	96,423	14,854	6.49
2002	69,359	48,888	IDPPE (2004)	-	118,247	18,676	6.33

[a]Based on a 45% proportion of collectors to total fishers, as derived from reported data for 1995 & 2002

The ratio of fishers plus 'collectors' to the entire Mozambique population (based on interpolated census data available at www.populstat.info) was determined for these seven years, while ratios for the remaining years were estimated proportional to the whole population trends. We used this derived time-series of ratios to estimate numbers of fishers and 'collectors' for 1950-2004 (Figure 2).

Combining these derived fisher plus 'collector' estimates with the derived catch rates provided total small-scale catch estimates from 1950-2004.

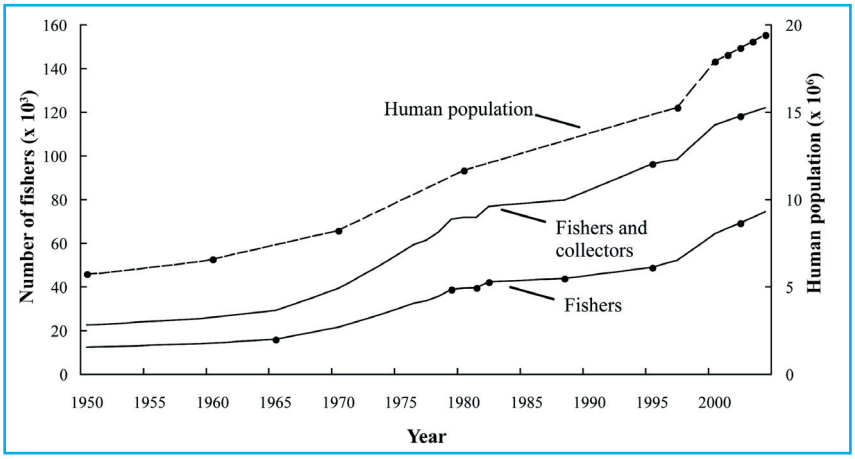

Figure 2. Time series of ratios to estimate numbers of fishers and collectors 1950 - 2004

Industrial sector

Landings

Historically, more resources have been allocated to monitoring and reporting the fisheries catch by the industrial sector. Thus, grey literature reports indicating industrial catch were accepted as reported .

For years when data were unavailable, catch estimates were interpolated linearly between adjacent periods, thus assuming that no direct correlation existed between industrial catch development and human population trend (see also Zeller et al. 2006).

Table 3. Industrial sector reported catches and sources for Mozambique, 1955-2003.

Year	Reported catch	Source
1955-1960	3,300-3,900[a]	Krantz et al. (1986)
1961-1975	3,285-15,655[b]	DNP (1976)
1981	24,650	Konigson et al. (1985)
1982	20,000	SIDA (1982)
1985	49,100	Gerboval et al. (1994)
1986	51,610	Gerboval et al. (1994)
1987	48,050	Gerboval et al. (1994)
1990	33,436	Gerboval et al. (1994)
1994	23,229	Charlier (1994)
2003	22,037	Tembe (2004)

[a]1955 catch was 3,300 t; 1960 catch was 3,900 t
[b]1961 catch was 3,285 t; 1974 catch was 15,655 t

Discards

The increase in industrial shrimp fisheries in the 1970s (Anon. 1984) meant a corresponding increase in by-catch (landed) and discards (not landed). By-catch is likely under-reported, while discards are entirely absent from the reported data. Schultz (1997) reported an annual by-catch of 21,000 to 29,000 t between 1993 and 1996, while in 1982, shrimp fisheries discards were estimated at 15-20,000 t (Anon., 1982). However, it is thought this latter amount is conservative and was likely at least 25,000 t (Tenreiro de Almeida, former Secretary of State for Fisheries in the 1980s, pers. comm.) Thus, assuming 25,000 t of discards in 1982 and comparing this to total FAO reported shrimp catch of 8,900 t for 1982 resulted in a 2.8:1 ratio of discards to shrimp catch. This ratio was applied to the time series of reported shrimp catches to produce time series of estimated discards (Table 4).

Table 4. Decadal industrial shrimp catch and estimated discards for Mozambique, 1950-2000.

Year	Reported Shrimp catch (t)[a]	Estimated Discards (t)[b]
1950	0	0
1960	400	1,120
1970	800	2,240
1980	11,700	32,760
1990	10,539	29,509
2000	11,195	31,346

[a]FAO FishStat
[b]Based on 25,000 t of discards for the early 1980s, a discard:shrimp ratio of 2.8:1 was estimated

Total reconstructed catch was thus derives as estimates of small-scale catch plus industrial catch plus discards.

Tanzania

Examination of Tanzania's FAO statistics revealed that data for Zanzibar, a region of Tanzania comprised of two large offshore islands (with substantial fish catches), are missing from official statistics. This may be an artifact of the complexity and history of Tanzanian bureaucracy: mainland Tanzania and Zanzibar each have autonomous institutional and legal structures for managing fisheries, and thus have separate systems of reporting. Thus, we estimated total catches for the mainland and Zanzibar separately, and combined these estimates to derive country totals.

Mainland Tanzania

For the mainland, we retained the data as reported by FAO for the years 1950-1969, which were the best estimates we could obtain. However, it is possible that this period continues to be under-estimated. A new data collection system implemented in Tanga (the northern most province) suggested that catches since the 1970s were at least 35% greater than previously reported (Verheij et al. 2004). Thus, we increased the 1970-2005 time series of reported marine fisheries catches for the mainland by 35%. This adjustment is likely conservative (Martin Guard, Eco2 Dive Centre, pers. comm.).

However, this adjusted time series of fisheries catches did not include any catches by 'collectors' (shore-based collectors and boat-based divers). Mainland frame surveys estimated 576 and 796 'collectors' in 2001 and 2005, respectively. For 1970-2000, for which we had reliable number of fishers, we took the ratio of 'collectors' to fishers from 2001 (3:100) and applied that to the 1970-2000 number of fisher time-series (Table 5). The numbers of 'collectors' for 2002-2004 were estimated using linear interpolation between 2001 and 2005 reported numbers of 'collectors'. To obtain estimates of 'collector' catch, we used the reported 'collector' catch

Table 5. Number of fishers and collectors on the Tanzanian mainland, 1970-2005.

Year	No. of fishers	No. of collectors
1970	6,719[a]	202
1971	8,200[b]	246
1972	8,531[b]	256
1973	8,188[b]	246
1974	8,331[c]	250
1975	8,500[b]	255
1976	11,157[d]	335
1977	10,033[d]	301
1978	9,800[b]	294
1979	8,100[b]	243
1980	7,600[b]	228
1981	13,200[b]	396
1982	13,500[b]	405
1983	9,500[b]	285
1984	13,783[e]	413
1985	11,392[f]	342
1986	12,619	379
1987	12,739	382
1988	13,855	416
1989	13,887	417
1990	16,178	485
1991	16,361	491
1992	15,027	451
1993	15,027	451
1994	15,027	451
1995	13,822	415
1996	13,822	415
1997	13,822	415
1998	20,625	619
1999	20,625	619
2000	20,625	619
2001	19,071	576[g]
2002	19,071	631
2003	19,071	686
2004	19,071	741
2005	29,754	796[h]

[a]Fisheries Division (1970) [b]Bagachwa et al. (1994)
[c]Fisheries Division (1975) [d]Mikisi (1984) eBagachwa et al., (1994) [f]1985-2005 F. Sobo, Fisheries Division, pers. comm. [g]Fisheries Division(2002) [h]Fisheries Division (2005)

rate and effort data for Matemwe, Zanzibar (4.0 kg·collector-1·day-1 for 240 days per year, see below; Jiddawi and Stanley 1999). As there were no data on the number of fishers and number of 'collectors' from 1950-1969, we took the estimated 1970 'collector' catch as a ratio to fishers catch (0.8:100) and used this to conservatively estimate collected catches from 1950-1969. Total marine catch estimates for the mainland were thus obtained by combining the adjusted catch time series for fishers and the estimated catch time series for 'collectors'.

Zanzibar

For Zanzibar (consisting of the two islands Ungaja and Pemba), fisheries catches by boat-based fishers were available from 1980-2005 (missing data for 1989 was interpolated). For 1980 and 1981, however, the catch data are thought to represent only Unguja island. Furthermore, for 1980, we had data for the number of fishers on Unguja and Pemba (5884 and 7058, respectively; Ngoile [1982]; Table 6).

We thus calculated the 1980 catch per fisher of 0.67 t·fisher-1·year-1, and used this rate for the number of Pemba fishers to establish the Pemba catch for 1980. For 1981, we interpolated the number of fishers between frame surveys (1980 and 1985) and then repeated the steps used for 1980 to determine the 1981 catch data for Pemba.

However, these data did not include the catch by 'collectors' except for the years 1980, 1985, 1989. We interpolated the number of 'collectors' between these years to determine the number of 'collectors' from 1980-1989 (Table 6).

Table 6. Number of fishers and collectors for the islands of Ungaja and Pemba (comprising Zanzibar, Tanzania) for 1980-1989.

Year	No. of fishers (Ungaja)	No. of fishers (Pemba)	Collectors (Zanzibar total)
1980	5884[a]	7058[a]	4555[a]
1981	5954	7194	3937
1982	6024	7330	3319
1983	6094	7467	2700
1984	6164	7603	2082
1985	6234[b]	7739[b]	1464[b]
1986	-	-	1679
1987	-	-	1894
1988	-	-	2108
1989	-	-	2323[c]

[a] Ngoile (1982) [b] Carrara (1987) [c] Mongi (1991)

Jiddawi and Stanley (1999) estimated catch rates for 'collectors' in Matemwe, Zanzibar to be 4.0 kg·collector-1·day-1. At Matemwe, fishers go to sea 16-20 days per month, while in other parts of Zanzibar fishers go to sea as often as 25 days per month (N. Jiddawi, Institute of Marine Sciences, pers comm.). Here, we assumed the catch rates from Matemwe to represent the average rate for 'collectors', which is likely conservative for earlier years because catch rates appear to have declined. Thus, we assumed a catch rate for 'collectors' of 4.0 kg·collector-1·day-1 and an effort of 20 days per month (i.e., 0.96 t·collector-1·year-1). This rate and effort was multiplied by the time series of 'collectors' (from 1980-1989) to obtain 'collector' catches from 1980-1989.

Because 1989 was the last reliable data point for the number of 'collectors' in Zanzibar, we used the ratio of 'collector' catch to boat-based catch in 1989 (23:100) to estimate a time series of

collected fish from 1990-2005 based on assumed proportionality to reported fisheries catches.

For 1950-1980, we had only two data points for estimated catches: 1959 and 1975, which were presumed not to include 'collectors'. We thus interpolated these boat-based catch data between 1960-1974 and 1976-1979. For 1950-1958, we extrapolated the catch backward based on the linearly increasing catches interpolated annually from 1959-1975 (an increase of 250 t annually). To estimate catches taken by 'collectors', we used the ratio of 'collector' catch to boat-based catch in 1980 (33:100) and carried this ratio back unaltered to 1950. We then aggregated the boat-based and 'collector' catch for a time series of Zanzibar marine fisheries catches from 1950-2005. Finally, we aggregated the estimated total catches for Zanzibar and the mainland to obtain an estimate of total catches for the United Republic of Tanzania from 1950-2005.

Results

For Mozambique and Tanzania combined, the overall reported catches underestimated likely total catches by a factor of 3.5 over the 1950-2005 time period. For each country taken separately, reported catches were 6.2 and 1.7 times lower than estimated catches for Mozambique and Tanzania, respectively.

Mozambique

Catch data as reported by FAO on behalf of Mozambique suggested a steady increase in catches from 7,800 t in 1950 to a peak of 37,130 t in 1981, before declining to around 25,000 t per year in the late 1990s-early 2000s. In contrast, the estimated total marine fisheries catches as reconstructed here suggested a rapid increase in catches starting in the late 1960s and continuing through the civil war, reaching a peak of 222,080 t in 1986 before beginning a decline that seems to continue to the present day (Figure 3a).

Thus, using the reconstruction approach as outlined here, Mozambique's annual catches were likely between 47,000 and 177,000 t higher than the reported data suggested. Since 2000, the FAO has reported annual catches between 24,000 t and 32,000 t, while the present study suggested annual catches between 150,000 t and 173,000 t for the same time period.

The reconstructed time series data also illustrates the magnitude of small-scale catches. In terms of tonnage, the small-scale sector caught almost six times the amount of the industrial sector

Figure 3a. Estimated marine fisheries catches as recostructed compared to FAO estimates

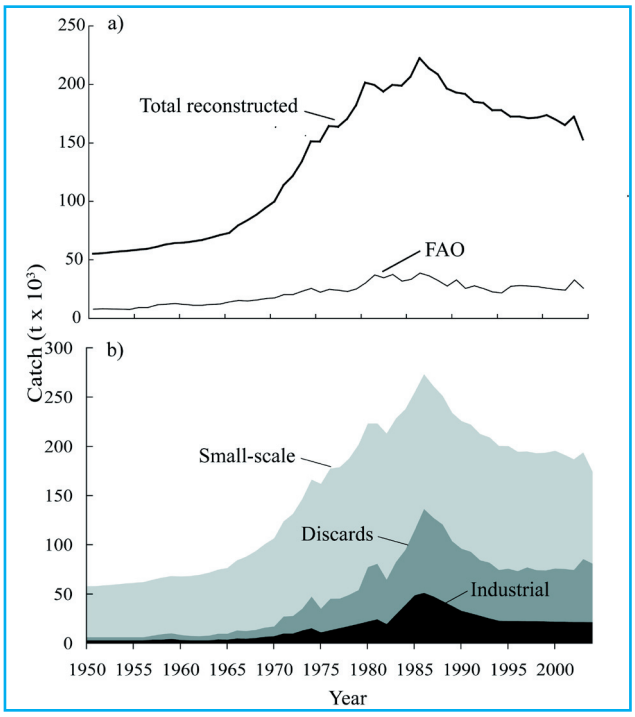

Figure 3b. Recostructed time series data illustrating magnitude of small-scale catches compared to the industrial sector

(Figure 3b). Excluding freshwater catches and ignoring imports and exports of industrial catch, and assuming that the entire small-scale catch was consumed within Mozambique, the average per capita marine seafood consumption over the 55-year period was 9.6 kg·person-1·year-1 for Mozambique. From 2000-2004, marine seafood consumption was estimated between 4.8 and 6.7 kg·person-1·year-1.

Tanzania

Catches as reported by FAO for Tanzania suggested an increase in fisheries catches from around 14,000 t through the 1950s to a peak of nearly 62,000 t on 1996 followed by a slow decline. In contrast, reconstructed catches show that fisheries catches increased from 25,000 t in the 1950s to around 97,000 t in the millennium (Figure 4a). Overall, for the 1950-2005 period, the reconstructed catch was 1.7 times larger than that reported by FAO.

Figure 4a. Estimated marine fisheries catches as recostructed compared to FAO estimates

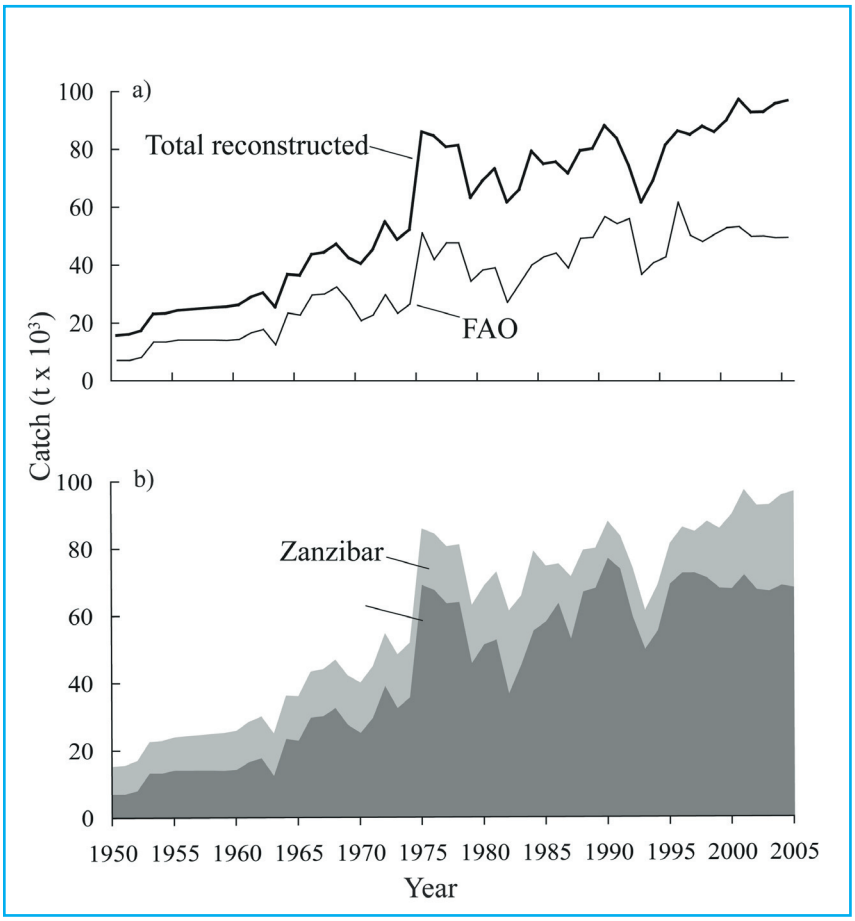

Figure 4b. Recostructed time series data illustrating magnitude of small-scale catches

The present study indicated that, for the Tanzanian mainland and Zanzibar, total marine catches over the last few decades ranged between 10,000-25,000 t and 36,000-77,000 t, respectively. Thus, mainland catches were about three times those of Zanzibar (Figure 4b). On the mainland, catch per fisher has been around 3.5 t·fisher-1·year-1 in recent years and total catches have declined, while catch rates have been much lower in Zanzibar, ranging between 0.5 and 1.5 t·fisher-1·year-1, while total catches have increased due to increased fishing pressure.

Discussion

The Western Indian Ocean represents 8% of the world's oceans but, according to FAO data, generates only 4% of reported global landings (van der Elst et al. 2005). As we have shown here by examples of Mozambique and Tanzania, such an assessment is more an indicator of poor and substantially incomplete reported data than underutilized fisheries productivity. According to our reconstructions, Mozambique and Tanzania's marine fisheries catches from 1950-2005 were 6.2 times and 1.7 times greater, respectively, than those reported by FAO based on country reports. These findings support broader research in the Western Indian Ocean that suggested that FAO data reflect less than half of the real catch in the region (van der Elst et al. 2005). Our findings also reinforce what Pauly and Zeller (2003) emphasized: there is a need to complement FAO data and incorporate estimates of previously ignored catches, even if these are based on approximations and assumptions.

In both countries, marine fisheries catches recorded by the national fisheries divisions were not extrapolated countrywide. Furthermore, the catch by 'collectors' (fishers on foot and divers) was often omitted from official fisheries data. The reconstruction for Mozambique, as undertaken here, now accounts for catches by all fishers and 'collectors', as well as discards by the shrimp fishery. For Tanzania, reconstructed catches now incorporate Zanzibar, as well as catches by 'collectors' on both the mainland and Zanzibar. They also conservatively compensate for general underreporting on the Tanzania mainland. Thus, the reconstructed data as presented here better reflects total catches taken from marine ecosystems. Although there is a level of uncertainty associated with our estimates, we remained conservative in our assumptions throughout. Thus, the reconstructed data illustrate more likely historical trends and patterns for Mozambique and Tanzania over the last 50 plus years. Importantly, the catch estimates presented here are likely closer to the truth than the alternative of continuing to rely on reported catches, and therefore to assume that no data means no catch.

For national governments, the earning potential from tax revenues on commercial and export fisheries is often enticing. But the lack of data on total fisheries catches puts management authorities in serious risk of over-licensing. In negotiations of fisheries access agreements, reference tonnage is partly used to determine initial cost of the agreement. In the absence of better data, FAO data and other unreliable existing statistics that underestimate fisheries catches are often taken as benchmarks, which results in low tonnage values.

The present study is specific to Mozambique and Tanzania; however the situation presented is relevant for all the Western Indian Ocean countries, and Mozambique and Tanzania are likely representative. In sub-Saharan West Africa for example, foreign fishing nations' payments for access agreements greatly under-represent the true value of the resource being extracted by foreign vessels from local Exclusive Economic Zones (EEZs). In Guinea-Bissau, the revenue the country received by 'selling' the fishing rights to the EU is only 7.5% of the value of the fish had it been processed in Guinea-Bissau (Kaczynski and Fluharty, 2002). More holistic estimates of total catches being taken by countries (such as presented here) will assist in ensuring more appropriate compensation for foreign fleet access agreements. Declining trends in fisheries catches over time, such as those documented here for Mozambique, also reveal on the potential for already ongoing overfishing of local resources. Given the common ontogenetic linkages between inshore (shallow) and offshore (deeper) shelf waters for many fish and invertebrate resources (e.g., Zeller

and Pauly 2001), the likely heavy or excessive fishing pressure by the small-scale fisheries in shallow, nearshore waters will likely be exacerbated by inappropriate or excessive catches granted by access agreements. This may substantially impact local food security.

In recent years, the Mozambique's Fisheries Research Institute has made great improvements in data collection, which is reflected in recent government reports, e.g., resulting in an 800% higher reported catch than using previous approaches (e.g., Afonso 2006). These recent improvements to data monitoring will likely be adopted by FAO after several years of reporting have taken place (D. Gove, IIP, pers. comm.). But unless Mozambique, and hence FAO, retroactively use these data to hind cast back to 1950 to adjust the substantial historic underreporting, the future data will continue to misrepresent the historic baseline, with potentially dire consequences for ecosystem-based interpretation of the effects of fishing.

Furthermore, in the reconstruction presented here, small-scale fisheries catches were substantial and, on average, accounted for 75% of total marine catches. These inshore resources are important to coastal people, many of which live marginal existences. The high level of poverty among fishers, combined with the reconstructed estimates, suggested that fish is a more important part of food security than would otherwise be perceived. Our reconstruction showed that previous per capita fish estimates based on reported data (e.g., 3 kg for Mozambique but 8 kg for sub-Saharan Africa as a whole) likely substantially under-estimated true consumption. Using the reconstructed data, average countrywide per capita marine fish consumption over the 55-year period was 9.6 kg·person-1·year-1. In Mozambique and Zanzibar, 'collectors' play an important role in food security as the invertebrates they collect are often eaten at home while the fish caught by men at sea are sold (Semesi and Ngoile 1993; de Boer and Longamane 1996; de Boer et al. 2000; Guard et al. 2000; Silva 2006). On the Tanzanian mainland, collecting appears to occur at a reduced rate, compared to Mozambique and Zanzibar, possibly due to the availability of alternative sources of animal protein.

Overall, however, the sustainability of the resource should be questioned. The present catch reconstruction confirmed reports of declining catch rates on the Tanzanian mainland (Silva 2006). Historically, fishers in Tanzania were considered better off than farmers (Wenban-Smith 1965), but this has changed as more fishers participate (Shao et al. 2003). Catch per fisher peaked in the early 1980s. On the mainland, catch per fisher in the mid-1990s was roughly 5 t·fisher-1·year-1 while in recent years it has been around 3.5 t·fisher-1·year-1.

The decline in catch rates is coupled with other indications of overexploitation, e.g., reduced mean size and decreased abundances (Kristiansen et al. 1995; de Boer et al. 2001) and the widespread use of unsustainable fishing practices (Lopes and Gervasio 1999; Verheij et al., 2004). Population pressure also exists. Overall, the number of small-scale fishers in both countries appears to have quadrupled over the last four decades. Combined, fishing practices and population pressure strongly suggest that 'Malthusian overfishing' (Pauly 1997) is occurring in Mozambique and Tanzania. Though there are attempts at fisheries management in both countries, and the level of enforcement has increased significantly in Mozambique (Afonso 2006), enforcement of existing legislation should be a high priority along with parallel efforts to develop, implement, and support additional community-based management actions, such as community-based no-take fishing zones (MPAs). However, focus on fisheries and related measures alone will not be sufficient, as overall poverty needs to be addressed through vigorous and innovative moves to enhance and

support alternative livelihood options.

Equally important, increasing global markets for seafood are also a point for scrutiny. In 2002, there were 12 licensed industrial fishing vessels fishing in Tanzania's EEZ (Jiddawi and Öhman 2002). By 2004, this number had grown to 24 (Mngulwi 2006). Currently, there is a government provision to lift the export ban on marine finfish in Tanzania that had been in place since the colonial era, and allow ten different groups of fish to be exported (Mgawe 2005). Anderson and Ngatunga (2005) point out that an export fishery would raise local prices and reduce the supply to domestic markets. It may also exacerbate hunger and poverty (Mgawe 2000), and likely result in further non-sustainable increases in targeted fishing effort.

The present study illustrated that the marine fishing sector is a more important asset to national food security for Mozambique and Tanzania, and the magnitude of resource extraction much greater than was previously recognized. In both countries, little data do not mean small catches. Mozambique and Tanzania should be very cautious in allowing international markets to stimulate additional fishing effort given the domestic reliance on fish for fundamental food security purposes, especially in regards to access agreements.

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